January 2013 **<u>Flying Multi-Engine Aircraft</u> (Pt. VIII)**

Continuing our series on flying FAR Part 23 (CFR 14, Chapter 1, Subchapter C, and Part 23) certified, small multi-engine airplanes, we are looking at the issues involved in a multi-engine transition course. This month we will proceed on our tour through a typical General Aviation Manufactures Association (GAMA) standard format Airplane Flight Manual (AFM) issued for FAR Part 23 certificated airplanes.

Largest WWII, Piston Twin-Engine Transport – C-46F

"Tinker Belle" at Air Venture 2012 ***Hobie Tomlinson Image***

<u>Last Month</u> we paused after completing **Section VI** on **Weight and Balance**. This month we will pick up our discussion with **Section VII** on **Systems Description.**

<u>Section VII</u> (Systems Description). Like the previous issue on Weight and Balance, I want to take a slightly different slant on the subject of Aircraft Systems and look at this subject from a cockpit perspective instead of from a classroom system design standpoint. Because of the large differences in aircraft system designs and complexity, it is probably more relevant to look at how these items are best taught to transitioning pilots rather than to wade into the system intricacies of any particular aircraft type

<u>As Previously Stated</u>, in the absence of a formal cockpit procedures trainer, the best place to teach aircraft systems is sitting in the cockpit of the actual aircraft. This works best when the aircraft can be placed in a well-lighted hangar and "powered up" by a ground power unit (GPU). The actual aircraft cockpit is thus used as the cockpit procedures trainer.

The Object of cockpit procedures training is to allow the student to become knowledgeable and familiar with all aircraft systems from an operational point of view. This process will occur in the following three phases:

1) **Classroom Ground School** on Aircraft Systems utilizing the Aircraft Flight Manual (AFM). This step is designed to produce background knowledge and a general understanding of aircraft systems before proceeding to the CPT phase.

2) **Cockpit Procedure Training (CPT)** – either in a dedicated CPT or the actual aircraft cockpit – utilizing the Normal, Abnormal, and Emergency Checklists. This step is designed to teach both the aircraft "Flows" (control/switch operational sequences learned by muscle memory) associated with Normal Checklist procedures and the "Read, Verify, Do" procedures associated with the Abnormal and Emergency Checklists, including all relevant "Boxed" Memory Items required by the Emergency Checklists. This will produce a functional knowledge of aircraft systems before proceeding to the flight phase in either a Level D full flight simulator (FFS) or the actual aircraft. Before completing this phase of systems training, the transition pilot should have mastered the following information relative to each aircraft system:

    a. **Location –** Where is the system located in the cockpit?
    b. **Controls –** What controls are provided to operate the system and what does each control do?
    c. **Function –** When (i.e. under what circumstances) is each control actually used?
    d. **Back-up –** How is the system managed if the primary control fails to properly operate the system? (I.e. what alternate means of system operation are available?)

3) **Flight Training –** either in a Level D FFS or in the actual Aircraft is the last phase of system training. This step is designed to allow the transitioning pilot to integrate previously learned system knowledge with the applicable flight profiles, including all relevant Normal, Abnormal, and Emergency flight profiles.

Next, let's "walk-through" a sample set of training items using the Beechcraft Baron (BE-58) AFM as typical of the light piston twins which might be used for multiengine training. Because of the cost factors involved, most flight schools now use the smaller "four-cylinder" twins (i.e. Beechcraft BE-76 Duchess and Piper PA-44 Seminole) rather than the traditional "Six-cylinder" twins (i.e. Beechcraft BE-58 Baron, Piper PA-23 Aztec, and the Cessna 310). Because of the differences in cost, training in the more expensive "six-cylinder" twins is now pretty much limited to transitioning new owners into their respective aircraft.

The Piston Twin market has been hit very hard by competition from high performance singles and insurability issues. The new technology, high performance single engine aircraft such as the Cirrus SR-22 and Cessna 400 Corvalis offer performance that is equal to or better than the piston twins at a fraction of the operational cost – not to mention the training issues. (The same can be said for aircraft like the Socata TBM 850 and the smaller turboprop twins.) In addition to that issue, insurability is also a major factor in light twin engine aircraft. Due to the marginal single engine performance of FAR Part 23 certified light twins and the fact that many multiengine rated pilots were products of the "diploma mills" and have not maintained their proficiency level with quality, in-depth recurrent training in these aircraft, their safety record is not the best. This has caused insurability issues for the aspiring owner of a small multiengine aircraft. Lastly, the relatively low acquisition cost of the older piston twins, gives a false impression of the high operation and maintenance cost which will be experienced with these aircraft. Thus the only piston twins currently left in production are the Piper PA-44 Seminole, the Piper PA-34 Seneca, and the Beechcraft BE-58 Baron.

I Have One Final Note on the BE-58 Baron aircraft before proceeding. Beechcraft used a "non-standard" throttle quadrant and flap/gear switch arrangement on their older aircraft – prior to the 1984 models. (I.e. throttles were in the center of the throttle quadrant instead of on the left side and the flap/gear switches were reversed with the gear switch on the right side and flap switch on the left). The big change in panel/system layout on the BE-58 models occurred in 1984 and included relocating the throttle, gear, flap, propeller and mixture controls to the industry-standard positions. Thus, when flying a mix of older and newer BE-58 models, it is of critical importance to always stay consciously aware of which control you actually have your hand on prior to moving it!

Airframe General is usually the first subject covered. Depending on the detail provided in the AFM, the following items should be covered.

- External preflight of the airplane and aircraft service locations.
- External dimensions of the aircraft, especially wing span and tail clearance height – important for hangar selection and clearance required during ground operations.
- Ground turning radius of the aircraft – important for small airport operations.
- Swept wing aircraft AFMs sometimes give the pitch/roll attitudes at which airframe ground contact will occur during takeoff and landing.

Flight Controls should include the following information:

- The type of control used to make flight control inputs (i.e. conventional control yokes, side stick controls, or in the case of some Beechcraft BE-58 aircraft, a single "throw-over" yoke. The throw-over yoke can be positioned in front of either the left or right front seat, but only one pilot at a time can have access to the aircraft's controls. The throw-over yoke is obviously designed for single pilot operation of the aircraft and is unsuited for flight training events.
- Rudder Pedal adjustment? (On the BE-58, how to stow and unstow the right side rudder pedals against the floor.)
- Do the right side rudder pedals have brakes installed?

- Does the aircraft have a steerable nosewheel (BE-58) or a free castering nosewheel (CE-310)?
- Does the aircraft have an "interconnect" spring between the rudder and aileron controls? (These tend to increase control pressures during crosswind operations).
- Is the aircraft equipped with spoilers or speed brakes, including aftermarket modifications?
- Has the aircraft been equipped with aftermarket vortex generators (VGs)?
  - These significantly improve the handling qualities of the aircraft.
  - If you trained on a VG equipped aircraft, be aware that a non VG equipped aircraft can have significantly different handling qualities, especially at low speeds.
- How do the trim controls work?
  - Does the aircraft have two axis (rudder and elevator) or three axis (plus aileron) trims controls?
  - Where are the trim controls located?
  - How is the trim tab position indicated in the cockpit? Be sure to verify the accuracy of the cockpit trim indications on older aircraft.
  - Does the aircraft have electric elevator trim.
    - Where is the trim switch located?
    - What is the required preflight test?
    - How is the system disabled in case of a runaway trim condition?
- Are Internal or External control locks used?
  - Where are they located
  - How are they engaged/installed and disengaged/uninstalled?
  - What safety procedures are in-place to insure that all controls are free prior to engine start?

Instrument Panel should include the following information:

- Is the aircraft equipped with the old "steam gauge" instruments or a modern "glass" panel?
  - If a "steam gauge" panel, what backup instruments are installed (i.e. standby attitude indicator) and where are they located?
  - If glass, how is the information displayed, how are the required data inputs accomplished, what are the failure modes, and how is data "reversion" accomplished?
  - Is stall warning system a sensing vane type or angle of attack (AOA) type?
    - What is the warning horn sound?
    - How is the information displayed on glass panes?
- Are the powerplant instruments analog, electronic, or glass? Where are they located?
- What types of avionics are installed and where are they located.
  - If only old style radios, have they all been functionally checked including navigation systems?
  - If GPS equipped
    - Is the Navigation Data Base current?
    - Is the system IFR certified?

- How is the navigation output selected and displayed?
  - If the aircraft has a Flight management system (FMS) and/or Remote Tuning Units (RTUs) installed, how is the information displayed; how are the required data inputs accomplished; what are the failure modes; and how is data "reversion" accomplished?

Wing Flaps start to become more important as an aircraft's wing loading increases. The slotted, fowler type flap predominates on modern aircraft with the older design types typically having a plain or split flap design. Flap information should include the following.

- How are the flaps selected and does the flap switch/ lever allow for flap "preselect?" (Some type flap switches must be monitored during flap movement in order to stop the flaps at the correct setting.)
- What are the various flap settings?
- What flap setting(s), if any, can be used for takeoff?
  - **Note:** The use of flaps for takeoff reduces the takeoff runway length required at the expense of degradation in second segment climb performance. Because of the marginal nature of engine inoperative second segment climb performance in FAR Part 23 certified, piston powered, multiengine aircraft, the only takeoff performance data supplied is for a flaps-up takeoff configuration.
- What are the flap-limiting airspeeds?
- How are the flaps actuated (manual, electric, or hydraulic) and is there any backup actuation method?
- Is there a no-flap, partial-flap, or split-flap procedure specified?

Landing Gear System is almost always retractable on multiengine aircraft. (The Champion Lancer being an exception) This is because of the need maintain climb performance with an engine inoperative and precludes the high-power, fixed gear solution which has become prevalent in the single engine world.

- How is the landing gear actuated and what powers the gear system?
  - All electric (Older Beech Barons)
  - Electric powered Hydraulic pack (Cessna 310)
  - All Hydraulic (Piper Aztec – **Note:** Many PA23 aircraft only have an engine-driven hydraulic pump installed on one engine!)
- Where are the gear position indicators located?
- What are the landing gear indications for the following?
  - Up (does system utilize up-locks)
  - Down and locked
  - In-Transit
  - Unsafe
- Is there a gear warning system (Horn) and how is it actuated?
  - **Note:** Multiengine Sea (MES) aircraft did not have gear warning systems installed as original equipment due to the nuisance warning they would present during water landings.
  - Throttle position only (Single or Both throttles)

  - Throttle or Landing Flaps selected
  - Throttle, Landing Flaps, or Radio Altimeter Altitude
  - Is there a Gear-Horn silence switch/procedure for EI flight?
  - What activates the gear safety-circuit when the aircraft is "weight-on-wheels?"
- What is the emergency gear extension procedure; where are the controls located; and can the procedure be practiced in-flight without requiring maintenance reset after landing?
- Does the right front seat have brakes available?
- Where is the parking brake located; how are the brakes parked; and can they be parked from the right front seat? (In the Beech Baron, the answer is "no")
- Where is the hydraulic brake reservoir and can it be checked during preflight?
- What "Cautions," if any, are associated with the landing gear?
  - **Note:** Never taxi any aircraft with a flat landing gear strut as damaging loads can be transmitted to the aircraft structure by taxiway irregularities.
  - In the Beech Baron, do not reverse direction on an "in-transit" gear, as this can damage the retraction mechanism.
  - In the Beech Baron, insure the hand crank is stowed after practicing an emergency gear extension and prior to retracting the gear electrically. (Unless perchance, you like broken fingers)

Baggage Compartments should be noted for location, accessibility (both on-ground and/or in-flight), capacity, floor loading capability, and cargo restraint capability (especially important for internal compartments).

- Be sure to note when internal sub-compartments within a compartment have distinct loading limits.
- Be especially aware how nose compartment doors are properly secured and locked. (Nose compartment doors opening during takeoff have been noted as causal factors in several accident sequences!)

Cabin Area should be noted for seating configuration (standard or club), seat, seat belt/shoulder harness operation/condition, best loading procedure, and the proper operation of all doors, cabin windows (which are operable for ground ventilation), and emergency exits.

- **Note:** It is important that the pilot take responsibility for verifying that all doors, windows, panels, etc. are secure **and** that a proper passenger safety briefing and check is provided prior to engine start!

Powerplants may be piston (carbureted, fuel injected, geared, mechanically supercharged, or turbo-supercharged), turboprop, or turbojet.

- If turbo-supercharged, are the waste-gates fixed (Piper Seneca), controlled manually (Twin Comanche), or automatically (Cessna 414)?
  - Is over-boost protection provided?
- If piston, where are the induction air controls located?
  - Carb Heat operation for carbureted engines.
  - Alternate Air operation for fuel injected engines.

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- Does system provide in-cowl, "suction door" alternate air bypass protection from ram icing of the air filters? (Beech Barons).
- When is unfiltered air being provided to the engines?

- If piston, where are the cowl flap controls located?
  - Manual on early Barons
  - Electric on later Barons with an in-transit/open indicator light.
- What is the minimum oil level, oil type required, and how is oil quantity checked?
- What engine anti-icing provisions are provided for turboprop/turbojet engines?
- Where are engine starters located and how are they activated?
- What are the engine starting procedures and limits?
- What are the pertinent engine operational limits and parameters?

Propellers on multiengine aircraft are usually always constant speed, full feathering propellers for the obvious reason of allowing continued flight with an engine inoperative (Again, the rather infamous Champion Lancer being an exception).

- Propellers can be operated by engine oil pressure, a combination of oil pressure verses a propeller dome spring and air charge, or electric.
  - Electric propellers have a rather checkered history and exist on some large transport category aircraft.
  - Radial engine aircraft typically have "hydromatic" propellers operated by engine oil pressure and use electric "feathering" oil pumps (activated by a red "feather button") to provide feathering oil pressure to the propeller dome. (Twin Beech).
  - Most modern aircraft use engine oil pressure verses a mechanical spring/ air pressure in the propeller dome to feather a propeller.
  - Aerodynamic loads on a propeller blade tend to move it toward the high pitch/feathered position, while centrifugal loads on a propeller blade tend to move it toward the low pitch position. Counterweights are used on some propellers to adjust the relationship of these forces.
  - The loss of engine oil pressure will immediately cause a single engine aircraft's constant speed propeller to "go-flat" and "run-away" (overspeed), while a multiengine aircraft's full feathering propeller will automatically feather. (This will always be your first notice that a loss in engine oil pressure has occurred in these aircraft!)
- Propeller Synchroscope is a small rotating disk which is located in the propeller tachometer case and painted with a black and white cross pattern. When the propellers are "out-of-sync," this painted disk will rotate in the direction of the higher RPM propeller with the rate of rotation increasing in direct proportion to the RPM difference. When the propeller rpms are exactly synchronized, the rotating disk will be stationary.
- Propeller Synchronizers are installed on many of the newer aircraft. The propeller synchronizer has a "master" and "slave" propeller. When it is selected "ON" it synchronizes the slave propeller RPM to the master propeller RPM, as long as the two engines remain within the synchronizer's operating range (typically 25 RPM).

- Propeller Synchrophasers are an advanced synchronizer which is also able to keep the slave propeller's blades in the correct phase relationship with the master propeller's blades. These are typically found on turboprop aircraft and help lower the effect of propeller "thrust pulses" on the horizontal stabilizer.

Fuel Systems in older multiengine aircraft tended to be complicated and fuel starvation induced accidents (available fuel not reaching engines due to improper fuel system operation) are not that uncommon. Fuel system knowledge should include the following items:

- Where are the fuel selectors and how are they positioned for the following?
  - Main tank to engine feed
  - Aux tank to engine feed (if aux tanks installed)
  - Fuel crossfeed for engine inoperative flight
  - Fuel OFF for emergencies
- Are the fuel selectors
  - Easily accessible and visible?
  - Properly Marked?
  - Adequately lighted?
  - Provided with good detents (tactile feel)?
- How many fuel tanks and where are they located?
  - Are tanks single compartment or multi-compartment?
  - What is the capacity of each tank?
  - Where are the filler caps located (or single point fueling on turbojets)
  - What is the fuel filling (and fuel use) tank sequence?
  - Are there tank tabs, or wing gauges, for partial fuel loads?
  - Are there any fueling cautions to prevent fuel overflow?
  - Are there any fuel tank restrictions (i.e. maximum fuel imbalance, etc.)?
  - How many fuel sump drains and where are they located?
  - Can aircraft be defueled by the crew or only by maintenance?
- Where are the Fuel Pump switches and how are they positioned for the following?
  - Engine Start
  - Takeoff and Landing
  - Enroute
  - Fuel Crossfeed
  - Loss of Fuel Pressure (or to prevent "vapor lock" when hot and high)
- Where are the fuel flow gauges located and how are they marked?
  - Is an aftermarket fuel-use monitoring system installed on the aircraft?
  - If so, how is the fuel quantity data entered and displayed?

Electrical Systems are straight DC on piston and turbo prop aircraft and can be either straight DC or a combination of DC and AC on turbojets. Aircraft systems are generally of the single-wire, ground return type for weight savings. Electrical system knowledge should include the following information:

- Location and function of the electrical system panel, switches, and gauges.
- Location and function of the various circuit breaker panels.
- Alternator, starter, and battery load and/or cycle limits.

- Aircraft battery type (lead-acid or NiCad) and location.
  - What is battery voltage and load capacity?
  - Is there an external battery disconnect?
- Alternator (or generator on old aircraft) voltage and load capacity.
  - Does system use load meters (alternator output) or amp meters (Battery charge/discharge status)?
  - Are warning lights provided for alternator failure?
  - Is the electrical system a single bus or split bus system?
  - If system provides back-up voltage regulator, how is it selected?
- Is an external ground power plug provided?
  - Where is it located?
  - What is the ground power unit (GPU) capability required?
  - What is the electrical system set-up for the safe use of GPU power?
  - Any system safety features provided against "bad" GPU power?

Lighting Systems, both interior and exterior, should consist of the following items:

- Function and location of all interior lighting switches.
- Any lights available with battery switch OFF (hot battery bus)?
- Function and location of all exterior lighting switches.
- Exterior lighting restrictions (i.e. on-ground landing light time restrictions).

Heating and Ventilation Systems vary from simple systems on unpressurized piston aircraft to complex systems on turbojet aircraft. The typical light piston twin will have a combustion type cabin heater (usually located in the nose area) and a simple ram-air cooling system. Some piton engine aircraft may be equipped with air conditioning units, but because of their weight and high engine-power draw, they are not as common as one would think. (Because of the engine-power draw, piston engine air conditioning systems usually are required to be OFF for take-off.) Turboprop and turbojet aircraft use engine bleed air for heating, pressurization, and usually for cooling via air-cycle machines. Some older aircraft still use Freon type cooling units. The following information should be considered for aircraft environmental systems:

- Combustion heater (if used) location, controls and operating limitations.
  - **Note:** *Aircraft combustion heaters can be dangerous and require proper respect for their correct operating procedures, limitations and maintenance requirements!*
  - Location and function of all cockpit environmental controls.
  - Knowledge of any ground operating restrictions and proper "cool-down" procedures at flight termination.
  - Location and function of the overheat circuit breaker (ground reset only and should not be reset without a maintenance check unless the overheat cause was clearly pilot induced).
  - Consider turning the heater OFF during flight training involving slow flight and high deck angles. This can cause turbulent airflow in the heater air inlet and produce "sooting" of the combustion chamber.

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Oxygen Systems may be installed in turbocharged aircraft and pressurized aircraft will have emergency oxygen systems. The knowledge items here are as follows:

- Oxygen bottle(s) location, capacity, quantity gage, shut-off valve, and fill port location.
- Oxygen mask types, locations, and limitations.

Pitot-Static Systems should have the following information:

- Location of pitot tubes and static ports.
- Location of pitot heat switches and ground time limitations, if any.
- Location of alternate static air source.

Pressure Systems consist of cabin pressurization and service air systems.

- Service air on piston aircraft is provided by two engine-driven, pressure (vacuum) pumps though a common manifold which typically provides pressure for air driven flight instruments, de-ice boots, inflatable door seals, autopilot servos, and outflow valves on pressurized aircraft.
- Service air on turbine aircraft is provided by bleed air through a step-down regulator.
- Glass panels have imbedded attitude-heading reference systems (AHRS) which relegate the dreaded "vacuum pump failure" to a relic of history.
- Cabin pressurization systems use bleed air from the engines on turboprop and turbojet aircraft. On piston aircraft the air is bleed from the supercharger systems.
  - Information about pressurization systems will include the location and function of all control's and indicators.
  - Knowledge of the systems operational limits

Ice Protection Systems are usually installed on multiengine aircraft. Piston and turboprop aircraft typically use de-icing boots while turbojets tend to use heated leading edges. Propellers and windshields can either be de-iced electrically or by the use of alcohol. Knowledge items for ice protection systems are as follows:

- Especially important for piston aircraft is whether or not the system is certified for "Flight into Known Icing" (FIKI). A lot of piston twins have partial ice protection systems installed but were never certified for flight into known icing conditions. While something is always better than nothing, these aircraft are still not legal to operate in areas where icing conditions are forecast or reported.
- Location and operation or all system controls and indicators.
- Time limitations of alcohol supply (or TKS supply for "weeping wing" systems)
- Location of cockpit controls and indicators, operational procedures, limitations and cautions for electric windshield and propeller deice systems.
- Knowledge of pitot heat, stall warning anti-ice, and heated fuel vents.

This is our stopping point for this month. Next month we will wrap up our look at the GAMA format AFM with **Section VIII, Handling, Service, & Maintenance, Section IX, Supplements** and **Section X, Safety Information.** Then we will move into the associated flight training by working through **FAA-S-8081-12C**, ***Commercial Pilot – Practical Test Standards (PTS)* for Airplane, MEL & MES.**

The thought for this month is: "**Books give not wisdom where none was before, but where some is – there reading makes it more." ~ *John Harrington,* British Writer.**

So, until next month, remember to **Think Right to FliRite!**

Beechcraft C-45 (aka D18S / SNB – Secret Navy Bomber) ~ Small WWII, Piston Twin-Engine Transport

1942 C-45 in civilian paint at Air Venture 2012 ***Hobie Tomlinson Image***