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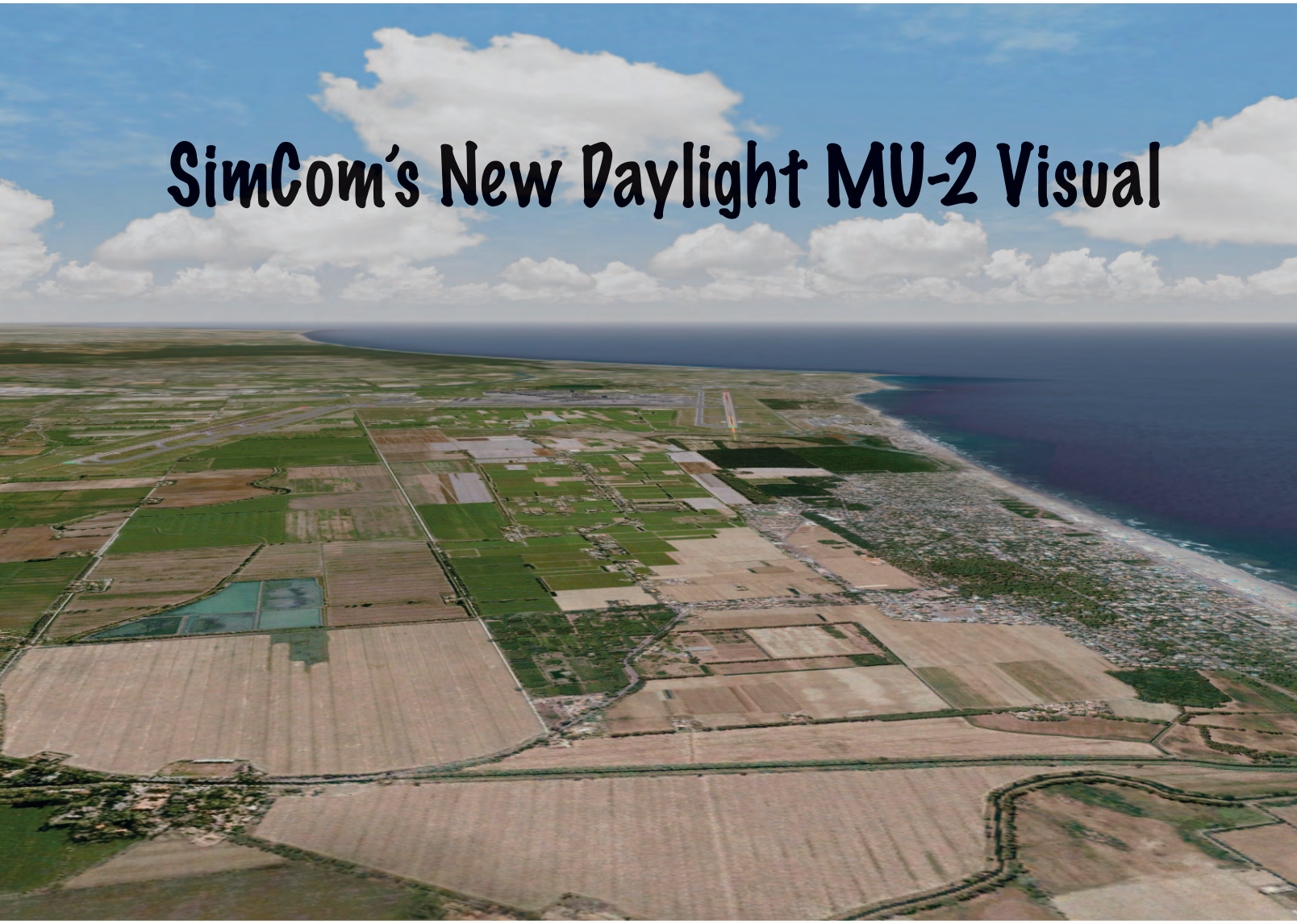

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Engine Starts and the MU-2

by Rick Wheldon

Every MU-2 flight begins with two engine starts. Engine starting is a complex process where fuel and engine acceleration must be precisely controlled until the turbine can produce sufficient energy to sustain its own operation. Too little airflow and/or too much fuel and the engine will start hot. With too little fuel scheduled, the starter will lack sufficient power to accelerate the engine to its proper speed. Because the engine is the most expensive component on the aircraft, and the risk of damage has such costly consequences, it behooves the pilot to know the start procedure cold, to be prepared for irregularities, and to be intimately aware of starting limitations. With that in mind, let's look at some starting malfunctions and "best practices."

In the MU-2 AFM, the **Starting Engine** procedure contains a **Caution** which reads, in part:

"If any malfunction occurs, engine stops, or rpm stagnates prior to 40% rpm . . . Shut down the engine with the condition lever."

I've always looked at this general **Caution** and wondered what **"if any malfunction occurs . . . "** really means. It turns out that all of the information describing the various malfunctions is in the flight manual, but there is no single list to refer to. I found a list in the TPE-331 Installation Manual, however, which addresses the matter concisely. The Installation Manual states:

Engine start should be aborted when:

1. *Propeller fails to rotate*
2. *RPM does not reach 10 percent within approximately 10 seconds*
3. *EGT/ITT is not rising approximately 5 seconds after 10-percent rpm; or approximately 10 seconds when cold soaked*
4. *EGT/ITT rises rapidly toward start limit*

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5. EGT/ITT approaches start limit
6. Oil pressure fails to rise by idle rpm
7. Rpm stops increasing prior to idle rpm
8. Any unusual noise or vibration occurs
9. Engine instruments indicate abnormal conditions

The Installation Manual does not describe how to accomplish the abort, but the MU-2 AFM says to abort the start with the RUN-CRANK-STOP switch under certain conditions and use the CONDITION LEVER for other malfunctions. However, because of the language in the CAUTION, the case could be made to use the CONDITION LEVER for all start aborts, which simplifies the procedure enormously.

Let's look at the individual malfunctions. Regarding items 2 and 3, the AFM says that the EGT or ITT should rise "Within 10 seconds past 10% RPM or by 20% RPM." Otherwise, place the RUN-CRANK-STOP switch to stop. Placing the CONDITION LEVER to EMERG STOP would accomplish the same thing, but in either case, the starter motor is still engaged after the fuel is removed. While the engine is still turning, continue to crank for 10-15 seconds, which expels all fuel from the plenum area of the engine. Next, deselect the starter by placing the start selector to AIRSTART & SAFE. Do not crank the engine for more than 10-15 seconds, to avoid exceeding the 30 second limitation on the starter. After the start abort, if you were performing a battery start, recharge the batteries or get a power cart, and allow at least one minute with the starter OFF before re-attempting the start. Do not reengage the starter while the propeller is still turning.

Items 4 and 5 deal with an impending hot start. If a start is progressing to a hot start, it is good practice to shut down the engine early. Don't wait for the EGT or ITT indication to reach the start limit. If you do, you run a very significant risk of exceeding the limit. We've started our engines often enough to know what a normal start looks like. A hot start will have an abnormally rapid EGT/ITT rise and very possibly a slow RPM acceleration. Battery voltage during start may drop well below 20 volts, indicative of weak batteries. Trust your instincts. If it doesn't "feel" normal, it probably isn't. Again, once you abort the start, let the starter motor crank the engine for a few seconds to "cool" it down and purge the residual fuel.

The AFM is actually more restrictive than the Installation Manual regarding item 6, the oil pressure rise requirement. The Installation Manual calls for an abort with no oil pressure by idle RPM, while the AFM requires a RUN-CRANK-STOP switch abort if there is no oil pressure indication by 50% RPM. Typically, I see first oil pressure indications between 20% and 30% RPM.

RPM should continue to rise throughout the entire start sequence. While the AFM states that RPM stagnation prior to 40% is cause for an abort, actually, any stagnation at any RPM warrants shutting down the engine with the CONDITION LEVER. The Honeywell Installation Manual and the TPE-331 Pilot Tips booklet both recommend that RPM be increasing at least one percent per second during the start.

Finally, malfunctions 8 and 9 give the pilot wide latitude to abort the start when he/she hears unusual noise, feels an unusual vibration, or notices any abnormal engine indications. If you've started the engine a few times, you should be able to determine what "normal" and "abnormal" mean.

A final abort situation in the AFM, not mentioned in the Installation Manual, is when the starter does not "cut out" at either 50% or 60% RPM, depending on your model of MU-2. If the starter light remains illuminated past the normal "cut out" point, place the RUN-CRANK-STOP switch to STOP.

One of the worst practices I've noticed over the years is this – because the start is automated, especially on Solitaire and Marquise models, where the SRL computer provides auto fuel enrich to optimize the start temperature, the pilot presses the start button, then no longer monitors the start. If you do this in a simulator, your instructor ought to give you a hot start. If it happens in real life, the results could be much more expensive. Frankly, it seems to be a sloppy practice to not pay close attention.

One way to avoid complacency during start is to make aural call outs. On our airplanes, I typically say out loud, when each event occurs:

- Starter engaged, Beta light out.
- 10%, Ignition and Fuel Flow.
- Light off.
- Beta light on, NTS checks good.
- Oil pressure rise.
- Starter cutout.

My monitoring during the start (other than the callout items) is 75% on the EGT/ITT, and 25% on the RPM. Using aural callouts, I can anticipate the next item to look for in the start sequence. Simulator instructors tell me that roughly 10% of their students miss the Beta light out / NTS check during start. Good aural callouts can help you avoid this simple but potentially hazardous mistake.

There is a fair amount of misperception regarding the proper use of the fuel enrich system. The AFM only addresses its use above 25% RPM during start, and says that if the EGT/ITT is low with slow acceleration above 25% RPM, then use fuel enrich to control EGT/ITT and RPM acceleration. The Honeywell Pilot Tips booklet provides additional guidance. Essentially, Honeywell recommends using fuel enrich prior to light off, releasing it at light off to check that the fuel enrich valve is not stuck open (the rate of temperature rise will moderate when the fuel enrich

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button is released), and then use fuel enrich again after light off. Nothing in the AFM prohibits the use of fuel enrich prior to light off, so best practice would be to depress the fuel enrich button prior to or at start engagement, hold it to light off, release it until the RPM reaches 25%, then use fuel enrich again above 25% as necessary to modulate the ideal start temperature. For EGT equipped airplanes, maintain the EGT between 650 and 700 degrees, and for ITT airplanes, modulate between 850 and 900 degrees.

What if you have just shut down your engines and dropped off a passenger? You're ready to depart, but you look down during the BEFORE START checklist and note that the residual temperatures exceed 300° ITT or 200° EGT. Do you have to wait until the temperatures decrease below start limits? Not necessarily. What if the start was aborted for high temperature? Same answer. A "manual" engine start can be accomplished by performing the normal starting engines procedure, except that you leave the RUN-CRANK-STOP switch in the CRANK position, not RUN. Engage the start switch, watching the RPM. Once the RPM increases to 15%, place the RUN-CRANK-STOP switch to RUN and monitor the normal start sequence. Do not use fuel enrich until it is determined that the engine will not exceed temperature limits.

Starting with cold oil can result in a number of problems. Frankly, if your airplane remains overnight on a below freezing ramp, and engine/battery heaters have not been installed and used, there is a strong likelihood that the batteries will not be able to provide sufficient power to overcome the increased viscosity of the engine oil and start the engines. You may have to remove the batteries, top charge them, and warm them up. I learned this the hard way, being a Southerner through and through. On a trip to Jasper, Canada, one winter, there was no FBO at our destination. I elected to remain overnight, using just plugs and covers, instead of repositioning to Edmonton, where there was a heated hangar and a power cart. By the next morning, the engine oil was so thick that I could barely turn the propellers by hand. Fortunately, there was a helicopter operator in town who generously provided "warm" batteries, and I was able to get the engines started to get home. It wasn't my finest hour.

Battery starting presents several issues illustrated by the example above. Batteries should be warm to provide maximum power, so cold batteries are a big problem. But batteries can be weak for any number of reasons, and bad batteries can easily be the cause of hot starts or slow starts. Either is hard on the engine, regardless of whether the start temperature limits are exceeded or not. A good practice is to look down at the starting voltage after the start is initiated. If the voltage reads much below 20 volts, be prepared for a hot or slow start. Each 100 hour inspection requires a battery analysis, and since most of us are operating lead acid type batteries these days, it might be good practice to replace the batteries every few years. I pay close attention to batteries after 2 years or 400 starts.

We once had a slow starting engine not caused by weak batteries, and maintenance determined that we had partial "clogged" nozzles. This is sufficient justification for religious adherence to "cool down" procedures, and we might have been remiss. Once the nozzles were cleaned, the engine started normally. One thing that we did right, though, was that we dealt with the problem promptly. Honeywell recommends cleaning the nozzles every 400 hours. I know of several operators who clean them twice as often. At very minimum, cleaning nozzles is a cheap insurance policy on the engine.

Engine starts demand close attention. Much can go wrong, and damage can easily run into six figures. Damage can be eliminated or minimized, however, if AFM procedures are carefully followed. Because engine starts cannot be simulated in the airplane, I think every pilot should spend at least one training event in the simulator, where each of these malfunctions can be seen and practiced. With that preparation, then, dealing with the real life event will be a snap. **AAOG**

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