**Airplane Engine Dilemma…**
Tom Huber, Fall 2016

You are a member of the Board of Directors of Safe-Airlines-R-US. An airline mechanic looking at a plane bound for Las Vegas notices an unexpected crack in the mat that holds turbine blades in place in a jet engine. Even though the mat that holds the blades are now made by different manufacturers, they were originally made by C.L.Y. Corporation, so they are generically called “the ClyMat.” She is concerned that this change in the ClyMat may cause turbine blades to break off, which would cause the engine to catastrophically fail in flight. She calls over other mechanics, and they all agree that this is a problem. They call in mechanics from competing airlines, experts in metallurgy, engineers who designed the engine, etc. Eventually, 100 different ClyMat experts look at the problem engine. 97 out of the 100 experts who study the ClyMat are convinced that there is a serious problem, and that the engine needs urgent repairs. Only 3 experts feel that there is not a problem with the ClyMat. In deciding how to proceed in dealing with this “ClyMat Change Crisis”, discuss the following:

1. There happens to be 100 of the world’s best Elvis impersonators on the flight going to their annual competition in Las Vegas. They crowd around the airplane engine, with their mutton-chop sideburns, leather pants and white capes, and say that the ClyMat looks fine to them. Similarly, groups of Pediatricians and Meteorologists on the way to their respective conferences in Las Vegas say that they don’t see a problem with the ClyMat. All of these experts (Elvis impersonators, Pediatricians and Meteorologists) did not recognize a ClyMat change problem, so there should be no problem to fly the plane – right?
2. One of the board members states that it is too uncertain to do anything about the ClyMat. They saw a debate on the Vulpus News Channel. The debate featured two individuals (one “expert” stating that there is not a problem and another stating that there is a problem with the ClyMat). How do you respond to the board member’s opinion that because there were two opposing people on the debate they saw on TV, there must be a 50-50 chance of a problem and that there is strong debate within the ClyMat community?
3. Some share holders in the company say that you cannot trust anyone who is paid to design, build or maintain ClyMats, airplanes or any other airplane parts. These share holders say that every “ClyMat Expert” has a conflict of interest or bias. The reasoning goes that the experts are making up the ClyMat change issue because they are earning money to study and fix the problem. These share holders say that the only people who can be trusted to give an unbiased opinion on whether there is a problem with the ClyMat are individuals who have never worked on the design, maintenance or construction of airplanes in general, or the ClyMat in particular.
4. Thousands of ClyMat experts from around the world look at many different engines on many different planes using state-of-the art scientific techniques. After careful consideration and deliberation, even though they work for different airlines and have different areas of expertise, they write a long consensus report. Their report states that, based on their expert opinion, they have 95% confidence that ClyMat change is a worldwide problem that inevitably will lead to severe aircraft failures, massive loss of life and complete disruption of the entire airline industry. Someone tells you not to trust this report because it is a massive conspiracy. (Of course you, and all of the people who wrote the report, know that in the aircraft industry if there is even the slightest hint that an individual conspired in fraudulent activities or a cover up, their career would be over and there would be no possibility of ever working again)
5. Another member of the board states that you should not do anything because the consensus report states they have only 95% confidence that there is a problem. If even the ClyMat experts are not 100% certain, it might be better to wait until there is 100% certainty. Another issue that some express about the report: the ClyMat experts aren’t exactly sure what will happen and when. They quote probabilities of failure and ranges of uncertainty instead of exact dates and times that specific airplane engines will fail.
6. You are sent the link to a website, The\_Big\_ClyMat\_Hoax.com. This website says that every single “crash-and-burn” ClyMat expert looking at this problem is wrong, and that it is a big hoax. They claim that all of the “crash-and-burners” who have looked at the engines either completely forgot or are purposely ignoring the fact that iron is magnetic: magnetism will hold the engines together even if the ClyMat changes get very large. This website says that “crash-and-burn” reviewers at every academic and technical publication of the airline industry have rejected their paper, even though it was featured as a full-page article in the Windows Street Journal. The website concludes that this is a big hoax, since ClyMat “crash-and-burners” who review papers for technical publications are insiders who are trying to repress this important new information to save their own jobs.
7. You run across another website, Airplane\_Engines\_Are\_Big.Com. They claim that since airplane engines are so large and have so many turbine blades, even if one of them breaks off inside the engine in flight there are still lots of other blades. They say that the “crash-and-burn ClyMat experts” must be wrong, because something as unimportant as a small change in the ClyMat or a single broken blade could not possibly endanger something as large as an engine or even an entire airplane. They also list the same concern about getting their paper published because “crash-and-burners” are deliberately blocking their publication.
8. Engineers and other experts write some very complex computer programs that simulate how the ClyMat behaves. The program starts with a normal ClyMat, and uses the best understanding of ClyMat physics, chemistry, engineering and other disciplines to simulate the changes that accumulate during thousands of flights. While agreement with current measurements isn’t perfect, the program demonstrates an increase in ClyMat changes that are statistically consistent with the observations of failures that are occurring. The simulation predicts that in the future there will be continuing ClyMat changes and makes statistical predictions of an ever increasing probability of future failures. Experts at other airlines make similar simulations that predict similar results. Especially when the results of these simulations are combined together, they produce increasingly accurate predictions of both the past and future ClyMat behavior. Can you trust these computer simulations since the results do not perfectly agree with current measurements? Especially since the computer simulation isn’t perfect about “predicting” the past failures, are its statistical predictions of increasing future failures valid?
9. You ask some of the experts: Are you certain that the failure of the turbine blade on a specific airplane is due to this ClyMat change, or could it be a “normal” failure. The experts respond that the failures that they are observing are completely consistent with the ClyMat problem, and there is a statistically significant increase in turbine blade failures. Therefore, while they cannot specifically state whether one particular failure is due to this ClyMat problem, the overall trend is consistent with the ClyMat change problem.
10. Even after the ClyMat experts recommend fixing the problem, your airline decides to keep flying the planes to make sure that the problem is real. Unfortunately, the problems are getting worse! It is clear that ClyMat changes are occurring and are increasing in frequency; luckily, most of the major problems have happened while the plane is on the ground instead of in flight. Your company can continue to make a profit as long as the planes are flying, and there have not been huge catastrophic failures. At what point do you decide it is better to fix the problem instead of waiting for a nearly inevitable, and very costly disaster?
11. Evidence also piles up that not only is there a problem, but that the longer you wait to fix the ClyMat, additional damage accumulates that makes it substantially more expensive to repair. How long should you wait “to make sure” that there is a ClyMat problem, when waiting makes the problem worse and the ClyMat repair much more expensive?
12. You are very excited to hear that your daughter and her husband are flying in for your 60th birthday party. You are especially excited because your new twin grandson and granddaughter, who you have never seen before, will be coming with their parents. As the plane is boarding, you realize the plane they are flying on is the exact one that 97 out of 100 ClyMat experts said would eventually fail catastrophically. Although it would be expensive and disruptive for the company, you can make a phone call that would stop that plane from taking off. Do you?

Tom Huber, Physics Department
Gustavus Adolphus College
huber@gustavus.edu
November 14, 2016

(Thanks to other Gustavus faculty for helpful suggestions including Jessie Petricka, Julie Bartley, Laura Triplett, Chuck Niederriter, Jim Dontje, and Jon Grinnell)