A Practical Application of STEM in Aviation

Originally Titled:
Steve and Bill’s Excellent Adventure:
Flying in the Clouds with a Temperature Inversion

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Forward

Being a pilot requires knowledge of mathematics and science as well as technology. There is a new genre of airplanes called “TAA” for Technologically Advanced Airplanes. The reader will see examples of this as this article continues.

The math would consist of computation for flight planning as well as trigonometry (sine) for calculating the strength of a crosswind. The science, physics actually, consists of Bernoulli’s Law, Newton’s Laws of Motion, load factor, G’s and center of gravity. Lastly, there are critical thinking skills as well as logic and reasoning. This latter is extremely important, since nearly 95% of all airplane accidents are attributed by the National Transportation Safety Board, NTSB, to pilot error. More often than not, pilot error reflects flawed or faulty decision making.

In addition to the math and science knowledge there are quite a few Federal Aviation Regulations, which pilots have made into an acronym called FARs. For the kind of flying that the pilot in this article and the author do, there are two parts, which apply. These parts are somewhat like chapters.

- FAR Part 61 – Certification of Pilots, Flight Instructors, and Ground Instructors – this part covers all of the criteria for getting a particular type of pilot certificate as well as flight instructor and ground instructor certificates.
  - FAR Part 61.57 – Recent Flight Experience: Pilot in Command – this regulation lays out the experience requirements that a pilot must regularly fulfill to be current to fly. There are experience requirements for carrying passengers during the day, carrying passengers at night, and for instrument flying, i.e. flying in the clouds.
- FAR Part 91 – General Operating and Flight Rules
  - FAR Part 91.103 – Preflight Action – this regulation lays out everything that the pilot must do before conducting the flight. The reader will see FAR Part 91.103 happening in the section entitled “About the Trip Down.”

Also, the FAA requires a test for nearly everything. For a student getting ready to solo, the instructor must make up the test, which is mostly about the airplane that the student will fly as well as the airport that the student will fly from. Each pilot certificate has a computerized knowledge test as does each instructor certificate. There is a special one-time test called “Fundamentals of Instruction” that each instructor candidate must take. People with a state-issued teaching certificate are exempted from taking the “Fundamentals of Instruction” test. With the exception of the pre-solo written exam, all of the FAA knowledge tests use multiple choice questions.

I hope that the cadets and seniors who read this article find it informative, thought provoking, and entertaining.

And maybe, just maybe, one or more cadets will decide that they want to be pilots!

About Altitude

Throughout this article there are many references to altitude. There are two types of altitude used in the article:

- MSL altitude – Mean sea level (MSL) is a measure of the average height above the ocean’s surface (such as the halfway point between the mean high tide and the mean low tide). In this article all of the references to enroute altitudes, cruise altitudes, or altitudes to which Air Traffic Control clears N907MM are MSL altitudes. For example, when Atlantic City Approach clears N907MM to 4,000 feet, the clearance is to 4,000 feet MSL. The airplane’s altimeter also reports in feet MSL.
- AGL altitude – AGL means above ground level. In this article all of the references to cloud ceilings are in feet AGL.
About Temperature

In our everyday lives when we deal with temperature, we usually deal with degrees Fahrenheit. The temperature in our home could be somewhere between 68°F and 72°F, while the temperature outside could be 29°F. If we are not feeling well, we will use a thermometer to compare our body temperature to the normal of 98.6°F.

In aviation the temperature readings are in Celsius.

The formula to convert °F to °C is shown below. Here we use the boiling point of water which is 212°F.

\[ °C = (°F - 32) \times \frac{5}{9} = (212°F - 32) \times \frac{5}{9} = 180 \times \frac{5}{9} = 20 \times 5 = 100°C \]

The formula to convert to °C to °F is shown below. Here we use the boiling point of water which is 100°C.

\[ °F = °C \times \frac{9}{5} + 32 = 100°C \times \frac{9}{5} + 32 = 20 \times 9 + 32 = 180 + 32 = 212°F \]

32°F is the freezing point of water, while its Celsius counterpart is 0°C. When you are flying at 0°C or a lower temperature in clear air, there is no risk. The airplane actually performs better. When you are flying at 0°C or a lower temperature in visible precipitation, such as rain or clouds, there is a risk of structural icing. This means that ice may form on the airplane’s wings, engine cowling, or windshield. Structural ice is very dangerous because of the increased weight and the disruption of the air flowing over the wings. A continued buildup of structural ice can cause the airplane to fall out of the sky.

About the Author

I took my first flying lesson in April 1991. Since then I have logged 3,000 hours. The airplane in this article is a Cirrus SR20. I have logged 700 hours in that make and model.

The furthest I have flown was in May 2011 when I flew from Doylestown, PA to Columbus, MS in a Cessna 182T. It was 7½ hours each way. I stopped for gas and a leg stretch at Greenville-Spartanburg Airport, SC on the way down and then at Raleigh-Durham Airport, NC on the way home. For the most part I flew between 8,000 and 9,000 feet, though at one point I went to 10,000 to clear mountains near the South Carolina-Georgia border.

The highest that I have flown is 12,500 feet MSL from Franklin County State Airport, VT to Pottstown-Limerick, PA. I was ferrying a Cirrus SR20 for a client. The turbulence was horrible, giving meaning to the term “James Bond Martini Flight – Shaken, Not Stirred!” Without onboard oxygen, 12,500 feet was the highest I could climb, but at that altitude it was as smooth as glass. Air Traffic Control (ATC) kept me at 12,500 feet until I crossed over Wilkes-Barre, PA where they took me down to 10,000 feet. By the time I crossed Allentown, they had me down to 6,000 feet and then 3,000 feet as I approached Pottstown-Limerick.

For me, flying was a true passion. Unfortunately, last August I had a min-stroke. As strokes go, I was very fortunate. My mental acuity was not impaired. I quickly transitioned from walker to cane to unassisted.

The “downside” is that the FAA suspended my medical certificate for two years. While I can still fly, there are limitations. The FAA will not allow me to act as Pilot in Command, which they and pilots refer to as PIC. Basically, I cannot be the only pilot on board. So in effect I am sort of a student pilot once again.
As I recuperated, I did everything that I could to keep my mind focused on aviation. This included doing ground schools and presentations for my flying club at Doylestown Airport, the Civil Air Patrol’s New Jersey Wing, and the FAA.

The flying adventure in this article represents the first time in six months that I was in an airplane.

**About the Pilot**

The pilot holds an FAA Private Pilot certificate. He has been flying since 1992. He is instrument-rated for Airplane Single Engine Land and has accumulated over 800 hours of flight time. The instrument rating means that he can fly N907MM in the clouds.

He flies as a hobby, and has flown as far as Kitty Hawk, NC in a small airplane.

On the flight in this article, I asked him if he had the pitot heat\(^1\) turned on. He replied that his instrument instructor always taught him to use pitot heat in situations like this. Since I was the instructor, I replied in my best “Darth Vader” voice, “Obi Wan taught you well!”

That said, the pilot gives as good as he gets. One time I was flying a practice instrument approach into Doylestown and had drifted slightly left of course. At that the pilot started chanting, “Stay on target! Stay on target!”

All I can say is that Star Wars goes well with aviation!

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\(^1\) The pitot tube measures airspeed. Since it is possible for ice to obstruct it, there is a heating coil on the inside of the pitot tube. On the instrument panel there is a switch labeled “Pitot Heat.”
About the Airplane
Tail number N907MM is a Cirrus SR20 that was built on 02/20/2003. It was the first of the SR20 Version 2 series. The “N” in the tail number means that it is a U. S. registered airplane. If it had a “C” instead of an “N,” it would be a Canadian registry.

N907MM cruises at 145 knots. Each knot is 1.15 miles per hour. So N907MM can cruise at 167 MPH. At different times, both the pilot and I have gotten decent tail winds, resulting in ground speeds of over 200 knots, or 230 MPH.

Since N907MM does not have on-board supplemental oxygen, it has an effective operating altitude of 12,500 feet.

The first Cirrus SR20 airplanes were manufactured and marketed in 2000. The FAA considers this airplane to be a TAA, or Technologically Advanced Aircraft. By today’s standards it is a first generation TAA.

The picture below shows N907MM on the parking ramp at Cape May County Airport².

The picture below shows N907MM’s cockpit. The large screen is called an “MFD” or Multi-Function Display. It is the size of a laptop screen and is a large moving map display that interfaces with the two Garmin GPS units below it.

² The pilot took the picture with his cell phone and then posted it to Facebook. I grabbed it from Facebook and pasted it here.
This is the set of basic flight instruments. It is called the “Six Pack.”

- **Air Speed Indicator** – this instrument indicates how fast the air is flowing over the wings. It uses color coded arcs to identify speed ranges:
  - White – flap operating range, speeds below the white arc result in a stall
  - Green – normal range
  - Yellow – caution range, okay to fly in this range in calm, non-turbulent air
  - Red Line – beyond this structural failure can result
- **Attitude Indicator** – this instrument indicates whether the airplane is climbing (above the horizon in the blue) or descending (below the horizon in the brown). It also indicates whether the airplane is turning left or right as well as whether it is in a shallow, medium, or steep turn. It has nothing whatsoever to do with your mood.
- **Altimeter** – this instrument is designed to look like a clock. Human factors engineers designed it for fighter pilots at the beginning of World War II. The “big hand” represents hundreds of feet. The “little hand” represents thousands of feet.
- **Turn Coordinator** – this instrument indicates whether the airplane is in a standard rate turn. This is also called a two minute turn because at 3° per second it will take the airplane 120 seconds to turn 360°. When the “ball” is centered, it means that the airplane is coordinated. If the “ball” is out of center (uncoordinated) and the airplane stalls, the stall will degenerate into a spin. The term “stall” has nothing to do with the engine. A stall means that the flow of air over the wing has been disrupted and that Bernoulli’s Law has been broken.
- **Heading Indicator** – this instrument indicates the airplane’s magnetic heading. The four cardinal directions are: N for North (360°), E for East (90°), S for South (180°), and W for West (270°).
- **Vertical Speed Indicator** – this indicates how fast the airplane is climbing or descending. The “5” above the “0” means the airplane is climbing at 500 feet per minute. The “5” below the “0” means the airplane is descending at 500 feet per minute. When the indicator needle is on “0,” it means that the airplane is in level flight. 500 feet per minute is the recommended speed for climbs and descents. It is very comfortable for non-pilot passengers and it is the vertical speed expected by Air Traffic Control (ATC).
These instruments are the avionics instruments. Avionics is a contraction meaning “aviation electronics.” This vertical array of instruments is often called the “avionics stack.”

- Audio Panel – this panel controls the radios. The “COM” buttons are for voice communications. The “NAV” buttons are for navigation frequencies. The “COM1/2” button allows the pilot to send and receive on the COM1 radio, while the copilot can simultaneously send and receive on the COM2 radio.
- GPS Database Cards – these need to be updated every 28 days by a download from the Internet. Subscriptions can cover the Northern Hemisphere, entire U. S., eastern U. S., or western U. S.
- Garmin GNS 430 GPS – this device can accept signals from both space-based and land-based navigation sources.
- Garmin GNC 420 GPS – this device can accept signals only from space-based navigation sources.
- Digital Transponder – this device can broadcast a discreet signal to Air Traffic Control radars. It lets them know who we are and where we are.
The most distinctive feature of the Cirrus SR20 is the ballistic parachute system. The parachute is deployed by pulling down a T-shaped handle in the ceiling of the cabin. The parachute can be deployed in the following circumstances:

- The airplane goes into a spin.
- The airplane is involved in a mid-air collision.
- The pilot becomes disoriented or otherwise incapacitated.
- The airplane has an engine failure over mountainous or other inhospitable terrain.
- Any situation where death looks certain for the occupants if the parachute is not deployed.

The airplane must have a minimum altitude of 2,200 feet for the parachute to be effective. Once the parachute is deployed, it cannot be undone.

The parachute is designed to save the occupants, but not the airplane. Once the parachute is deployed, the airplane will be badly damaged when it makes contact with the ground.
About the Trip Down

When a cadet wants to drive the family car to the supermarket, the mall, or a movie theater, it is usually means asking Mom or Dad for the car keys. It is also a matter of making sure that there is enough gas in the tank. In the case of the family car, this amounts to filling to a half tank or to a full tank. Of course, how much gas depends on how much gas money Mom or Dad hand over.

With an airplane, it is not just a matter of telling the “line guy” or the “line girl” to “fill’er up,” though the correct phrase is “top’er off.” Each airplane has an FAA certificated Maximum Allowable Takeoff Weight. There is also a certificated Basic Empty Weight, which comes from an official weigh station.

In the case of N907MM, the maximum allowable takeoff weight is 3,000 pounds and the basic empty weight is 2,118 pounds. The difference between the two values is called the Useful Load. In the case of N907MM, the Useful Load is 882 pounds. This is the weight available for pilot, passengers, baggage, and fuel.

The total weight of the pilot, me, and our flight kits comes to 490 pounds. This leaves 392 pounds for fuel. N907MM can hold 28 gallons in each wing tank for a total of 56 gallons. Fuel weighs 6 pounds per gallon, which comes to a total of 336 pounds for full fuel. The spreadsheet below shows the weight computation.

The values in the Arm column come from the airplane’s documentation manual, which is called the Pilot’s Operating Handbook, or POH. The POH is classified by the FAA as an airworthiness item. This means that if it is not on board the airplane, and within reach of the pilot, the airplane is not legal to fly.

The product of the weight and the arm is called the moment. Total Moment divided by Total Weight yields the Center of Gravity. The chart below shows the center of gravity for this flight as the blue takeoff diamond.

The weight computation and the center of gravity computation are collectively known as weight and balance. The FAA requires that it be calculated before each flight.
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The chart above shows the center of gravity envelope in blue. If the center of gravity, or CG as pilots call it, is to the right of the envelope, the airplane is in a tail heavy situation. While the pilot will be able to takeoff, he or she will not be able to lower the nose. The airplane will experience an aerodynamic wing stall and crash shortly after takeoff. When this happens, it almost always results in a fatal accident. This situation is caused by overloading the airplane in the cargo area and the back seats.

A few years ago a family of five in Alaska died because of this. The cargo area held baggage, rifles, ammunition, a chain saw, and a tent. The backseat was designed for two people, but there were three teenagers squeezed into it.

If the CG is to the left of the envelope, the airplane is in a nose heavy situation. Here the pilot will not be able to take off. If the pilot does not abort the takeoff, he or she will run off the end of the runway. The airplane will be substantially damaged and the occupants may be seriously injured.

I found a forward CG situation a few years ago when I was building a weight and balance spreadsheet for a client. My client had a Cirrus SR20 with a three-bladed propeller. When I entered our weights for the pilot and copilot seats, we were forward of the CG envelope. We eliminated the problem by loading two 50-pound sand bags in the cargo area whenever we flew.

The weight and balance computations were done with an Excel spreadsheet. There are also apps for the iPhone and iPad that will do the same thing. Pilots are supposed to do these computations at home before leaving for the airport.

Once you do the weight and balance, you need to determine your route of flight. You also need to obtain a weather briefing for your route. This briefing includes a lot of information. While you get the weather for the route, both current conditions and forecast conditions, you also get advisories for your departure airport and your destination airport as well as TFRs (temporary flight restrictions). TFRs have become a fact of life since 9/11. If you inadvertently penetrate a “VIP” TFR, i.e. president or vice-president, there is a good chance that you will be intercepted by F-16’s or armed helicopters and forced to land.

Our plan was to fly from Doylestown Airport to Cape May County Airport. Our route of flight was Doylestown Airport to Philadelphia Northeast Airport to South Jersey Regional Airport (Mount Holly, NJ) to Cedar Lake VOR (Vineland, NJ) to Cape May County Airport. We took off from Doylestown Airport and landed at Cape May County Airport. The other airports were just waypoints in our flight plan that we flew over.

The weather forecast for our departure time was cloud ceilings in Pennsylvania of 10,000 feet broken and in New Jersey of 15,000 feet broken. Since we planned to fly at 3,000 feet, this was no factor at all.

For the trip home, the cloud ceilings were forecast to be 5,000 feet overcast. For the FAA to be happy with us, we needed to be 500 feet below the clouds. This forecast gave us a 2,000 foot margin.

While there was snow in the forecast, it was not expected to occur before 4:00 PM or 5:00 PM local time.

There were no TFRs. So we did not have any risks there.

I gave the pilot a JICIGTHIAHB\(^3\) query asking him if he was instrument current. This turned out to be more prophetic that I ever dreamed.

\(^3\) Just In Case It Goes To Hades In A Hand Basket
We used the Aircraft Owners and Pilots Association (AOPA) to plan our flight. AOPA has an Internet application called IFP, or Internet Flight Planner. IFP produced the chart below. It also calculated that we would be flying 84 nautical miles (97 statute miles) and that our flight would take 40 minutes.

The chart below shows what the airspace for the route of flight would look like prior to 25 JUL 2013.

The chart below shows what the airspace for the route of flight would look like on or after 25 JUL 2013.
Once we got to the airport we had to preflight the airplane. This involves the use of a checklist\(^4\) and can take 30 to 40 minutes. Pilots are encouraged to take their time. This reduces the risk of overlooking an important item. It is an unsafe practice to attempt doing these preflight tasks from memory.

- Preflight Walk Around – 66 inspection tasks, include checking fuel and oil
- Before Starting Engine – 5 tasks
- Starting Engine – 17 tasks
- Before Taxiing – 4 tasks
- Taxiing – 5 tasks
- Before Takeoff – 31 tasks

The picture below is Doylestown Airport as seen from Google Maps. There is a single runway (5 – 23), measuring 3,000 feet by 60 feet. Compared to Cape May County Airport, Doylestown is a small airport.

We departed Doylestown Airport from Runway 5. The number 5 means that the runway has a compass orientation of about 050°.

When we returned to Doylestown Airport, we landed on runway 23, which has a compass orientation of about 230°. This is the opposite end of runway 5. Ends of runways always differ by 18. This is because the ends are 180° apart.

The end of the runway that you land on is primarily determined by the wind direction. Ideally, you should always land and take off into the wind.

We flew down to Cape May at 2,500 feet using the GPS. I set up the flight plan in the GPS. I was ecstatic that I still remembered how to do it, since it had been over a year since I had been in an SR20.

About 10 nautical miles north of Cape May we descended to 1,500 feet. The pilot did an excellent approach into Cape May as well as an excellent landing. He landed on runway 19.

Cape May has two physical runways. Runway 1 – 19 measures 5,003 feet by 150 feet. Runway 10 – 28 measures 4,998 feet by 150 feet.
About the Trip Home
We departed Cape May County Airport using Runway 10. This was around 1:30 PM. As we climbed out and turned on course, I noticed that the cloud ceilings had changed from broken to overcast. They were also lower than on the flight down.

As we flew north the weather deteriorated further. We were about 15 miles south of Mount Holly when it looked like we would go into the clouds if we continued our heading.

I suggested to the pilot that we turn around and head back to Cedar Lake VOR, the navigation beacon at Vineland, and orbit it. Once there I called Atlantic City (ACY) approach and got them to put us on an instrument flight plan so we could get back to Doylestown. I set everything up in the GPS and the pilot did the flying. When you pick up a clearance like that, the workload really gets busy. By taking care of the communications and setting up the GPS, I took nearly half of the workload off the pilot’s shoulders. This is a form of Crew Resource Management (CRM).
ACY had us climb to 4,000 feet (from 3,000 feet). At this point the outside air temperature was -1°C. We went into the clouds at 4,000 feet. ACY turned us over to McGuire Approach who had us climb to 5,000 feet. There the temperature was -4°C.

When you get outside air temperature at or below 0°C in visible precipitation (rain or clouds) you risk picking up ice. So while we were in the clouds, both of us were very concerned about picking up ice. The SR20 is an aerodynamically slick airplane. This means that there is not a lot hanging off the airplane that the pilot and copilot can use to detect an ice buildup. The stall strips are about the only thing that can be used to detect an ice buildup.

In the event of an aerodynamic, or wing, stall, these strips are designed to make the stall occur first at the wing root rather than the wing tip. The stall strips are illustrated in the picture below.

Needless to say we both kept a close watch on our respective stall strips.

There are three types⁵ of ice:
- Clear ice – glossy, clear, or translucent ice formed by the relatively slow freezing of large, supercooled water droplets. This type of ice is the most difficult to shed.
- Rime ice – rough, milky, opaque ice formed by the instantaneous freezing of small supercooled water droplets. This type of ice is the easiest to shed.
- Mixed – a mixture of clear ice and rime ice

I have been in icing situations twice. One involved clear ice. The other involved rime ice. Both situations happened 12 years ago and occurred within a month of each other.

The clear ice situation occurred at 3,000 feet over the Susquehanna River. We were on a practice instrument approach into Lancaster Airport. The pilot felt the cockpit was getting too warm and toasty. So he turned off the heater-defrost. The windshield immediately iced over. When he saw the ice he gave up and asked me as the instructor to fly.

We were on a precision instrument approach. This meant we were tracking two radio signals. One was called the localizer and helped keep us pointed in the right direction. The other is called the glideslope which helped us keep the nose pointed down at the right pitch angle. This approach is designed for the pilot to go visual at 200 feet. This would not work for me because the windshield was iced over. Consequently, I flew it down to 40 feet so I could see where the asphalt runway met the grass medial

strip. The outcome was successful. When I got home I called the instructor who trained me and thanked him for being a demanding teacher.

The rime ice situation occurred at 5,000 feet enroute from Allentown, PA to Robbinsville, NJ. As soon as I saw the ice start to accumulate, I called Philadelphia Approach and reported it. They immediately cleared us down to 3,000 feet. While no further ice accumulated, the ice that was there stayed there. When we came out of the clouds at 1,700 feet near the Great Adventure Theme Park, the ice peeled off like a banana skin.

So when the pilot and I went into the clouds at -4°C, I knew enough from those two prior experiences to be really scared.

I don't know about the pilot, but I was mentally asking the Force to be with us as well as talking to any Deity that I thought would listen.

At one point McGuire had us fly to direct to the Yardley navigation beacon, then handed us off to Philadelphia Approach. Philly took us down to 4,000 feet and then to 3,000 feet.

When we came back down to 4,000 feet, we came out of the clouds. The Outside Air Temperature gauge showed -6°C.

So it was at this point that we encountered the temperature inversion. I studied about them during my training, but had never noticeably encountered one before. This could have because I was really watching the Outside Air Temperature gauge and the stall strips.

**What is a Temperature Inversion?**

As air rises and expands in the atmosphere, the temperature decreases. The rate at which temperature decreases with an increase in altitude is referred to as its lapse rate. As air ascends through the atmosphere, the average rate of temperature change is 2°C (3.5°F) per 1,000 feet⁶.

When N907MM was circling Cedar Lake VOR at 3,000 feet, the Outside Air Temperature (OAT) gauge reported -1°C. This is the baseline. When McGuire Air Force Base (AFB) Approach cleared N907MM to climb to 5,000 feet, the OAT gauge reported -4°C. This is relatively consistent with the lapse rate. There was a 2,000 foot change in altitude and the outside air temperature decreased by 3°C. This is consistent with image below, which illustrates that as the altitude increases, the air temperature decreases.

![Normal Situation Diagram](http://www.faa.gov/library/manuals/aviation/pilot_handbook/)

After McGuire AFB Approach handed N907MM off to Philadelphia Approach, Philadelphia Approach cleared N907MM down to 4,000 feet. When N907MM leveled off at 4,000 feet, it was out of the clouds and in clear air. At

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this time, the OAT gauge reported -6°C. A few minutes later, Philadelphia Approach cleared N907MM down to 3,000 feet. When N907MM leveled off at 3,000 feet, it was still clear of the clouds. At 3,000 feet, the OAT gauge initially reported -7°C, but shortly afterward time it reported -6°C.

This is unusual. The expectation would have been that the temperature would increase with a descent to a lower altitude, theoretically into warmer air. The OAT gauge would possibly have indicated -1°C or even 0°C.

This atmospheric anomaly is called a temperature inversion. Inversion layers are commonly shallow layers of smooth, stable air close to the ground. The temperature of the air increases with altitude to a certain point, which is the top of the inversion. The air at the top of the layer acts as a lid, keeping weather and pollutants trapped below.

The fact that it was colder closer to the ground was not a risk for N907MM. Since the airplane was clear of clouds there was no icing hazard.

Reflections
The pilot was paying $116 per hour to rent N907MM that day. The hourly rate is not based on a wall clock, but on something called a Hobbs Meter. The Hobbs only runs when then the engine is running. So the time we were in the restaurant at Cape May was not billable.

When we encountered the lowering ceilings, the pilot and I turned around and flew back ten miles to Cedar Lake VOR (Vineland, NJ). This took 4 or 5 minutes and cost about $11 on the Hobbs. At Cedar Lake, we went onto an instrument flight plan. This involves assigned routing and altitudes. ATC, or Air Traffic Control, fits the airplane and crew into the “System.” In this case it was separating us from commercial traffic going into or departing from Philadelphia International, Atlantic City International and Trenton as well as military traffic arriving and departing McGuire Air Force Base. In return for this, we had guardians watching over us on their radar.

The price for this is that it takes longer. The pilot has to fly the assigned route. It is not a case of a straight line from Point A to Point B. In our case, it amounted to approximately an extra 30 minutes for the assigned routing. Since time is money, this cost an extra $58 on the Hobbs Meter. So between the return to Cedar Lake and the assigned routing, N907MM cost about an extra $70. Was it worth it for us? I would say that it was, because it gave the pilot and me that extra measure of safety that kept us alive. $70 is a cheap price to pay for two lives.

Some pilots would have balked about spending that much money and would have tried to fly under the clouds. This is called “scud running.” Sometimes when the underside of the clouds is at a steady altitude, you can get away with it.
Even if you do get away with it, it is a very dangerous thing to do. To be legal, the FAA wants you to be at least 500 feet below the bottom of the clouds. So in complying with the law, how much ground clearance do you have?

Sometimes “scud running” turns out to be an exceptionally poor choice: you descend to get below the clouds but the clouds keep getting lower. Consider the true story below.

In early spring of 1993, I had been a private pilot for 18 months. While I was an instrument student, I had not yet earned my instrument rating. One Saturday, just after Noontime, my aunt and I departed Doylestown Airport in a Grumman Tiger\(^7\). We were flying to Lancaster Airport for lunch. The weather forecast along our route of flight was for overcast ceilings of 3,000 feet. I had submitted a flight plan for 2,500 feet. So I was legal from the FAA’s point of view.

As I climbed through 2,300 feet I suddenly found myself in the clouds. I did a gentle 180° turn, accompanied by a gentle descent to 1,800 feet. I called Williamsport Flight Service Station, told them the circumstances, cancelled my flight plan and returned, uneventfully, to Doylestown. My aunt and I had lunch at Perkins on Route 313. Throughout the day I wondered if I could have made it if I flew out and back at 1,800 feet. I will say that this kind of thinking was not consistent with the pilot judgment and decision making that my instrument instructor was imparting to me.

The next morning a news article reinforced to me that I made the right decision. A 17-year old girl who was a senior at Solberg-Hunterdon High School was completing her long distance\(^8\) student cross county flight. On her flight back to Sky Manor Airport, it got dark, the ceilings started lowering, and she started “scud running.” She crashed into trees and died just north of Lake Nockamixon. To this day I am still saddened by her death, because I feel it was avoidable. She had been accepted to the Air Force Academy and had so much to live for. What I don’t understand is why her flight instructor authorized her flight that day. I had to cancel my student long distance cross country flight several times due to weather. I learned back then that there is always tomorrow.

\(^7\) While the Tiger was a nice airplane, very agile and relatively fast, it did not have a GPS.

\(^8\) At the time this was a 300 nautical mile trip with landings at three airports. In August 1997, the FAA reduced the requirement from 300 nautical miles to 100 nautical miles.
Sources of Information
This section contains a lot of reference material. Parts of it may be useful for teachers looking to relate classroom theory to “real world” examples. For students, it might be useful for reference materials for a senior project.

The articles and presentations represent 10 – 12 years of providing aviation education to pilots and student pilots.

All of the PowerPoint presentations are password-protected at the insistence of the FAA. When opening one of them, just click on the “Read Only” button.

Career Awareness
- [http://home.netcom.com/~doylewj/Aviation/student_pilot_flight_training/default.htm](http://home.netcom.com/~doylewj/Aviation/student_pilot_flight_training/default.htm)
  - This website presents the tasks that a person needs to do to earn a private pilot certificate. It also presents the tasks that a person needs to do before even starting flight instruction.
  - There are many federal requirements: FAA and Homeland Security.
- [http://williamjdoylejr.net/Careers/Career_Awareness_Aviation_St_Marks_2012-05-30.ppt](http://williamjdoylejr.net/Careers/Career_Awareness_Aviation_St_Marks_2012-05-30.ppt)
  - This presentation identifies some of the careers available in aviation as well as the training requirements and the anticipated earnings.
  - I visit this high school in Wilmington, DE every year to make this presentation on Junior Career Day.

Mathematics
- [http://williamjdoylejr.net/FAAST/Crosswind_Operations_at_the_Edge.ppt](http://williamjdoylejr.net/FAAST/Crosswind_Operations_at_the_Edge.ppt) (Trigonometry)
  - Content includes calculating the crosswind using the trigonometric sine as well as some accident scenarios.
  - This is a presentation that I gave for the FAA at several locations around the Delaware Valley.
- [http://williamjdoylejr.net/FAAST/fuel_management.ppt](http://williamjdoylejr.net/FAAST/fuel_management.ppt) (Time-Distance)
  - Content includes flight planning from a fuel burn rate (gallons per hour or GPH) perspective.
  - This is a presentation that I gave for the FAA at several locations around the Delaware Valley.
- [http://williamjdoylejr.net/FAAST/fuel_management_banner_tow.ppt](http://williamjdoylejr.net/FAAST/fuel_management_banner_tow.ppt) (Time-Distance)
  - Content includes flight planning from a fuel burn rate (gallons per hour or GPH) perspective.
  - After a banner tow plane run out of fuel and crashed into a marsh, the FAA sent me to Cape May, NJ to remediate the banner tow company’s management and pilots.

Science
- [http://williamjdoylejr.net/Careers/Aviation_for_DYL_Boy_Scouts.ppt](http://williamjdoylejr.net/Careers/Aviation_for_DYL_Boy_Scouts.ppt) (Physics)
  - Content includes Bernoulli’s Law, Newton’s Laws of Motion, center of gravity, vacuums, G’s, load factor, centrifugal force, and centripetal force.
  - This is a presentation on aerodynamics that I gave to Doylestown area Boy Scouts (grades 6 – 12) so they could get their aviation merit badge.
- [http://williamjdoylejr.net/Careers/Aviation_for_Elementary_Students.ppt](http://williamjdoylejr.net/Careers/Aviation_for_Elementary_Students.ppt) (Physics)
  - Content includes Bernoulli’s Law, Newton’s Laws of Motion, center of gravity, and vacuums.
  - This is a presentation that I gave to the Simmons 5th grade on what makes airplanes fly.
  - Content includes scenarios involving night flying in the clouds, its risks, and pilot decision making.
  - This is a presentation that I gave for the FAA at several locations around the Delaware Valley.
- [http://williamjdoylejr.net/FAAST/W&B/Weight_and_Balance.ppt](http://williamjdoylejr.net/FAAST/W&B/Weight_and_Balance.ppt) (Physics)
  - Content includes moment computations using weight and arm, center of gravity, and accident trends.
  - This is a presentation that I gave for the FAA at several locations around the Delaware Valley.
- [http://williamjdoylejr.net/FAAST/wake_turbulence.ppt](http://williamjdoylejr.net/FAAST/wake_turbulence.ppt) (Physics)
  - Content includes wake vortices from large aircraft and how they can adversely impact smaller aircraft as well as some really great pictures of wake vortices.
A Practical Application of STEM in Aviation

- Slides 15 and 16 illustrate how an Army Blackhawk helicopter nearly rolled a Cessna 182 inverted at 150 feet above the ground. I was the pilot flying the Cessna 182.
- This is a presentation that I gave to the Dover Air Force Base Flying Club.

Technology

- **http://williamjdoylejr.net/FAAST/TAA.ppt**
  - Content addresses Technologically Advanced Aircraft (TAA) in terms of autopilot, GPS, moving map, et cetera and how these new digital systems (called the “Glass Cockpit”) contrast with the older analog gauges (called “Steam Gauges,” “Round Dials,” or the “Six Pack”).
  - This is a presentation that I gave for the FAA at several locations around the Delaware Valley.

- **http://williamjdoylejr.net/FAAST/gps.ppt**
  - Content addresses Technologically Advanced Aircraft (TAA) in terms of autopilot, GPS, moving map, et cetera and how these new digital systems (called the “Glass Cockpit”) contrast with the older analog gauges (called “Steam Gauges,” “Round Dials,” or the “Six Pack”). While it is a continuation of the TAA presentation, it specifically addresses the GPS space-based satellite systems (called “Constellations”)
  - This is a presentation that I gave for the FAA at several locations around the Delaware Valley.

Language Arts, Reading, Adventure

- **http://williamjdoylejr.net/KV_Mystery_Reader/**
  - This is a short story about my first flight (4/6/1991) that was published in Today’s Spirit
  - I read the story to KV 6th graders and also delivered a PowerPoint presentation to them.

  - This is a short story (fiction), that I wrote about a pilot who has a night-time engine failure on Christmas Eve, lands on an unattended farm, and finds a teenage runaway.

- **http://home.netcom.com/~doylewj/GearUp_Landings.pdf**
  - This is an article that I wrote about pilots who landed with their gear still retracted. It was inspired by an actual occurrence (not me) in my flying club.
  - The FAA’s Philadelphia Flight Standards District Office published it in their quarterly newsletter.

Safety and Accident Trends for Selected Aircraft

- **http://williamjdoylejr.net/FAAST/Cirrus/Cirrus_SR20_and_SR22.ppt**
  - This is a PowerPoint presentation that I built at the request of the FAA.
  - Its content addresses the accident history of the Cirrus SR20 and SR22. While parts of it may seem scary, it intended to help pilots learn from the mistakes of others.
  - I presented it on 1/31/2013 at Wings Field in Blue Bell, PA and will present it again on 3/26/2013, at the Toms River Library in Toms River, NJ.

- **http://williamjdoylejr.net/FAAST/Cessna/Cessna_172_182_and_206.ppt**
  - This is a PowerPoint presentation that I built at the request of the FAA.
  - Its content addresses the accident history of the Cessna 172, 182, and 206 high-wing airplanes. While parts of it may seem scary, it intended to help pilots learn from the mistakes of others.
  - I will be presenting it on 2/14/2013 at the Flying W Airport in Lumberton, NJ, on 2/18/2013 to the Warrington Flying Club, and then sometime in March 2013 at McGuire Air Force Base, NJ for the Civil Air Patrol.
Appendix

Letters after My Name
The title page shows a lot of letters after my name. The list below explains what they mean.

CFI A&I, AGI, IGI, CFAI, FAAST Rep represent my FAA instructor credentials
• CFI A&I means Certified Flight Instructor Airplane and Instrument – I can teach someone to fly a land-based airplane and I can teach them to fly in the clouds
• AGI means Advanced Ground Instructor
• IGI means Instrument Ground Instructor
• CFAI means Cessna Factory Authorized Instructor – I can teach the Cessna Nav III, Garmin G1000 Flight Control System. This is a Cessna not an FAA credential
• FAAST Rep means Federal Aviation Administration Safety Team Representative – I am an FAA volunteer giving pilot safety seminars

COM ASEL AMEL IA represents my FAA pilot credentials
• COM means Commercial pilot certificate with the endorsements and limitations shown below (I am not certificated to fly seaplanes)
• ASEL means Airplane Single Engine Land – mostly I fly these
• AMEL means Airplane Multi-Engine Land
• IA means Instrument Airplane – I can fly in the clouds