

Economics of Weight Reduction

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Robert L. Nuckolls, III

On 5/15/2004 Eric Jones wrote to the Aero-Electric List offering some observations on weight reduction:

a tidbit from the original thread

>The wire I have found is 0.24 ounces per foot (35% of the weight of standard >RG142). Furthermore it has improved characteristics--50% better VSWR, 22% >lower insertion loss, reduce phase and attenuation drift, etc. Making even >much lighter cable is quite possible.

Eric Jones:

The real question is what is losing a pound worth? Here's my rough estimate:

Lets say your aircraft is worth \$100,000 and weighs 2,000 pounds. Does this mean your airplane is worth \$50/pound? Maybe.

A better way to estimate the savings is to look at the total operating cost for the life of the aircraft. In this case lets imagine the aircraft will go 10,000 hours and costs \$75 per hour to fly. Thats \$750,000. At the end of this time we assume the aircraft will be valueless. So thats \$750,000/2000 pounds; or \$350/pound.

Lets apply the reasonableness test to this: Does \$350/pound mean that your old tin barf-bird sitting on the ramp is worth \$350/pound? No. This figure says that the cost of moving a pound of airplane all over the sky for 10,000 hours (50 years at 200 hours per year for example) is \$350. Thats perfectly reasonable.

So how much should you pay to avoid the \$350/pound expense? If you invested \$35 compounded annually at 8% return with an inflation rate of 3.1%, you would have the \$350 in 50 years. So the answer could be \$35.

(This simple example does not include the increased value in having an airplane that goes a little faster, etc.)

(I would like aeroelectric listers opinions on this!).

So in summary I really don't know. If the cable costs even nearly the same, certainly get the better and lighter cable. But there are certainly other factors---

A couple weeks ago there was a lister who thought my Super-2-CCA copper clad aluminum FatWire (available in two weeks) was too expensive for the weight saved. I honestly don't know how best to calculate such a thing. I once flew from Van Nuys, Ca to Winslow, Az in a Cessna150 and landed with a pound of usable fuel remaining. I would have paid plenty for that pound of fuel instead of a extra pound of wire.

Regards,
Eric M. Jones

Bob Nuckolls:

Excellent points. I can expand on those ideas with the following anecdotes from my own experience. In 1964 when I was a tech writer for Cessna, a number commonly circulated around the engineering department suggested "For every pound of empty weight added to our airplanes, it will cost the owner(s) of that airplane \$100 to buy the pound of stuff, maintain it, and purchase fuel to carry it around over the lifetime of the airplane.

When I worked at Lear on the Gates-Piaggio GP-180 program in 1981, I asked

my management how much bonus I could offer suppliers for weight reduction. That got me a bunch of surprise looks. "Shucks Nuckolls, beat 'em up for every ounce you can get . . . but why should we offer a 'bonus'? I told them about my experience at Cessna. They went off into a huddle and a few days later came back with a figure of \$300. I was skeptical that it was truly so low a number . . . but it did mark a milestone in the way my management thought about the economics of designing, building and operating our products. The fact that they would offer ANY substantial number in dollars for weight reduction was pretty cool.

A few days ago, I meet one of RAC's upper engineering management folks in the Denver airport. He had been visiting kids in the Denver area and I was coming back from a consulting trip in Idaho. I bemoaned the state of an important system in one of our products that was too complicated (astounding parts count), too heavy (about 50-60 pounds), terrible service history (been in the #1 trouble reports slot on the airplane since day-one), and about 1.5 to 2x more expensive than more attractive options. I proposed RAC consider of a system that was at least 50 pounds lighter with a demonstrated zero faults performance record for many hours on a flight test aircraft.

I asked him what it was worth for weight reduction on this airplane? He didn't think long before he came up with the number of \$2,000 per pound. I described my proposal for replacing the system and suggested that if we can carve out 50 pounds plus, reduce cost of hardware by about \$20,000 per shipset, eliminate 95% of the installation labor and offer a system with an impeccable track record. One would think that with \$100,000 weight-cost savings to the customer (in ADDITION to good will generated by eliminating a troublesome system), that changing over to the new system was essentially "free" . . . yes, there are some up-front costs on the order of a \$million but this would amortize out VERY quickly.

He didn't argue with me. The discussion went to other topics but it will be interesting to see what his reaction and support

is when I bring this solution up in an upcoming meeting.

Eric's observations are accurate and right on point. There are economies of operation, financing, fabrication and parts selection that can argue most energetically with each other. During Voyager's design and construction phases we were told that it takes 5# of fuel to carry 1# of airplane around the world. This means that every pound of empty-weight elevates take-off weight by 6 pounds.

Here the economies of operation held sway and every effort was made to carve grams out of the airplane sometimes at great expense on an airplane that had a lifetime of a few hundred hours! Each of you needs to make your own decisions as to which economy drives various decisions for purchase and assembly of parts.

I've oft used the term "cost of ownership" in discussions where the long term benefit from a larger investment up front pays off. I've also championed the notion of parts-count-reduction where the economies of reliability are perceived as most important. If one can bring multiple benefits to bear (lower parts count, lower weight, lower cost of ownership) while improving performance . . . then I'll suggest this is the very ESSENCE of the OBAM aircraft fabrication philosophy that will never be fully realized in the certified world.

While OBAM aircraft have published gross weight limits, I think we can agree that those limits can be pushed under certain conditions (cool air, c.g. well inside limits, etc) and certain times when they cannot. It seems that spending lots of time and dollars on weight reduction for weight reduction's sake may not be the same overpowering economy in OBAM aircraft that it is in certified ships.

I'll join Eric in offering the notion that the simple-ideas underlying the really elegant decision are easily obscured by a lot of ol' pilot's tales and hangar wisdom. Bringing questions out to the List is the best place to filter the various ideas in search of the elegant solution.

'Lectric Bob . . .

Gary Casey:

I'll add my bit to the discussion. The other comments were very appropriate, but here is how I calculated it: My current airplane is worth about \$60,000 and carries about 600 pounds. \$100 per pound. I don't carry all 600 pounds very often, but when I do an extra pound would be valuable. The important thing is that once you set a value use the discipline to stick to it. I've set it at \$100 and so far have paid for things that cost \$50/pound, like throwing away all the nylon locknuts that came with the kit and buying all-metal locking nuts - average of \$48/pound.

One of our customers related that for a military aircraft project they were giving an incentive of \$1,000/pound. For cars I've heard of \$1/pound. I think anything from \$50 on up would make sense. Just don't do what some of

the OEM's do and worry about the airframe for hours, but when the time comes to add the last 10% of the stuff they seem to figure "oh, well, what's an extra pound?" Just from the few things they buy from us they could save maybe a pound for very little effort, but they don't seem to be interested.

Gary Casey
