PHILIP GREENSPUN: All right. We're going to go in and outline, how do you navigate an airplane? It's become a lot easier now in the GPS age, but you still have to know a little bit about how people used to do it in the old days, partly to pass the exam, and partly because it's interesting.

All right. So we're going to talk about looking out the window. That's called pilotage, planning your flight and then looking out the window. We'll talk about the old non-directional beacons, basically homing in on a radio station.

In the 1950s, there was something called the VOR that we'll talk about that lets you figure out exactly your magnetic heading to or from a radio station. And finally, the way that most people get around these days, the GPS and the moving map.

OK. So when you're doing pilotage, you come up in advance with a bunch of visual landmarks that you think you'll be able to see from the air. You're going to cross a river. You're going to find a reservoir. You're going to see a big radio tower. You're going to pass a town that has the name of the town written in a high school athletic field.

And the VFR charts, they emphasize-- I think you saw that, maybe with the iPad or we have charts up here. We can look at it later-- but they emphasize objects that you can, as a practical matter, see from the air.

So the procedure, and we'll go through this carefully, is you plot your planned course using a pencil and a ruler, essentially, on the chart. You select what checkpoints are going to be visible on your flight. You measure the distance from point to point, and then you've got this plan of what heading you're going to steer. You get the forecast winds as well.

So you say, look, I'm going to fly this. I'm going to be going 100 knots over the ground. I'm going to be being blown off course very slightly by a crosswind from the north. You plan all of that. And then you've got your navlog. So as you reach each checkpoint, you can make a correction. Well, it took me a little bit longer to get here.

I'm a little bit left of where I thought I was. So you can make these corrections as you go along. All right. So here's an example. Let's say you wanted to go from MIT to Bennington College to visit a friend. Well, there's an airport right there called DDH, and it's about 90 nautical miles. I think I did this with a SkyVector.

So your planning goal is to come up with this navigation log. So you're going to say, OK, I'm going to depart Hanscom Field up there at the top. And it's going to take me-- looks like it's going to take me nine nautical miles before I reach my cruising altitude and about four minutes.

Then after that, it's going to take me five minutes to reach Fitchburg Airport, which airports are great landmarks. They're very easy to see and they have distinctive shapes. And notice here, the magnetic course is 298, but with the wind, we're going to have to correct that and steer 292.

And of course, the compass card with the deviations indicated might give us another degree or two. But basically, from the wind, that wind correction is going to have us steering a slightly different course. Anyway, so you're going to come up with this navlog of how long it's going to take, what course you're going to steer from your compass, and as you go along, you're basically doing what's called dead reckoning.

It's tough over the ocean because there's not any landmarks. So those early pilots who went over oceans were real heroes. If you're going over the land, you can actually make these corrections. So the procedure is just as I said. You plot the course on the chart. You measure the true course. So let's say you're going straight north. That's going to be zero.

Then you correct for the forecast wind to find the true heading. Then you correct for the magnetic variation because remember, you're in-aircraft sources are magnetic heading, not true heading. And finally, you're going to estimate the ground speed and estimated time and route for a leg. All right.

Let's talk about some terms. We're using them, let's reinforce them. Your course is the direction over the ground, but your heading is going to be, in general, different from the course due to wind. True is if you steer true north, you'll get to the North Pole and hang out with Santa Claus. If you go magnetic, you'll go to a slightly different place every time. All right.

Magnetic variation, we had this chart pretty much before. So unless you're somewhere down in Florida or it looks like in Chicago, there's going to be some correction from true to magnetic. The local magnetic variation, remember, is indicated on the chart. So it's right here, 14 degrees west, and remember, again, if you get confused about how true and magnetic relate, just look at the OR diagram.

Here's an example, a compass card that you might see in your aircraft. I haven't seen any that are quite this dramatic. I think this is for effect, but you can see it says, look, if you want to fly 60 degrees, a heading of 060-- oh, if you want to go east, instead of steering 090, steer 85 on your compass.

It gets updated every couple of years, I think, and as I added earlier, if you have things in the airplane or systems like a heated windshield turned on, the compass may become kind of worthless. All right. So let's get out the tools. We're going to go through these more with flight planning. But basically, you get your sectional chart.

Tina showed you this. I have one too. I just got it yesterday at East Coast Aero Club, front desk. Flight schools usually sell them. I think they're missing out on the revenue now that it's all free on SkyVector and similar sites. You've got your plotter.

So this is basically a ruler, and the ruler is, on top, in statute miles. I'm not sure when you would ever want to use that, but on the bottom, you have nautical miles which is what we generally use in the aviation world. And you have this protractor that you might remember from elementary school that helps you figure out, on the chart, what the true course is going to be.

All right. So I think you guys can probably figure out how to use that. This is the E6B flight computer. So I think the E6B designation comes from the US military. I'm not exactly sure when this came out. Probably it says in Wikipedia, but I'm assuming it was a World War Ii era kind of device. And it lets you make all kinds of computations of density, altitude, of how fast you're going truly through the air, as a function of your altitude and what you're seeing on your airspeed indicator.

It lets you, on the backside, correct for wind. You can make pencil marks and then start twisting to figure out whether the wind is going to give you a reduction or a boost in airspeed, and also how much of a course correction you're going to need. So it's a very useful instrument.

Now fortunately, it comes with instructions because your modern pilots have mostly forgotten how to use this. It's a historical artifact at this point. But we'll go through some of it so you'll get a flavor for it, and it is fun.

All right. So you put your plotter down on the chart. And as you can see, you'll be able to read from the protractor, depending on the line that you've drawn, what the course is. I will tell you that one of the most important skills, if you're old-school flight instructor, is drawing a straight line from one side of the chart to the other.

I can't tell you how to do it. It's a really complicated folding system that enables you to actually draw a course line when you have to flip the chart over to get from your source and destination airports. OK. Using the plotter, you can see people's charts. They would have to buy new ones every few weeks because they would be so marked up with pencils.

Here we find the true course is 038. So as you can see, they're just reading that off the protractor part. There are paper E6Bs and metal ones. So this is a picture of a paper one. Again, you can see that you can just set up, for example, that we're going to go 90 knots, and then that's here.

If we go 90 knots, then it will take us 10 minutes to go 15 miles. Not very exciting. The wind side is more interesting. You can get your ground speed and your wind correction angle. That's the most important thing.

So this one is hard enough to use that they actually put the instructions right on the top here, on the back of the E6B. So they say, place the wind direction under the true index. We'll go through this. Anyway, the wind's from 210, and we're trying to fly straight south, a true course of 180 at an air speed of 147 knots through the air. We've already computed that.

And the wind's 20 knots from 210. So we're trying to go south. Let's say, this is south at 180 and the wind is coming from the right. So when we're all done, I sure hope that the answer will be that we have to steer a little bit to the right of 180, true at least. All right.

So here we are on the wind side. We start by marking 147 knots, it looks like. And then we rotate it. You can see that pencil mark has been rotated off. It started at 210. Oh, let's go back. Yeah. So we had it set up to 210. Says wind direction under true index.

Then we marked the velocity. Then we twisted it a little bit. So now, we've got an index of south, and we can read that our ground speed will have fallen right there under the little grommet there to 129 knots, and the wind correction angle is going to be 4 degrees. You can read that off of this little scale here. See, it says 5 and 10.

Anyway, so we do all of that, which is very tedious. It's based on a forecast, again, of the winds aloft, so it's never going to be exactly right. And we use it to fill out one of these navigation log forms. Once it's all filled out, you can see that it's a lot easier to do if you just ask some computer application to do it for you, like SkyVector is free and will do it for you, using the forecast winds.

Then when you're flying along, as I said, you make corrections. So here, for example, unfortunately, the one bad thing about SkyVector, I put in these user fixes, a beam to Fitchburg Airport and crossing the Connecticut River, I think, because I thought those would be easy to see from the air.

But unfortunately, there's no way to name them in SkyVector. So they just come out as user fix. But maybe you could write that in with a pencil. Anyway, so you can see here, the wind is forecast to be from 272 at 15 knots. You're going 140 knots of true air speed. Your track over the ground is supposed to be 287 true, minus 2 degrees wind correction angle.

I just did this, actually, for Sunday night, I think. The true heading, therefore, will be 285, but then you'll have to add 16 degrees for the local variation. So you'll end up with a magnetic heading of 301. So you steer that for a while, see how it goes. It's supposed to take you about 12 minutes from the time you took off to the time you reach that point.

And you write down what actually happened. And if you see the airport-- let's see, it's supposed to be on our left. If you see the airport on your right, you say, well, the wind's not quite what I thought. I'm going to steer 10 degrees right. And then, that river crossing, I guess, isn't really ideal for heading correction. You probably want to find some other landmarks as well. All right. Pilotage-- oh, question?

AUDIENCE: How far [INAUDIBLE]?

PHILIP GREENSPUN: They do. Tina might know. I think the winds aloft are forecast either 24 or 30 hours in advance. Yeah. That's a good question. We can look that up for you later. But yeah, so you can predict, to some extent, with prevailing winds. Some of these applications will work with averages and so forth, if it's not there. But yeah, within 24 hours, you have a pretty good wind forecast.

But again, with a modern GPS system, you can immediately see whether you're going off course, and the autopilot may automatically make the correction for you anyway. So this is kind of a historical lecture. It's good to know. What I would say is, well, yeah, so what I would say is, it's still worth doing, but I would say generate the navlog electronically. It's not really worth doing anymore, like the full pain.

The knowledge test does have a built-in electronic E6B. The tests are not that demanding, except that you will need the plotter. So they'll give you a supplement with a bit of a chart, and you need the plotter to figure out how far it is from place to place on the real test. That's if you want to get 100.

Yeah, you see the summary of how it works. It's a fun skill. I will tell you, I had two interactions on basically the same day. I met an alumna of this course at the East Coast Aero Club, and she was tearing up a storm with an E6B and filling out the navlog, and doing all this. I said, why are you doing that? Every East Coast Aero Club plane has a Garmin 430 in it.

Just punch in your destination and you can go. And if that doesn't work, call up air traffic control and tell them you're lost. So she said, well, like every flight with my instructor, he fails everything. He makes me go back and assume that everything's broken and do it all old school and manually.

So she was doing this on every cross-country flight that she was doing, both dual and solo. And I said, well, that's good. I'm not sure how much relationship that has to safety because the other interaction I had that day was with a commercial pilot, instrument rated, who wanted to rent the Cirrus. And I was the previous user of the airplane.

So I said, how much fuel do you want? He said, I want it topped off. I said, you're going to fly for six hours? Where you going? He said, I'm going to Albany. I said, well, it's an hour away. What do you want six hours of fuel for? He said, the airport I'm going to doesn't have any fuel.

I said, Albany, the crosswind runway there is longer than Hanscom's main runway. It's 7,500 feet. They've got a beautiful FBO. It's basically free. What do you mean, they have no fuel? And he wanted to go to this other airport. It was on the east side of town. It was actually farther from his destination. He was taking his son to Rensselaer, and the big airport's actually closer.

And this was a 2,500-foot airport with a note in the chart supplement saying to call a phone number before you even try to go there, to check out the local conditions. It's unattended. If you blow a tire, there's no way to get a mechanic out there other than maybe driving from Albany or Boston.

And it has a displaced threshold too. It's 2,500 feet, but because of the trees on both ends, you're not supposed to land right on the numbers. You actually land a few, like 500 feet or 400 feet down the runway. So I said, the Cirrus takes about 2,100 feet to land over a 50-foot obstacle. So you're budgeting to use more than 60% of the runway, which the airline minimum is, you have to plan to land in 60%. That way if you are a little bit sloppy, you don't go off the end of the runway and hit something.

So I said, why would you give yourself, with your son, less safety margin than a two-pilot airline crew? And so he said, well, I don't want to deal with an FBO, which was really weird to me. So basically, there's no point to that story other than-- no, there is a point to that story. There is no point to that story.

Safety is not about doing everything really tedious. It's more about having reasonable judgment and asking, why am I better than a two-pilot airline crew? So yeah, she was smart. She's an engineer so of course, it doesn't overtax her to do this kind of stuff, but let's not really confuse it with adding safety, which is more about having the judgment to know when to take a co-pilot or when to make your life easier by going to an airport with a really long runway.

All right. Let's talk about ADFs. This was very exciting in 1952. Have a look there. That was a Lear. Some of you have probably heard of Lear Jet. So the founder of Lear Jet was also the inventor of the first practical car radios.

So all the money that was made on car radios was eventually turned into an aviation company, and before the Lear Jet, there were these avionics that made it super easy to figure out where the station was. I think at the very first, the pilot would tune, or the navigator more likely would twist this dial and hear when this tone reached some kind of maximum.

Then there was the automatic direction finder, which would just point the needle in that direction of the station. See here, it's just pointing. Yeah, here's something. This is from the pilots handbook, I think, on how to use an NDB. But you can see that with a heavy wind, you don't end up really tracking exactly towards the station.

All right. So relative bearing is how far to your left or your right the station is. And then you can get the magnetic bearing if you add your own heading in there. So this is not rocket science. If you're going south, and the station is 90 degrees to your left, then the magnetic bearing to the station is going to be, I guess, well, I guess the bearing to the station would be 090, in that case.

All right. This was an exciting thing where you could actually turn the card on your ADF. So if you were heading northwest of a heading of 330, you would twist that and then you just, without having to think, you can see that you have to fly roughly with no wind. You would fly 210 to get to the station.

I guess some planes that operate in Europe a lot, they were requiring this to later. Planes that just have a lot of stuff on the panel still may have this, but in general, they're hard to find now. VORs are still around. They have 360 radials that the radio receiver can just identify. So the receiver can just say, I know that I am exactly south or I know that I'm exactly east or I know that I'm exactly 060 direction from this station.

So you'll be able to know where you are, and if you can tune in two different ones, and you've got your handy pencil out, and your chart, in the aircraft, you can draw intersecting lines and figure out where you are on the chart. So again, in the moving map GPS days, this is not as exciting a skill as it once was.

I think there are a few questions about the symbols on the chart for different kinds of VORs. So one thing is distance measuring equipment, whereby sending out a pulse and having the station send that back to the aircraft, it's possible by measuring the transit time to actually get your distance in nautical miles read out to you in the cockpit.

Be advised that's the actual distance through the air, so it's not the horizontal distance projected over the ground. But if you're up a few miles, it might be, and if you're close to the VOR, it might be slightly different.

Service volumes-- there are these terminal VORs. I think a lot of them may be decommissioned or being decommissioned now. But the FAA has made various kinds of VORs. These high altitude ones will probably be the last to go because actually, with airliners, the certification costs of new avionics are so high that the last aircraft flying without a GPS will be some huge Boeing. It won't be a Piper or a Steerman or something. OK.

The parts of the VOR-- so you have this thing called the Omni Bearing Selector which you can tune here, and on the canonical instrument here, all it does is rotate this card around the top. So that is to pick out the radial that you want, and then you get the To/From flag.

So you can see here, this is showing you that the 360 radial is off to your left. And if we were to fly-- we don't have to. This is not related to the actual heading of the aircraft-- but if we were to fly basically north, we'd be going away from the VOR. OK. We're going to get into this more.

The HSI down there offers you the same information, but superimposed on the aircraft's actual heading, which makes life a lot easier. OK. How do you test your VOR and know that it's actually going to work? There are these VOR test stations, or VOTs, test facilities. If you can remember Cessna 182, every VOT puts out the same signal, and what you should see is an indication of 2 when you dial up, and it should be centered on the 180 radial.

So that's how you know if your VOR is working. If you're going to use it for instrument flight, you have to test them every 30 days. All right. Let's have a look. You're going to probably have to study and think about this a little bit more at home.

But one easy way to think about this is to build yourself a virtual HSI. So if you see a test question, and it shows the indicator set up to tune to like the 030 radial, just draw a little airplane or imagine an airplane actually heading northeast on a 030 heading.

So you can see this airplane at left, this one, it's showing that the 030 radial is to the right of the wing, assuming we were actually heading 030, and that we're going vaguely towards the VOR because the To flag is set up.

Over here, it's the same, but it's the From flag. Over here on the right, we've got the radial off to our left, and we're going From the VOR over here. Again, the radial's to our left and we're going To. So just let that sink in a little bit.

I think I'm going to show you an FAA written test question, so you just know. It says, the VOR's turned to the Elizabeth City VOR. That, I believe, is right over-- if you want to know the value of a marketing degree, this Elizabeth City is right next to a big place called the Dismal Swamp, the Dismal Swamp Park.

Anyway, so if you're anywhere near the Dismal Swamp, and you want to go visit, and you're at Elizabeth City, tune to the VOR. It says the aircraft is positioned over Shawboro. One of the hardest things about this is finding Shawboro on the map. But I've drawn it there for you.

So we're northeast of the VOR, and it says, which VOR indication is correct, 2 which is at the top there, 8 or 9 on the bottom? What do you guys think? So we're northeast of Shawboro. Who wants to vote for 2? 210 from. Nobody? Who wants to vote for 8? That's 0302. Who wants to vote for 9? A few hands? Yay.

OK. So basically, we're right on the radial. So Shawboro, you can see here at the end of the arrow, it is, I think, that actually might say-- I don't know what that says, actually. I have no idea. 10, 20, 30, yeah, it's right there at the 30. OK. So it's definitely on the 030 radial, which is also the 210 radial, the reciprocal. I mean, this is not a totally trivial question.

But if we were to fly 210, we would be going To. The flag should be To. If we were actually flying southwest, we'd be heading towards the VOR, so it should be a To flag. If we're flying away from the VOR, further out on 030, and it should be a From flag which is not an 8, and this one is the only one that's consistent because if we actually were to fly 030, we'd be going away from the VOR.

Don't sweat it if you haven't got it. There is actually a cool simulator in Adobe Flash which was actually cool when you guys were born. And AOPA, also, I have linked here to the Airplane Owners and Pilots Association, the big lobbying group for private aviation. They have a list of-- I don't think they're free, unfortunately. That web simulator is free.

But there's little simulators you can get on your phone for VORs. That used to be really important. I mean, GPS is now more important, basically. It was a 1973 US military idea. If you just broadcast the time and the position of a bunch of satellites from the satellites, then the receiver can see how long did it take to get from the satellite to where the receiver is.

So if you think about it, let's say one of the transmitters is by that exit sign. So if I know my distance from the exit sign, that puts me on a sphere of uncertainty, right? I could be up in the ceiling. I could be down on the first floor. I could be in a lot of different places, as long as I know that I'm-- let's call it 30 feet from the exit sign. OK.

Well, that's not great because I'm still pretty uncertain about where I am. But how about if there's another transmitter in that corner of the room, that gives me a second sphere. Two spheres will intersect in a circle, I believe. So now we have a circle of uncertainty. And we pick up another transmitter maybe somewhere over there.

So the more satellites we can see, the more intersecting spheres we have, and eventually, we'll get down to a very small little area of uncertainty, indeed. So that's how GPS works. You just rely on the fact that the speed of light is constant. If you know the distance to each of a bunch of satellites, and you know where they are, then at that point, you know where you are.

The 32 satellites, as of 2016, were up. 31 were in use. You can always see five. For IFR, the idea is to try to get some redundancy. There are some tweaks to that system. I think what I just described would work really well in outer space where there's no atmosphere to bend or distort any of the radio signals.

But there is a certain amount of distortion that happens, and there are these ground-based reference stations. So you know exactly where they are. They don't move. And they listen to the signals. And they try to figure out how much error there is as a result of the signals traveling through the atmosphere at that location.

Those corrections are then pushed back up into space and sent back down from the satellites to ordinary receivers. And with those corrections, you can become really accurate. You can get accurate enough to actually fly down right towards the runway. So the GPS system which launched in the mid-'90s, that enabled the moving map, and you never were lost again. You always knew where you were.

But the WAAS system is what enables these GPS approaches where you navigate in 3D to within-- I don't know-- 10 feet or something of precision, right down to the runway. All right. What does it look like in practice? This is the pilot's view. This is a modern Garmin 750.

It's a single box that actually has three sub boxes, and the sub boxes are the GPS, a nav radio, which lets you tune up VORs and instrument landing system for approaching a runway. Tina may talk about that a little bit tomorrow in a little IFR intro, and also a com radio,

And they actually, I think they actually have three separate power supplies. So there's a connection to the box, maybe for power, but after that you can have tremendous amount of failure inside the box and still have a subset of the functions working.

I guess if the screen fails, you're out of luck, which is why every IFR certified airplane that I know of that's newish has a second one of these, usually smaller, a Garmin 650, which is physically smaller. The Garmin G1000, it's even bigger. It's on this huge multifunction display. If that fails, you can swap all the information over to the primary flight display or vice versa.

So that just gives you a little view to it. Here's your com radio on the G1000, and here's your nav radio, and see, it's even identified. The VORs put out a Morse code signal, and the Garmin has listened to it and identified it as the PPG VOR, the FJR VOR. All right.

The G1000, actually, this is one of the worst human factors design I think I've ever seen. Wonder who else can identify this. Like what is truly terrible about this design? I'll give you a hint. Well, there's the all the engine instruments on the left there too.

So what kind of pretty common failure, accident causing failure, does this really not help you prevent? Electrical-- that's not very common. And I'll tell you that most airplanes that have an accident are in perfect mechanical, electrical, and sheet metal condition.

AUDIENCE: Fuel starvation?

PHILIP GREENSPUN: Fuel starvation. Yeah, like your battery, your amps. I mean, basically, fuel is given the same status as all of this stuff. Fuel is almost always relevant. And this other stuff is almost never relevant. And here it is. It's small. As you run out of fuel, as you get really down into the red zone, does this thing grow? You think it would grow to consume half of the display.

But It doesn't do anything like that. So I think it's a terrible, terrible design, and aviation really needs some help. Avidyne is a little better, I think, on the user interface. This is kind of a legacy system from the Cirrus. This is NEXRAD data link weather. We're going to talk about that in a little bit.

Here is just a little thing about navigation. If you're going anywhere near the DC area, either get your instrument rating and file IFR, and then it becomes like everywhere else, or you have to take this online course at some point and learn about the special rules in the DC area. They're not that hard to go down to Gaithersburg. You have to VFR. You have to go in from certain gates. You have to file a flight plan in advance, and you have to keep a unique transponder code so that air traffic control can track you.

So if you have any brilliant ideas for how folks in DC could do things better, you can just get in a little Piper or Cessna or Cirrus at Hanscom, zip down to Gaithersburg, and there you are. All right. After the navigation mistakes, so let's say you bust into class Bravo airspace without a clearance, or do something else that you shouldn't have done.

The FAA and NASA are really not there to bust you. There's this special form you can fill out where you if you write down what you did, why you did it, how you think things could be improved-- maybe it was a user interface issue. Maybe somebody else was using the airplane before you and turned off all the airspace alerts.

You just fill out this form and mail it in, and that limits the amount of discipline that they can subject you to. I mean it doesn't protect you from intentional violations. All right. Here's a summary. Pilotage, NDBs, VOR, and GPS. That was the progression. You've seen, now, 100 years of aviation navigation. Actually, one thing that I hope this does is give you a new appreciation for some of the achievements of people who flew around the world in the '60s or the '50s.

There's a woman, Jerrie Mock, I think, is her name. A great book. She flew a Cessna tail dragger around the world in the 1960s. And she was often lost. She'd be over the ocean with icing on her wings. She would be having to track NDBs in Egypt or whatever.

So all of that stuff has gotten so much easier, it's almost not fair. And you've got these data links. So we can't compare our achievements to the achievements of pilots or the risks that we're taking to the risks that folks were taking in the old days. They didn't have EPIRBs if they went in the water. They didn't have moving maps.

So they just didn't know where they were most of the time. They had a vague idea. All right. So this is for Francis. This is a quote from Captain Sully's book, the single pilot Airbus hero, according to most of you. So he's got a failed GPS and a failed compass, Francis.

He says he could just keep Venus in the left front corner of the windshield, and we would reach California. What else could Captain Sully have done as an alternative to using Venus?

AUDIENCE: The sun?

PHILIP GREENSPUN: The sun? Well, it's nighttime. What?

AUDIENCE: Polaris?

PHILIP GREENSPUN: Polaris.

AUDIENCE: Follow Route 90?

PHILIP GREENSPUN: Yes, actually, the helicopter follow an interstate highway. That's a common helicopter technique, probably because the interstates always go through the lowest points. How about this one? Request vectors SFO. You could probably climb right out of Hanscom and call it Boston approach, and they would be happy to help at any time.

Actually, that is a good question. That's actually a good point into crew resource management.

Don't try to be a single pilot hero. Ideally, if it's a challenging flight, you've got a co-pilot, and even if you don't have a co-pilot, you always have air traffic control as another crew member. All right.

Let's take a few questions. Who's got questions about navigation?

AUDIENCE: In your [INAUDIBLE] use for GPS signal at certain altitude?

PHILIP GREENSPUN: Ah. So the question is, can the airplane show you your true altitude based on the GPS signal? And it's buried in there. It can't be shown on your altimeter in your primary flight display. But you can dig it out of either a separated GPS like the Garmin 750 or 430, or the integrated glass panels like the G1000.

AUDIENCE: Still the [INAUDIBLE]?

PHILIP GREENSPUN: Yes. What you're navigating from, how you're being separated from other aircraft, that's all based on the static information. But if you just want to see, I know that mountain's 8,000 feet high, I want to make sure it says at least 8001 for the actual altitude, you can dig that out. And I think the terrain warning system will use that.

AUDIENCE: [INAUDIBLE] an older aircraft, does it have the GPS or [INAUDIBLE]? What are the rules and regulations about using GPS [INAUDIBLE]?

PHILIP GREENSPUN: Yes. I'll repeat the question back for the tape and anybody who didn't hear. So this phone has more computing power and better design than everything inside a Boeing 747 or an Airbus A380. In fact, I talked to some Airbus A320 captains and they said they wanted to get rid of everything in the airplane except the altitude indicator, and they just wanted to navigate off of an iPad running a European app called Sky Demon, which is kind of like the American forefather of Garmin pilot.

They said, that would be just way better, to just use the iPad for everything. So as a practical matter, in your ancient airplane that might not even have an electrical system, yes, of course, you can navigate quite effectively with some battery-powered electronics or portable electronics that you stick around the aircraft.

And the interface can be very good, and they have comprehensive databases of everything you'd want to know. For legal purposes, and for practical ones, for instrument flying, you have to have FAA certified stuff that's hardwired to the aircraft and it's in the panel. And that makes sense because, think about it, your phone may die. The battery may die. So it's nice to have.

If you want to do an instrument approach, for example, you're going to need to have something like-- even an experimental airplane-- you've got to have one of those certified, like a Garmin 750 in there.