Group - 3 Member List

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DESIGN PROGRESS REPORT

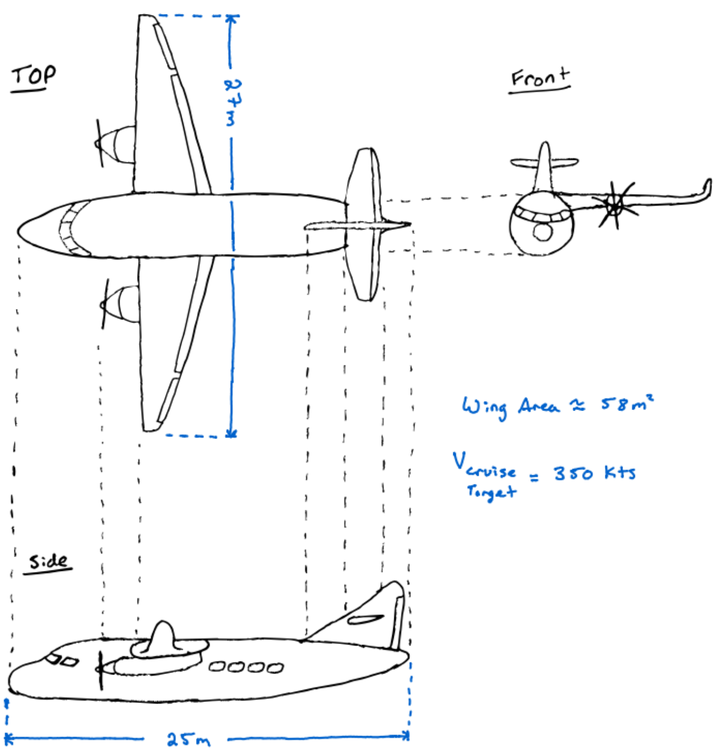
Contents

1 Answers to Questions

1.1 Performance Requirements

- Must carry 50 +0/-4 passengers. Minimum seat width is 17.2 inches with a minimum arm rest width of 2 inches. Aisles of the plane width is of at least 18 inches.
- Range with full passengers must be at least 1000nmi.
- Minimum cruise speed required is 275KTAS.
- The maximum wingspan is 36 meters.
- The maximum takeoff and landing length on dry pavement after clearing a 50 foot obstacle with standard sea level density and pressure and 18 degree Fahrenheit weather is 4500 feet.
- Distance to climb to initial cruise altitude must be less than 200 nautical miles with an initial cruise altitude of at least FL280.
- Must meet 14CFR25.121 climb gradient requirements.
- Must meet applicable certification rules in FAA 14 CFR Part 25
- Able to fly under VFR and IFR flight rules with autopilot.
- Payload of 2 pilots and one member of cabin crew for the 50 passengers. Pilot/crew weight is 190 pounds and the per person passenger weight is 200 pounds. Each pilot has 30 pounds of luggage while each passenger has 40 pounds of luggage.

1.2 Sketch Overview



1.3 Aspect Ratio Estimation

Using the method in Raymer's book, Table 4.1, the estimate for the Twin Turboprop configuration results in an estimated AR of 9.2. However, studies of current twin turboprop 50 passenger aircraft use aspect ratios in the range of 11-13. As such, we are initially targeting an AR of 12.

1.4 Proposed Airfoils

We narrowed down the list of airfoils to NACA-63XXX, NACA-44XX, MS-03XX and MH11X series for the main wing. It is shown in Table 1.1 that the the selected airfoil for our initial sizing based on our target cruise speed ($V_{cruise} = 350KTAS$) is the NACA-63215 (highlighted in gray).

Table 1.1 – Aifoils Considered

Root	Tip	Tail
NACA-4415	MH113	NACA-0015
NACA-63215	NACA-4415	NACA 0012
MS-0317	MS-0313	NACA-0009

1.5 Expected Engine SFC

The SFC as recommended by the Raymer Table 3.4 estimates a cruise SFC of 0.5 and a loiter SFC of 0.4. Data from current existing turboprop regional transports average a cruise SFC of 0.477. To meet the requirement of a 20% reduction in fuel consumption, the SFC target is 0.3816 /hr for cruise and an SFC of .32 for loiter. The reduction in SFC must be accommodated for by the electric powertrain.

$$SFC_{target} = 0.80 * SFC_{known} = 0.80 * 0.477 = 0.3816$$

1.6 Estimated $\frac{T}{W}$ at Takeoff

Using Raymer Table 5.3, $\frac{T}{W}$ in cruise was estimated to be 0.243. Using a relation from page 123, a turboprop cruise $\frac{T}{W}$ is assumed to be somewhere between 60-80 percent of takeoff thrust. Estimating that cruise $\frac{T}{W}$ is 70% of takeoff, the $\frac{T}{W}$ at takeoff is estimated to be 0.347.

1.7 Wing loading $\frac{W}{S}$ at stall

Assuming $Cl_{max} = 2.2$ from Fig 5.3, we can use Eq 5.6 to get the wing loading at stall as

$$\frac{W}{S} = \frac{1}{2} * \rho * V_{stall}^2 * C_{max} = 86.14 \frac{lbf}{ft^2}$$

1.8 Estimated TOP

$$TOP = \frac{W/S}{\sigma * P/W * C_{L_{takeoff}}} = 450.0$$

1.9 Takeoff Distance to clear $50ft$

Using Fig 5.4, and the estimated Takeoff Distance, clear the object is approximately 3100 ft.

1.10 Wing loading $\frac{W}{S}$ at Takeoff

$$\frac{W}{S_{T.O}} = 450 * \frac{C_{Lmax}}{1.21} * 0.347 = 283.91\frac{lbf}{ft^2}$$

1.11 Estimated $\frac{W_f}{W_0}$

This fuel fraction estimate uses a mission profile of a standard takeoff, climb to ft, a cruise of 1000 Nmi, a loiter of 20 minutes, followed by landing. Additionally, these estimates use Raymer equations 3.5 and 3.7 for normal propulsion range and endurance respectively. . Using the SFC estimates for loiter and cruise, as well as the $\frac{L}{D}$ estimate of 17.44, the fuel fraction ratio, $\frac{W_f}{W_0} = 0.1231$. This seems optimistically low, but weight will be added with the battery, and the efficiency of the aircraft is expected to decrease with a greater energy fraction in the electrical powertrain.

1.12 Estimated $\frac{W_e}{W_0}$

From Raymer Table 3.1, the empty weight fraction for a twin turboprop aircraft is estimated to be

$$W_e/W_0 = 0.96 * W_0^{-0.05}$$

Using the estimated gross takeoff weight found in the next section, the empty weight fraction can be estimated to be 0.566.

1.13 Estimated W_0

Using equation 3.4,

$$W_0 = \frac{W_{payload} + W_{crew}}{1 - \frac{W_f}{W_0} - \frac{W_e}{W_0}} = \frac{12260lbs}{1 - 0.1231 - 0.96(W_0)^{-0.05}}$$

By using the iterative method, or using an online differential equation solver, takeoff gross weight is estimated to be

$$W_0 = 39382.7lbs$$