Aircraft Wiring for Smart People

~ A Bare-Knuckles How-To Guide ~

10 September 2004

by Greg Richter

Bibliography of documents:

http://www.aeroelectric.com/articles/richter/response_1.pdf

response_2 is as follows:

Gleaned from reader's postings on Bluemountainavionics.com on 25 September 2004

Clay says: It seems that Bob has a hard time engaging in constructive dialogue with people that present new ideas... and instead spends his time writing point-by-point dissection and rebuttal when anything new is presented.

> ***Bob says: I make my living sifting though piles of data in search of simple-ideas (and saved for future use) or identify bad/erroneous ideas (for discard). The next goal is to participate in considering how good ideas can be assembled (design) to advance our craft or how bad ideas have torpedoed a system (unhappy customers/high cost of ownership) that should be working better. That's my paid job. Evenings and weekends consume un-compensated hours a day on the AeroElectric List in support of that mission for the OBAM aircraft community.***
>
> ***There are hundreds of lists and bulletin boards all over the 'net. I have no idea how many comments are made every day that support or disagree with what I may have written. There are not enough hours in the day to monitor all of the discussion boards or list-servers in search of such topics of conversation. I have to depend on the observation of others who bring points of interest to my attention. When I take the time to respond, my first commitment is to service folks on the AeroElectric-List. If someone sees fit to post a link to the draft copy on the Blue Mountain discussion groups . . . great. Accusing me of avoiding constructive dialog assumes facts not in evidence and could not be further from the truth. Shame on you sir.***

True, he does have good points about some of the things that he raises, but he also has a very hard time acknowledging a good idea when it comes from someone else.

> ***Forgive me sir. . specifically which "new idea" are you referring to? The document I reviewed suggested many ideas. Which ones are you referring to as "new" and in what ways do you find my analysis or comments inappropriate or in error. May I declare the dialog officially OPEN? Let us discuss . . .***

I think there is room for "electrical wiring for those who want something that works, and don't want to overcomplicate things."

Can you help me out here? Which architecture are you referring too? If Greg's document is talking about apples, then be advised that the 'Connection talks about grapes, oranges, apples, grapefruits and watermellons. Please tell me which architecture in the 'Connection has been compared with Greg's suggestions and describe the features you find are overly complicated?

I doubt Bob's Aeroelectric connection was perfect on its first draft, and judging from the number of revisions, it has also had major changes over the years. I wouldn't expect Greg's document to be any different. Rebuttals and modifications based on what works and what doesn't will shape the document for the forseeable future.

The 'Connection is in its 10th 'draft'. Draft 11 is in the works. I don't see a 'final' version in the foreseeable future. It's a living document constantly being updated as the state of our art expands and evolves. "Rebuttals and modifications based on what works and what doesn't work have always been welcome. See the Peer Review Policy on the website. In fact, those discussions have directed the 'Connection's evolutionary step from one 'draft' to the next for over 15 years. This isn't "Bob's book" but a joint venture between Bob and a readership of over 10,000 folks who are helping make it better. Do you have something you'd like to contribute? How about a chapter on DC motors and controls? I'd love to have a nice section on selection and sources of tools. I'm trying to finish up a section on audio systems for "draft" 11. Again you assume facts not in evidence.

One of these days, even Bob is going to get around to modifying Z-24 with a note that says, "wiring your system like this and turning off the ALT field with the engine running will likely fry your alternator, but you should already know that."

More facts not in evidence. If you had been participating in Z-24 discussions on the AeroElectric List for the past 12 months, you would be aware of a lot of work including plans to update Z-24. Do you know what changes are being anticipated for Z-24? If you'd followed the List or dropped a note on the List to inquire, you'd know that testing has been accomplished and efforts are being expended to advance the state of the art with respect to that z-figure. It hasn't been a rush-rush deal because the risk to an alternator is low and it's ONLY the alternator.

But solutions to the problem are at hand and will be forthcoming. It's not going to say anything like what you've hypothesized . . . but since you choose to throw rocks of ignorance and mis-information, I'm not sure I should make it so easy. Why not drop a note on the List and see what Paul, Brian or any of a half-dozen other folks have to offer on the topic?

Bottom line is that much of what you think understand is in error. But it's not a secret. Everyone and anyone can participate on the AeroElectric List. Anyone and everyone can have input to the AeroElectric Connection, it's not private. So arm-chair quarter-backing Bob's review of a piece without yourself being a constructive participant is disingenuous.

Greg Richter posted on Tuesday, September 21, 2004 - 06:27 pm

Greg says: Bob and I disagree on several fundamental issues and have for a while. Reasonable men can disagree, and often do. Just bring up politics or airplanes and you'll see what I mean. Most of his hacks are not substantiative.

> ***Bob says: That's a REALLY broad brush. Please cite any one 'hack' and let's discuss it. Best yet, let's do it on the AeroElectric-List . . . we should not only conduct the conversation openly but invite others to participate.***
>
> ***This is not Nuckolls vs. Richter but a sifting of simple-ideas. Once reduced to the level of simple-ideas we find that politics, airplanes and opinions drop out of the equation. This isn't a matter of agreeing or disagreeing on anything. A simple-idea is a fundamental truth. Good on the face of it and understandable by anybody. It's our job as teachers to foster understanding.***

He just doesn't like my approach, which is understandable; it is very different from his. Politics and airplanes again. I am really honored that he apparently took a coupla days off work . . .

> ***My boss would be pretty unhappy if I did that . . . but it did take a couple of long evenings.***

. . . to write his critique. He does good research and is generally correct on most things. We disagree on methods and implementation details more than anything else. Frankly, DC power at this level is pretty cut and dried.

> ***I wrote very little about approaches to anything. In fact, I've not even commented on the architecture of the power distribution board. Most of my initial effort was intended to illuminate the simple-ideas involved BEFORE they're assembled into designs and inventions. If you understood the 'Connection's mission, you'd know that all of the choices offered in the architecture drawings are designed to meet the needs of builders working on ultralights to Lancair IVP. I don't recommend any of those architectures to anybody until we've talked about their project and its mission. In that venue sir, I'll suggest that the DC power decision is anything but "cut and dried".***

Now:

I wrote my booklet with an eye to showing how things can be done simply, and easily as opposed to how things have been done, and overdone, for far too long. As you'll note, I don't make my living selling books . . .

> ***. . . and neither do I although it would be nice.***

My still-unfinished booklet reflects my opinions on what I've done and seen, and how I think it can be done better. No more, no less.

Non-specific. I'll ask again, What do you find about any Z-figure that's "too complicated?"

Bob is absolutely correct on the historical development of Teflon vs. Tefzel, which isn't what the paragraph was talking about. My thought is that we have been using Tefzel for a long time, and now that Teflon is cheap, we never (as a group) looked at again. Teflon was once too expensive, now it's not. There you go. The bit about a tie-wrap cutting through it is utter nonsense, but my pitch was for colors more than anything else. Use colors. Teflon is my pick, Tefzel is fine too.

Why? Everyone I've worked with in the industry rejected Teflon when it first came out except for the narrow range of applications cite. The stuff was just too soft. The tie wrap doesn't "cut" the insulation. Constant force and temperature excursions over time will extrude Teflon. Besides, tie wraps cannot be placed on as tightly as string ties. I've seen this happen on RG-58 coax too. It appeared to me that the primary feature driving Teflon into your favor was availability in colors . . . a feature equally available in Tefzel. But if Tefzel is okay too, I'm pleased that we're not violating any specifications. I'm still curious about those "specifications".

My pitch for not using a 10 amp fuse for a 10 amp load, for example, is a point we also disagree on, amazingly enough. I still maintain that it's good practice to not load up a fuse or breaker to more than 80% of nameplate, and that's also common practice in other industries I've worked in.

Common practice is best based on knowledge and understanding of the physics of simple-ideas. In your text I find the statement: "a 50 Amp breaker will pop at 40 amps after 20 or 30 minutes. Just long enough into the flight to be a bother!"

Help us out here. I quoted exemplar data from a Bussman catalog that suggests current protection offered is already de-rated to prevent nuisance trips . . . you've made a statement that I can only interpret to mean that nuisance trips are built in to circuit breakers. I'm mystified. Can you enlighten as to the physics and manufacturer's data that supports your statement? I've never suggested that a 10A fuse should be used on a 10A load. I've always suggested designing in some head-room based on system requirements. For example, an 8A pitot heater will pop a 15A fuse due to very low cold resistance of this device. So we recommend 20A protection on 15A wire . . . a design decision tailored to the system. There are few blanket statements that can be made about sizing circuit protection. One should understand each system's behavior.

I had a Seawind in here yesterday with lots of tiny breakers that pop all the time. Was a real hassle to work on. Just because a 3 amp fuse won't blow until it gets to 4 amps isn't the point (which is known by everyone who deal with these things).

But that isn't what you suggested earlier. Understanding of simple-ideas suggests that the Seawind's electrical system was poorly crafted. If it's an OBAM aircraft and hasn't been combed out for nuisance tripping due to undersized fuses, breakers and wires, it's nobody's fault but the owner. If it's a certified ship and suffers from nuisance tripping, then we KNOW why the owner puts up with it. It's too expensive to fix.

The intent of the fuse is to protect the wire, which can probably handle 10 or more amps. My question is why are we using a 3A fuse to start with? Why not use a 10A fuse, and have it blow when we have an actual fault? That's the intent. He even says its a good idea to spec Alternator breakers this way, as if they are the only devices that draw more current cold than hot. I work with CCFL backlit LCDs that have the same issue. I still submit it's a good idea, and is common practice elsewhere. We just disagree.

I'm confused. What do we disagree on? I took issue with your statement that a breaker will open in 20 to 30 minutes when loaded to 80 percent of it's rated value - a statement that argues with engineering data from the circuit breaker and fuse manufacturer. Now you seem to have shifted to agreement with the notion that performance of accessories over the entire expected operating range is a good idea so that you don't get blind-sided on breaker and fuse sizing. You've brushed aside the questioned statement. I don't see that we disagree on this point at all now.

Sorry to start an argument, but Bob is solidly DEAD WRONG on his hack of my 24 volt discussion. Most avionics (electronics, not light bulbs) will run on 10 to 32 volts.

Didn't say that. Lots of modern avionics are fitted with switch-mode power supplies designed to perform in either a 14 to 28 volt aircraft without throwing any switches inside the radio or rewiring the power plug. I would argue with the term "most" because most devices are built for the certified market. While performance down to a stead state voltage of 10.5 volts is cool and within easy reach of the current technology, it's not common amongst the whole community of suppliers to the aircraft industry. Further, there's tons of "old" stuff finding its way into the OBAM aircraft market. You made a blanket statement 24-volt batteries are preferred for aircraft, period. I believe the supporting thesis was that this gives you more headroom during cranking IF the accessory begging for power has this modern 10-32 volt input power capability.

A 12 volt battery has a lot more energy left at 11 volts than a 24 volt battery.

"A lot" is non-quantified. Yes, the ENERGY contained in a 12 volt battery discharged to 11 volts is greater than for a 24 volt battery discharged to 11 volts . . . but we're comparing less than 5% versus zero percent. In fact, a 24 volt battery discharged to 11 volts may already be in cell reversal and balancing on the edge of the scrap heap. Do I understand correctly that the original thesis was that you're less likely to have a disrupting effect on 10-32 volt avionics during cranking if you used a 24-volt system?

Letting the performance characteristics of one or two radios or other avionics drive the system voltage selection process ignores other aspects of system performance requirements in airplanes that the certified side of the house understands and signs up for . . . which includes brown-outs and interruptions down to zero volts. More on this later.

Look at the curves. A 24 volt battery at 11 volts is nearly destroyed. A 12 volt battery at 11 volts is only partially discharged.

Okay, here's a curve. Check out page 7 of

http://www.enersysreservepower.com/documents/US_GPL_SG_001_0303.pdf

Take a look at the family of discharge curves. For all temperatures, by the time voltage drops to 11.0 volts (1.83 volts per cell) in a 12v battery the curves are all pointed decidedly south. Further, this inflection on the curve is at the END of the discharge cycle. Yes, a 24 volt battery down to 11 volts is down to 0.9 volts per cell. The phrase "partially discharged" is inappropriate when referring to energy left doing any useful work.

There is more room for voltage sag, and you just do not have the drop outs associated with 12 volt start systems with 24 volt start systems. He can wave his Aeroelectric wand all he wants, but the facts are what they are and installed airplanes bear this out.

Are we talking about two different things? Effects during starting are an entirely separate case from discussing ENERGY remaining at 11.0 volts . . . I can show you batteries with very low capacities but exceedingly low internal impedance. Voltage sag during cranking is driven by battery, wiring and switch-gear impedance. The relationship to the gross size (capacity) of the battery and voltage drop during cranking is only loosely connected.

He's also DEAD WRONG on the shield comment and cop-out on p. 21. Connecting both ends of a shield is a bad idea, it makes the shield not work. If the shield is required for a return lead, that's another story, and is not what is being discussed. Bob's an EE and he knows that. The PS Engineering guys and all the audio engineers I've ever worked with do it this way. Again, we disagree.

You cited Kirchoff's law in your text, let's review the work of Mr. Faraday. He describes the effects of electro-static coupling between conductors and the effects of "Faraday shields" in breaking that effect. It matters not whether a shield is totally independent (connected one-end only) or part of the system's designed in ground-returns (connected both ends).

Bob persists in ignoring what is written, . . .

Please cite any facts in evidence . . . anything that I've ignored. I'd be pleased to go look it up.

. . . preferring to throw rocks at anything he didn't write himself, which I find a bit tacky. I don't correct his stuff which is far from perfect, as Clay points out above, and has been revised many times to make it asymmtotically approach correctness.

> ***Another broad brush . . . Neither you or Clay seem perceive the evolutionary nature of the 'Connection. Please join us on the AeroElectric-List. I'd be pleased to discuss anything I or anyone else has written on the list, on the website or in the book.***
>
> ***The 'Connection has never been intended as the "gospel according to Bob Nuckolls". It's a gathering place for the best we know how to do. If you have something that should be included, please post it to the list or e-mail it to me at your earliest convenience. Rev 11 goes to press in a short time. If your contribution of simple-ideas is not included in future 'drafts' it's only because you didn't make an effort to contribute.***

I especially love the bit on p. 24 where he says that he has "zero faith" in the effectiveness of a spray on coating for a groundplane. Religious issues aside, that's what we did at Grumman, and that's what I've been doing for years successfully in both ham and broadcast radio.

> ***Spray-on coatings are often used for shielding. Any conductor you can put between a victim and an antagonistic source will have some beneficial effects. However, when you're trying to lower the connective impedances between components of an antenna system, it's easy to see where gas tight, weather tight, micro-ohm connections are a good thing to do.***
>
> ***Now, spray a coating on a layer of glass filled plastic. Clamp this material up to the base of an antenna with 10-32 screws at recommended torque limits and tell me we've got gas-tight, micro-ohm connections. Also, how can we assure that those clamp-up forces are maintained for years of service life we expect from most antenna installations on metal airplanes? I've fought these issues in the lab. The fact that any antenna performs "successfully" is non-quantified and subjective. If some inspector tries to measure the connection between the base of an antenna and the spray on coating over epoxy and Fiberglas with a bonding meter, the resulting measurement will produce a rejection of the installation.***

The fact that he hasn't tried it, apparently means it won't work! What a load of piffle. Not as ludicrous as the bit about ADF wiring being different from VHF, but still astoundingly arrogant.

> ***How do you know what I've tried? I don't recall that we ever discussed it. I HAVE used spray coatings . . . as shields for the attenuation of noise propagation. It's NEVER 100% effective. It may reduce noise to some acceptable level allowing a certification effort to go forward. Use of sprays for shielding has little in common with effective antenna design.***
>
> ***There's an "autopilot electric box" on the 20 series Lears that I helped design about 25 years ago. It featured a vacuum molded enclosure that had to be sprayed to bring some RF susceptibilities***

below limits. Now, could I use that coating as a chassis ground for the conduction of power? No way . . the sheet resistance is too high and further, I can't fabricate a high current, gas-tight bond to it.

VHF antennas are tuned. They have low impedance, high current matching points intended to drive coax at low SWR and low losses. "Ohmic" joints of very low resistance are much desired and sought after. This is a hallmark of every antenna design and construction text since Marconi was knee high to a spark gap. ADF antennas on airplanes are low current, sub-fractional wavelength, e-field devices. Their operating modes and installation requirements are strikingly different from tuned antennas used at VHF and above.

The most positive thing I read was where he said "I can deduce no big argument against this philosophy". He was clearly looking for a big argument at every turn, but blessedly didn't find one there.

I'm pleased that you feel blessed but the statement was made in support of the notion that an airplane COULD be totally wired with 10A circuit protection and 16AWG wire. I perceive no safety issues here. I do question the cost of fabrication and ownership value. I am not looking for anything except to assist my readers in understanding the simple-ideas which govern the operating characteristics of components and materials available for building their airplanes. I offered specific arguments for many statements you made. I'll welcome your participation on the AeroElectric-List or any other venue to straighten me out.

I put off publishing guidelines on wiring even though I've seen so much truly atrocious work, much of it per Bob's book, for this very reason: it is absolutely not my desire to engage in a public flame war over who makes the best shrink tube and why it should or shouldn't take a three man engineering team to wire a radio. There's far more important things to do than argue over how to do things that can be done multiple ways and still be done well.

lots of rhetoric, citation of facts not in evidence and not one specific point to be debated. Please take any simple-idea I've offered and make my day, show me where it's wrong. When you found something malfunctioning in someone's airplane and they claimed to have consulted the AeroElectric Connection, please cite the page and paragraph of the 'Connection responsible for so seriously misleading the builder. Was the difficulty because a technique suggested in the 'Connection was in error or was it because the builder did not understand or properly install it?

The AeroElectric-List, the AeroElectric Connection and the website have always been open forums where folks in quest of knowledge will be welcome. Folks with additional and/or alternative views supported by simple-ideas are equally welcome. If there are errors, I'd like to know about them. I'm disappointed that you aspire to be a teacher while allowing a publication of erroneous information to go unchallenged. How long have you known about any errors in the 'Connection and not made me aware of them?

If I were truly mean-spirited, I'd publish a critique of his book (which is emminently critiqueable), but who cares?

I care and so do my readers. So I'm mean spirited too? Give me a break Greg, we've never met and I'll bet you haven't read ten paragraphs of what I've offered on the List and elsewhere for over 15 years. Please don't take on the whole book. Take it one simple-idea at a time. If you don't have a copy, tell me and I'll mail you one at no charge.

It's not productive to discuss the invention of houses or tool sheds before we understand the boards, bricks, screws, nails and hammers available to the task. I've tried to be very specific in the review of your writings and to support my own words with simple-ideas. I'll request and expect no more and no less from you sir.

There's enough info out there for anyone who's interested to get a good handle on what to do, and how to do it.

We are awash in "info". There are terabytes of information on the Internet alone. However, the proportion of information supported by historical fact, simple-ideas in physics and lucid critical review is the proverbial grain-of-sand-in-the-ocean. It's our duty as teachers to find those grains and share how they fit into practical, failure tolerant, low cost of ownership designs with anyone who is interested. This is the hallmark of what the OBAM aircraft community has come to represent.

I just put another point on the graph, where one really needed to be.

I have often referred to "simple-ideas" . . . basic truths wherein their principal, value and application are easily understood. One such simple-idea is liberty. A condition that allows one to go through life free of force or fraud against their person or property. Another is honor. The honorable individual goes out of their way to protect the liberty of others. A third simple-idea I'll offer concerns that noble profession called "teacher." It is NOT the mission of a teacher to convince anyone of anything. The art of persuasion is for preachers, politicians and door-to-door salesmen. Teachers are disseminators of simple-ideas supported by historical facts and illustrations of how ideas may be assembled in useful ways i.e., understanding.

Teachers can be inventors too but it's really up to students to sift through the big box of Tinker Toys, Legos, and Erector Set parts to assemble their own inventions. If their teachers are true to the profession, then the student's path to success is made easier and more productive. Best yet, they too become teachers by demonstrating and sharing their successes.

I embrace these simple-ideas. In so doing, I'm not permitted to lie to you. I'm not permitted to write words intended to cause you harm or discomfort. I am obligated to defend you when others direct dishonorable behavior at you. As a teacher, I have a duty to understand anything you or anyone else offers as a simple-idea and either support it or spotlight its fallacies. If everyone embraced

these simple-ideas, the Challenger wouldn't have blown up, the Titantic wouldn't have gone down and TWA800 wouldn't have blown apart. Countless other disasters in history are the product of individual acts of fraud against innocent individuals.

I'll invite you to engage in a published discussion of the simple-ideas under consideration. I'll be posting this and other documents directed to this study on my website. I will encourage you to participate in the discussions and to post it to your website as well.

Please accept my invitation to participate in any of my weekend seminars free of charge. You don't even need a reservation. Just show up. We'll make a place for you right on the front row.

In the quest for uncovering simple-ideas, I've crafted the following questionnaire based on your original publication. I've studiously avoided pejorative verbiage in what I hope is viewed as a quest for understanding and enlightenment. Only after the questions are all deduced and answered can we both move forward as competent and honorable teachers.

"This isn't about all the possible ways to accomplish the job – it's about one, *Foolproof 100% Gonna Work* way."

My perception is that you suggest that one configuration of electrical system architecture is sufficient for all OBAM aircraft irrespective of size, mission, and planned equipment? Please elaborate.

A single keyswitch and automatic overload protection versus a stack of breakers and switches and a bundle of wiring to choke a horse. Does your car have an Avionics Master switch for its half dozen computers and on board FADEC?

Circuit protection can be made automatic, switches can serve as indicators, and less panel clutter means Easier To Use. We can do better!

Automobiles and other ground based vehicles are indeed "simpler" to operate. Would you agree that airborne vehicles have special considerations for failure tolerance and may benefit from architectures that are customized to the task of the vehicle?

Most small planes have nearly 50 pounds of wire in them. How'd you like to save 10 pounds of dead weight?

Do you disagree with my analysis of weight savings for 14 vs 28 volt aircraft? Please elaborate on my errors. I cannot begin to verify your assertion for 50 pounds of wire-weight in a small airplane.

A 24-volt system also has a LOT more reserve energy *available for use* than a 12-volt system. As in point #2, a failed alternator in a 12-

volt system leaves you 2 volts from shutdown. It a 24-volt system you've got a lot more reserve before your avionics and FADEC drop offline.

Do we agree that ENERGY is measured in time dependent variables like ampere hours, watt seconds, etc? Further, do we agree that RESERVE energy has to do with battery capacity and state of charge. Do we agree that that ENERGY contained within a battery is a function of weight of reactants . . . therefore a 24 pound, 24 volt battery contains no more energy than a 24 pound, 12 volt battery?

If you have a 12-volt system, you'll need a small backup battery to give you some margin of reserve, but that's easily done, and doesn't weigh all that much.

Are you suggesting that every 12-volt system would benefit from some size of second battery? There are hundreds of thousands of 12-volt airplanes flying with single batteries. Can you elaborate on this?

In my first response, I cited DO-160 recommendations for response to brownout and power interruptions. Would you agree that this is a good thing for every supplier of electronics to aviation to consider in the design of their products?

Alternators: One is plenty for almost all applications. If you have a good Alternator and regulator (I like the B&C stuff, it works well and the support is outstanding) the most likely reason for failure is bad wiring or overload. Either way, bringing another alternator on-line will probably just feed the fire. In another place you say, Secondary alternators are a neat idea, but with a single engine it doesn't really buy you that much more time aloft, and almost always buys you none at all.

Are you suggesting that IF a builder is interested in an all-electric airplane that an unused vacuum pump drive-pad is better left covered with a plate as opposed to supporting a second, 3-pound alternator?

If a builder's goal is to have 4 hour endurance in spite of main alternator failure, is it your suggestion that a single fat battery containing 4-hours of operating energy is preferable to a smaller battery teamed with a light weight, engine driven power source?

Just run the harness through the firewall, use a nylon bushing to make sure nothing scratches or chafes and you're all set.

Are you suggesting a simple, grommet lined holes for firewall penetration of wire bundles or other devices is sufficient for preservation of firewall integrity?

War Story Time: I've worked on a few homebuilts that are all but impossible to operate without recurrent training at Flight Safety every few months. On one very sexy homebuilt that rolled in to the shop you'd have to throw six (6) switches *and* press in four (4) breakers to get the EFIS to come up in normal operating mode. I never did understand the various emergency modes – they were beyond complex.

Can you cite the builder's source of simple-ideas and architectures that produced this condition?

Are you suggesting that the builder crafted this overly complex system relying on information gleaned from any AeroElectric Connection supported data source?

If so, please cite the Z-figure used and/or other sources.

Since the voltage measured across the wire is the Resistance of the wire times the Current flowing through it, you can see that you'll lose some voltage, *and* lose some precious power in your wiring.

I'm mystified by the word precious. Are you suggesting that a major goal of the system designer is to drive electrical system losses toward zero at every possible opportunity? The aviation industry has used rules-of-thumb as described in the 'Connection and elsewhere (Like the FAA's hallowed document AC43-13-1B) for what are acceptable and tolerable system losses. It's assumed that the trade off between losses and the ability to generate and store energy are easily balanced with each other such that there are no imperatives to craft extra-ordinary techniques for conserving energy. I.e. a small number of watt-seconds of energy are expected to be lost and therefore are not "precious". Can you elaborate on your thinking here?

Shielding: This covers wiring everything from a basic Nav/Com to EFIS, Autopilots and Radar. The signals you'll be dealing with here are low level (less than a volt) and are susceptible to noise and interference. Wire all of these with #22 Teflon wire, and shield microphone, headphone and speaker leads. Shields are to be connected at the radio end **only**, and cut flush at the other end using your Flush Cutters. Power and Return are #18 in the usual colors.

Please explain the physics of shielding that supports this advice.

Do you agree that shielding is an electrostatic de-coupling tool and has no benefits of electro-magnetic decoupling unless the shield also participates as half of a coaxial power path (outbound on center conductor, ground return on shield)?

Finally, have you never encountered a system werein the designer use the shield for electrostatic decoupling (classic shield), electro-magnetic de-coupling (tightly shared outbound and return paths like twisting) and power ground or signal return on the shield itself?

This is why I've always advised builders to follow the manufacturer's installation instructions with respect to shielding. If the schematics show shield connections at both ends, then install as instructed.

Kitplanes and General Aviation aircraft are still wired with Tefzel. You know why? Because old specs never die! Better stuff came along, but no one updated the spec. Satellites are wired with Teflon. Military aircraft use Teflon. Tefzel and Teflon are chemically similar,

except that Teflon handles cold better, is impervious to almost everything, doesn't burn or outgas and is available in a zillion colors.

I'm mystfied by any specification old or new that dictates Tefzel to the exclusion of Teflon. Can you enlighten us?

You mentioned Teflon is available in colors, so is Tefzel. You mention better cold temperature performance (-55C to 150C for Tefzel versus -65C to 200C for silver plated strands under Teflon). How is the extra 10 degrees at minus 55C useful to the OBAM aircraft builder?

Do you agree or disagree that Teflon is softer and more vulnerable to mechanical damage than Tefzel?

You state that Teflon doesn't burn or out-gas. Can you reconcile your assertion with the data cited here:

http://www.ewg.org/reports/toxicteflon/chemicals.php

Also, please reconcile a Teflon over Tefzel choice when we find documents like this among many

http://www.omega.com/techref/fluoro.html

where Tefzel is cited for superior ruggedness compared with Teflon.

Please cite for us any military aircraft you're aware of that uses Teflon as the airframe wiring insulation of choice.

In your document you illustrate a power distribution assembly consisting of a number of components soldered to an etched circuit board and wires brought off on terminal strips that capture the end of a stripped wire by "mashing" at the end of a screw thread.

With respect to aviation practices going back at least 50 years, can you help us understand how clamping wires into a terminal strip like this is equal to or better than crimping a wire into a PIDG style ring terminal or even soldering to a terminal where both wire connection and insulation supports are provided?

Would you agree that these terminal strips perform on a par with wrapping a stripped wire around a threaded fastener and tightening it down?

The etched circuit board assembly features soldered-on components standing off the board with no more support than their solid copper leads. Help us understand what steps are recommended to keep these components from breaking off in service due to vibration?

I have studied the schematic for the power distribution board assembly. It appears to support a mix of power distribution (busses), circuit protection (polyfuses) and systems components (solid state power switching and actuator controls). I also see a what appears to be a 28-14v down-regulator.

Systems features aside for the moment, it's not clear to me how this system wires into an airplane's electrical system. Would you be so kind as to provide a power distribution diagram (may I suggest the Z-figures from

http://www.aeroelectric.com/articles/Rev10/z10.pdf

as exemplar drawings). In fact, feel free to download the autocad drawing for Figure Z-11 at

http://www.aeroelectric.com/articles/Appendix_Z_Drawings/z11h.dwg

and then modify it as you see fit to illustrate the major features of your proposal. Z-11 is already a one alternator, one-battery system that should be fairly close to what you've advocated in your text. I'd be pleased to add your diagram to the book if critical review shows it to have merit.

The power transistor for the 12v down-converter, Q1 appears to be the TO-3 device in the corner of your etched circuit board. The bus this transistor drives five, 20 Amp PTC "polyfuses" for protecting wires that drive these loads.

What is the current rating for this 12 volt power supply. Is Q1 adequately heat-sinked for the rated load on this bus? If I fault one of those outputs to ground, have you verified that Q1 is not going to go into second breakdown failure before the PTC device warms up enough to relieve the short?

Your original proposal seemed to favor a one-size-fits-all power distribution system fitted 10A polyfuses. The diagram in your document cites 20A polyfuses. Can you reconcile those differences for us?

I have more questions but this will do for now. Please help us understand your proposal. I'll publish your response on my website and link to it off the AeroElectric-List as soon as I can.

For your convenience of being able to craft paragraph by paragraph response, I've posted this document in both .pdf and .doc formats. Use either as you see fit. The suite of documents to date may be found at:

http://www.aeroelectric.com/articles/richter/response_1.pdf

http://www.aeroelectric.com/articles/richter/response_2.pdf

http://www.aeroelectric.com/articles/richter/response_2.doc

Clay opines that I'm opposed to constructive dialog. I hope the foregoing is sufficient argument to disprove his hypothesis.

Kindest regards,

Bob . . .