Bob Nuckolls
6936 Bainbridge Road
Wichita, Kansas 67226-1008
Voice: 316-685-8617
E-mail http://aeroelectric.com/bob.nuckolls

Myths of Multiple Battery Installation

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A core component of the vehicular DC power system is some form of storage battery. When any vehicle is parked and the engine is shut down, the owner would like to walk away with some expectation of having the machine "come alive" the next time it is needed. The earliest incarnations of gasoline engine were fitted with hand cranks that offered a low cost if not hazardous means by which muscle power could be used to get the engine started. The earliest days of light plane aviation also exploited muscle power to get an engine started. One stood out front and hauled on the "long wooden handle" attached to the crankshaft.

Charles Kettering demonstrated that one could get several horsepower from a relatively small starter motor if you loaded it for only a few seconds necessary to get an engine running. The electrically driven self-starter was added to Cadillacs about 1912.

Cars were already using lead-acid, rechargeable batteries and generators provide lighting for some years. Mr. Kettering closed the loop on a package for engine cranking using energy from an on-board storage system that was replenished by an on-board generator. By modern standards, the earliest batteries, generators and starter motors were crude, inefficient devices with relatively short service lives. The simple-ideas (physics) upon which they depended for functionality has not changed in over 100 years. Until a few years ago, electrical systems aboard aircraft were no more complex than those used in automobiles. Aircraft engines did not generally depend on electrical energy to run. The suite of primary instruments for flight in IMC was driven by engine driven vacuum. Backups were powered from the DC electrical system.

Over the past ten years, the pneumatically powered gyro has been amply replaced with GPS aided, solid-state rate sensors and glass panel displays. Magnetos have been edged aside by performance enhancing ignition systems. Carburetors are giving way to electronic controlled fuel injection or even single lever FADEC controllers.

In 1946, the Piper Cub may have happily coexisted amongst the birds without batteries, generators, lights and radios. The modern owner built and maintained (OBAM) aircraft is likely to be dependent upon a reliable sources of electrical power for operation of engine, flight instruments, communications or all of the above. In short if we wish to take advantage of the host of smaller, lighter, more accurate, higher efficiency aids to flight, a dependable source of electrical energy is necessary. Further, the architecture of an electrical system is determined by the combination of electrically dependent systems and their various functions in the flight system.

Alternators are the primary component of energy production; batteries are components of choice for energy storage. The number, size and partitioning (architecture) of alternators and batteries are all easily tailored for the highest flight-system reliability at the lowest cost of ownership consistent with system design goals.

A variety of electrical system architectures for aircraft may be reviewed by printing the documents at:

http://tinyurl.com/5wxzn7

These drawings were crafted to meet a variety of design goals, some of which are serviced by installations of two or more batteries.

This paper will explore some capabilities and limits that drive how we select, integrate and operate batteries (particularly lead-acid) in our airplanes. A lack of understanding about how batteries operate provides foundation for the most popular myths.

When a power generation system is operating properly, the system bus will be supported at or above 13.8 volts, typically 14.2 to 14.8 volts DC. 13,8 volts is the "ideal" charging potential for fully charging a lead-acid battery at room temperature. Nobody runs a system at that voltage because after engine starting, we generally want to RECHARGE a battery in a few minutes of operation. As the battery approaches full charge on a 13.8 volt bus, recharge rate (charging current) tapers slowly to zero. The time to top-off a seriously discharged battery on a 13.8 volt bus may be longer than the run-time for that particular flight cycle.

Practitioners of the art discovered that a lead-acid battery can be moderately abused (higher bus voltage) without seriously affecting service life of the battery. Setting the bus voltage as high as 14.6 volts gets the battery topped off with dispatch a few minutes after take-off. The few hours of flight-time (battery abuse) per week of service has little effect on number of flights one can expect before the battery is replaced. Indeed, our automobiles have been charging lead-acid batteries at the 14.2 to 14.8 range for decades. Our car batteries get "abused" much more hours per year than do our airplane batteries. Yet it is not unusual for a car battery to perform as needed for three years or more.

Myth 1: You should charge a battery based on some profile tailored to the battery's technology.

This myth has prompted a proliferation of "smart" chargers that feature front panel controls that might be labeled "AGM", gell-cell and "deep-cycle". The idea is to offer an idealized recharge mode for the purpose of maximizing battery life. A typical product line of very capable smart chargers is illustrated at:

http://tinyurl.com/6nf7v3

These are great products. I own and use several models of Schumacher products. But let's think about this a bit. The alternator/regulator combination in our airplanes and automobiles are anything but "smart". There are no controls for giving these systems responsibility for idealized battery life.

The design goal for vehicles is to recharge a battery quickly and live with the small, difficult to measure degradation of battery life resulting from a less-than-ideal recharge profile. If one wishes to maintain a lead-acid battery in storage, the most useful feature in the battery charger/maintainer is to "top off" the battery (an activity not unlike what occurs in your airplane or car). After top-off, the charger drops to a maintenance voltage just above the battery's at-rest open circuit voltage (about 12.9 volts at room temperature). This functionality is plotted out here:

http://tinyurl.com/553kmu

This is recharge curve was produced by the Schumacher Model 1562 charger/maintainer sold by Walmart and other stores for about $20. This particular charger has no front panel controls for tailoring the recharge profile . . . but it's just fine for recharging and maintenance of any 12v lead-acid product.

Routinely deep-cycled batteries for wheelchairs, lawn mowers, trolling motors, golf carts, etc. may demonstrate improved battery life with a tailored smart-charger. After these specialty chargers complete a top-off cycle and go to the maintenance mode, they're all the same. However, in the ideal world, our airplane and automobile batteries are never deep-cycled. Further, there are no realistic benefits to be secured by the occasional tailored top-off mode used on a battery that receives an extended, non-tailored top-off charge every time you go flying. A "smart"charger will probably enhance service life for a battery that is routinely deep-cycled. They are of little value in maintaining batteries in vehicles where the battery's primary task is to simply get the engine started a couple times a month. It certainly doesn't hurt to use a "smart" charger on your airplane . . . but it doesn't add perceivable value either.

Myth 2: Systems fitted with more than one battery need some form of "isolation" to prevent deleterious arm-wrestling between the two batteries.

Batteries charge based on the voltage applied to their terminals. This voltage is set by the alternator's voltage regulator. When the alternator is operating normally, any number of batteries can be hard connected to the bus. By "hard connection" we mean a switch, relay or contactor having a very low resistance. Diodes (solid state check valves for electrons) waste energy and limit architecture choices for how power is put into or removed from a battery.

When the alternator is not producing power (for what ever reason) the bus voltage drops from a charging level (14.2 to 14.8 volts) to a battery discharging level (12.5 and lower). My electrical system designs always include some form of ***active notification of low voltage***. I.e, a light that turns on when the bus falls below 13.0 volts.

Okay, the light is on. Now what? Your plan-B should re-configure the system for battery-only operations. (1) Shut down unneeded equipment. (2) Partition batteries to their assigned tasks. (3) Shift flight management to an endurance mode that maximizes use of the scarce resource: stored energy in the batteries.

Myth 3: Batteries of different capacities should not be directly paralleled for the purpose of exploiting the energy they have stored.

The only reason to have two batteries in tandem is to increase total capacity. If you parallel a 12 a.h. battery and a 7 a.h. battery, you now have 19 a.h. of energy storage. You can parallel them for charging and discharging while expecting to (1) top them off during charge and (2) use all energy they contain on discharge.

Interestingly enough, it matters not whether the smaller battery is rated at 7 a.h. when new . . . or happens to be a 12 a.h. battery at end of service life. It doesn't matter what conditions have caused two batteries to be different capacities. Both batteries will deliver all their contained energy. Except for the now exceedingly rare instance of shorted cells, a battery of any size, condition or state of charge will not "sap the precious bodily fluids" of another battery.

Now, why would one wish to install more than one battery in an airplane? It depends on design goals. For example, float planes that have kicked off from the dock and are now drifting downstream can be in deep doo-doo if you can't get the engine started. I've helped folk install second batteries inside floats that are simply paralleled with the standard ship's battery on it's own contactor. This dual battery installation serves but one purpose. It increases the odds that at least one battery will be available to crank the engine in spite of failure of contactor or battery master switch.

How about a single alternator airplane with electrically dependent engine and flight instruments? If the alternator quits, one might wish to assign batteries to Task 1 (engine) and Task 2 (instruments/communication). In this case, the two suites of hardware are powered from their own battery busses. Contactors that parallel the batteries to the main bus are simply opened. The main bus goes dark and system components that depend on battery power enjoy separate, isolated sources.

Another example for dual battery installation is illustrated at:

http://tinyurl.com/54wszu

and

http://tinyurl.com/6s4meb

In this case, we have totally independent systems with a cross-feed capability. In normal operation, the two batteries are supported by their own alternator. Should one alternator fail, the pilot has the option of closing the cross-feed contactor thus paralleling both batteries and their buses on the remaining alternator. This is a perfectly rational thing to do. One may also close the cross-feed contactor to add both batteries capacities together during engine cranking.

If you have questions about batteries or any other component of your proposed electrical system, I suggest you take advantage of the AeroElectric-List hosted by Matronics. This service is free. You can sign on and sign off at your pleasure. The service is described and linked at:

http://tinyurl.com/57wytb

This service is supported by about 1800 builders and a several dozen knowledgeable individuals (including yours truly) who are willing to share their time and expertise in matters electrical.