
WHY AIRCRAFT FAILURES HAVE REACHED A CRITICAL STAGE
(OR THE FALLACY OF TRUSTING IN AVERAGE LIFE)

INTRODUCTION

Aircraft mishaps have just about become daily news items, with tragic reports of lives snuffed out. It has gotten to the point where an intelligent human being contemplating a commercial flight for business purposes or vacation must hesitate and ask himself "Will I be on a casualty list when I risk taking this flight?" The proliferation of air travel and competition, together with tight schedules, has led to an increasingly slipshod behavior in the inspection and maintenance of aircraft with respect to flight safety. Furthermore, there seems to be a profound ignorance concerning the statistics of the proper precautionary maintenance procedures which would assure an aircraft's flight worthiness at any particular age of the aircraft. What all this adds up to is an ever increasing risk of failures for airframes, fuselages, landing gears, engines, hydraulic systems, and controls in general. This is especially true for older fleets, which, sad to say, have accumulated a bunch of weaklings among the planes still in use. The main reason why these weaklings have been overlooked is a lack of understanding that in a population no two individuals are identical, i.e., every plane can't be average. Some are below average while others are better than average or above average in cycles to failure. In this bulletin we shall imagine a conversation between two aircraft parked at an airport. Their conversation will turn out to be very interesting when these two discussants frankly open up and tell one another their innermost concerns and facts about their own lives.

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IF AIRCRAFT COULD TALK
(A CONVERSATION BETWEEN TWO PLANES AWAITING TAKEOFF)

Two passenger aircraft were standing on a runway at the Busy Bee Airport. Let us call them Average Plane and B-10 Plane. Average Plane begins the conversation between them, and we hear the following dialog:

Average Plane: Hi there, my fellow of flight. What is your name?

B-10 Plane: My name is B-10.

Average Plane: What do you mean by that?

B-10 Plane: I'm a weakling in the plane population because I'm in the lower 10% of the whole collection as far as longevity capabilities are concerned. In other words, 90% of the planes last longer than I do without any need for renewal. By the way, what is your name?

Average Plane: My name is Average.

B-10 Plane: Well, you are much stronger than I am, and you don't need all the tender loving care that I need.

Average Plane: I figure my fuselage is good for about 15,000 cycles of pressurization before it needs complete renewal to full strength.

B-10 Plane: So that means that if you make two flights daily for 365 days a year you would complete 730 pressurization cycles per year, and your 15,000 cycle total would make you good for 20.5 years.

Average Plane: As a safety factor, my maintenance crew has been instructed to renew my fuselage in totality after my first 12,000 cycles, or in 16.5 years. This is because they figure that there is 95% confidence that my fuselage's true life is at least good for 12,000 cycles or 16.5 years when I make 2 flights daily. By the way, don't they give you the same treatment?

B-10 Plane: Unfortunately, they treat me the same as they do you. In other words, they assume I am also average. One of these days they'll be shocked to find out that I am not average as far as fuselage life is concerned.

Average Plane: Then just how many pressurization cycles is your fuselage good for ?

B-10 Plane: Well, I figure my fuselage comes from a normal population and that its life is at the 10th percentile, which would be 8757 cycles, if we know the average to be 15,000 cycles. This means that I'm only good for 12 years at 2 flights daily. As a safety precaution my fuselage should be renewed in totality after 9.5 years of flying. I've already put in 9 years of service, and if they wait until I put in 16.5 years, as they do for you, I'm not going to make it. I hate to think of the consequences.

Average Plane: Oh, my fellow in flight, you make me feel so bad. What can we do to make authorities aware of this fact of life, namely, that a B-10 plane needs more frequent attention than an average plane?

B-10 Plane: What they could do with that 16.5 year period they use on you and me is cut it down to 9.5 years for both of us.

Average Plane: That's a good idea. I wouldn't mind being renewed sooner myself, even though I wouldn't really need it. I'd consider it a wise move to help you retain your flight worthiness, and thus, avoid the shame the company would experience when your fuselage fails and causes untold havoc.

B-10 Plane: This all goes to show that failure probabilities are not to be considered to be the same for all planes of a fleet. Some planes are even weaker than I am. Take, for example, my fellow flyer in the runway next to us, whose name is B-1 Plane, because his fuselage is in the lowest 1% of the fuselage life population, where renewal is needed every 5 years at 2 flights per day.

Average Plane: So, in conclusion, all we can say is that for maximum safety in flight we need more frequent total inspection and renewal. According to our figures, the time between renewals should be made 1/3 of what it is at present.

B-10 Plane: That's right. I hope the people in charge of our health wake up and realize all this.

Thus, the conversation between Average Plane and B-10 Plane ended just before boarding time for their respective flights. The B-10 Plane was nervous because of its fuselage cycle age being so close to its critical value.

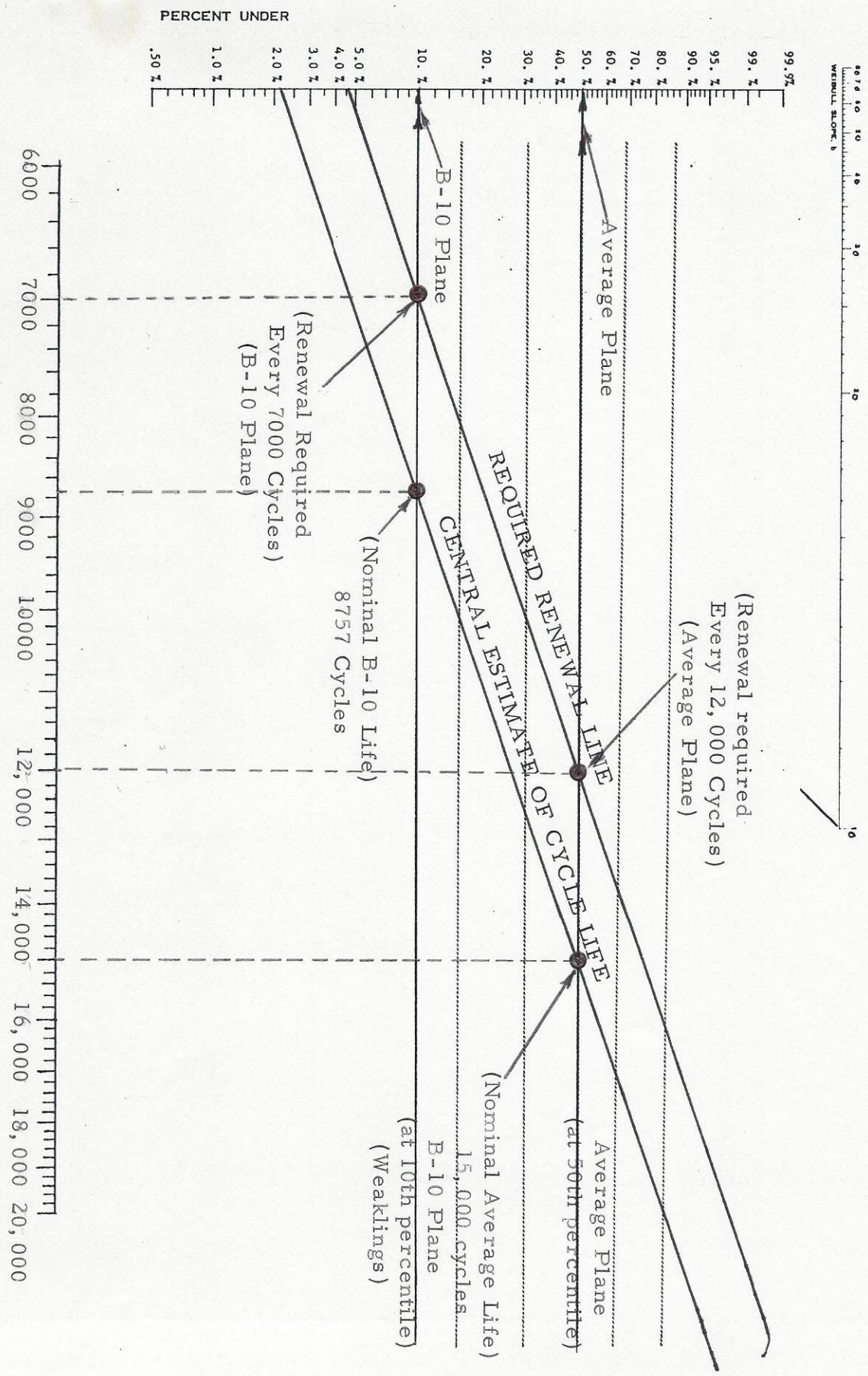
CONCLUSION

Whether we are concerned with fuselages or engines or landing gears or any other part of a plane's system, the same ideas apply, namely, the optimistic assumption of average life for every plane is far too dangerous. In other words, there comes a time in the service history of a plane when it needs complete renewal or replacement, and it is much earlier for some planes than it is for others. As a result, to ply it safe we must look at what the weaklings in the fleet need. All planes in the field should be treated in the same fashioned as far elapsed cycles of service between renewals are concerned. Since we don't know which planes are weak, we treat them all as weaklings which need special renewal 3 or 4 times as frequently as average planes.

The numbers pertinent to the discussion between AVERAGE PLANE and B-10 PLANE are shown graphically on Weibull paper in Figure 1. The Normal distribution mentioned by B-10 PLANE is represented by a line of Weibull slope 3.5, which is known to nicely approximate a Normal distribution whose lower 3-sigma limit is at zero life cycles.

FIGURE 1

WEIBULL PLOT OF SLOPE 3.5 (FOR A NORMAL DISTRIBUTION OF FUSELAGE LIFE)
 (EXPANDED 10:1 HORIZONTALLY)



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