**Note (3-3-2025):** this was a series of stream-of-consciousness ramblings from 2024, in which I was trying to wrap my head around the state of aircraft design in 2025.

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**July 1, 2024**

As I get into analysis of aircraft and try to understand where the market *should* be going, I want to consider a few things:

1. What propellants (or other technologies) are cheapest, highest performance, and most environmentally friendly? Plot it out. I want to look again at the implications of solar on an aircraft. Not saying it's practical… but it's interesting to look at as a range extender. Solar range extension works best if you minimize power consumption in flight. If your solar power is providing some number of watts of power, you want to reduce your power consumption to something on the same order of magnitude to achieve significant range extension. That usually requires flying more slowly.
2. If looking at historical data for existing aircraft, make sure you consider bias of old and new aircraft. Look for trends like that. Try to normalize for things like engine power-to-weight ratios and configuration. Try to be smarter than just using what's on a chart! If you're not careful, you can get bad correlations.
3. "Don't so much build the airplane for a mission or missions. Instead keep the airplane simple and lightweight. If needed, the remaining capacity can be used to add systems and functionality for the specific mission." – Ed Heinemann. I wonder if that holds for civilian aircraft as well? This does make sense for military aircraft, which are often designed for a mission and then never actually do it.
4. There's a balancing act between understanding what's been done, and not falling into the same dogma as everyone else.
5. I want to understand Barnaby Wainfan's philosophy behind the facetmobile and its successor. I want to revisit his presentation. Here's what I remember of it: "while it is nice to have a high L/D, if you're just using it to cart around your heavy airframe, then it's not that useful." There are different metrics of an aircraft's performance. I'm using , and one of the most important metrics is something like dollars (or lbs of fuel) per useful-load x distance. I'm using lb-mile-speed/dollar, because it accounts for payload, distance traveled, speed, and cost. So I'd be curious to plot a bunch of data points for different aircraft.
6. Your objective should be to keep an aircraft as simple as possible to maximize payload mass fraction, but understand that often a desire for performance will drive some amount of complexity. For example, desire for a low takeoff speed but high cruise speed will drive need for flaps or other high-lift devices, which add weight. There's a trade there.
7. It's also useful to consider what people hate about flying.
    a. TSA
    b. Waiting around
    c. Paying for parking
    d. Layovers
    e. Sitting in a cramped space
    f. No internet

   g. Getting nickeled-and-dimed for everything imaginable, mostly because the DHS shut down the airports and now you can be extorted.
8. By the way, I still think an electric flying car would be dope. Flying cars are desirable because I want one, and I'm sure lots of other people would want a decent one too. I want to do a study on one. What's great about electric motors, is they're very simple and power dense. What's heavy is the battery. You could have a flying car with separate drive and cruise motors with relatively minimal weight penalty. One of the hardest parts of a flying car is the different needs for:
   a. Weight distribution and stability
   b. Rotation for takeoff (related to a)
   c. Wtf do you do with the wings?
   d. Ground AND air propulsion

   Does Burt/scaled have a patent on the bipod?

9. Something that improves the design of any system (especially an airplane) is having components that are truly suited to the system. Not just off-the-shelf parts. No excess mass, no excess capability. Just optimized. This is easier to do with scale.
10. Safety and certification are huge drivers for the design of an aircraft.
11. What drives cost in an aircraft's operation
    a. Fuel
    b. Maintenance
    c. Insurance
    d. Storage/hangar
    e. Aircraft cost (driven by complexity, production rate, safety, liability, etc)
    f. Downtime? (for airliners and other aircraft that generally operate continuously)
    g. Paying the airport?
    h. Crew
12. Would people be tolerant of slower aircraft that flew more cheaply? (In some cases perhaps). If they flew direct, perhaps. Layovers can be annoying. For business aviation, I think people would pay more to fly faster. Not necessarily private business aviation, but commercial actually. Or something. Ugh, so much of what sucks about flying has NOTHING to do with flying. We need aviation REFORM. Fix/remove the TSA. Streamline shit. Make it less of a pain in the ass. Stop nickel-and-diming. It's a fucked industry. I do believe it should be cheaper. How do airports work? Financially? Do Airlines pay airports?
13. I need to understand how you generate synthetic jet fuel. And what's in Jet Fuel.
14. The basis of my hypothesis is that you can maximize performance-to-cost ratio with electric airplanes. A metric for that is lb-mile-speed/dollar?
15. There's a philosophical debate to be had on whether it's right to include range in that number. After all, most of the time you just need an airplane that can meet the range you need. Beyond that, you don't really care what the range is.
16. I suspect that batteries will continue to improve, and the industry front-runners will be the ones pre-positioned to take advantage of new batteries as they become available.
17. How fast an airplane can you practically make without the use of heavy high-lift devices? The determining factors are:

   a. Max allowable stall speed
   b. Minimum cruise altitude (There are propulsion implications to this. At high altitude, for a given propeller and thrust, propulsive efficiency drops off with air density. That's because for a given air density, you have to increase disc speed to get the same thrust.)

  For a 22k lb airplane taking off at 161mph (at sea level), you need to climb to 60k feet to have near-optimal cruise at 223 mph. Frankly, that sucks. Gliders have awesome L/D performance, but a huge part of that is because they're slow. The glider I got a ride in had max L/D at 52 kts. High-lift devices are the typical solution. Other solutions are to:

  - Accept lower L/D performance from your wing
  - Use high-lift devices
  - Fly slower (works for GA, might work for cargo. Won't work for passenger travel….unless it's way cheap.)
  - Fly higher and figure out the propulsion (more disc area required)
  - Vortex lift? (according to google, 50° sweep)

Ok. What architecture will enable glider-like L/D at good speeds? What innovation?

For a personal (GA) aircraft, probably sticking with a more simple blended-lifting-body. Maybe a canard one. Have to maximize L/D AND structural performance. It's a hard combo. Tandem wing seems heavy. I think to get an L/D of ~25, I'll need high-aspect ratio wing structures…. Which are inherently heavy. Yaw instability would help, but I DON'T want to have to go there. And anyway, I suspect the additional complexity of the fly-by-wire controls would add a lot of weight. An aircraft's fuselage/tail is also very heavy.

The other potential trick is to make use of what you have (for example, getting lift from your fuselage. Using wing sweep to enhance yaw stability, etc).

Right now I'm trying to come up with an aircraft design that aligns with my Excel sheet.

Turns out the zero-lift drag of the fuselage and wing are very important. And aspect ratio matters a lot.

The most important lever for setting the most efficient airspeed is wing loading.

I didn't understand this previously, but I think if your prop is well designed for your cruise condition, going fast won't necessarily result in a lack of efficiency.

1. OK, hear me out:
   a. High wing loading
   b. Swept-wing Canard aircraft
   c. Main gear on the downward-facing vertical tails
   d. The canard would need a lot of pitch authority.

2. Literally take a glider and put a motor on it. What kind of performance could you get? The wing-loading would go up, as would the gross weight. Flutter might be a concern. You might have to strengthen/stiffen the airframe.
3. Tandem-wing aircraft… probably very efficient, but could be heavy.
4. Conventional low-wing aircraft
5. A Blended-wing-body aircraft that terminates in a high-aspect ratio wing
6. How do tapered wings perform???
7. Or maybe something curvy like JP's?

**Fundamental Parameters:**

Wing Loading

Cl Max

Max L/D (often related to AR)

"Power loading"

Payload Mass fraction

Propulsion efficiency at cruise

The biggest problem I see with commercial electric airplanes is that you need a high mass fraction to get a useable range with an electric airplane, and a commercial aircraft that must be fast to be desirable will need lots of heavy high-ift devices (which will eat into the mass fraction). This isn't necessarily a show-stopper, but it's a factor. I need to look at mass breakdown data for current airliners of different sizes

What about leading-edge root extensions? That may sound crazy. What if they could get you the lift you need?

Or (simple and lightweight) deployable vortex generators?

Or boundary layer control of some kind?

Whatever it is, it'll have to be simple and lightweight.

For the GA aircraft,

My desired range requirement is ~400nm. Comparable to a Cessna 152. Far enough you could do a flight LA to SF. Or do an hour and a half flight to lunch and back without any range concerns. I want it to be faster than a Cessna 172 and most similar aircraft.

I would like to get the stall speed down to less than 60 kts.

I need to reread Barnaby wainfan's book on airfoil selection.