

Michael Burton

March 17, 2016

Assumptions

1. Fixed Engine Weight $W_{eng-tot} \leftarrow 6$ lbf $P_{shaft-maxMSL} \leftarrow 2.189$ kW. Also assuming that engine performance is affected by altitude and RPM. This BSFC model is technically fit for a single propellor. We are assuming that the the variance in BSFC curves in the family of propellers is small.
2. Fixed propeller 18x8
3. Fixed range to station $R \leftarrow 200$ nmi
4. Fixed payload $W_{pay} \leftarrow 10$ lbf $Vol_{pay} \leftarrow 0.5$ ft³
5. Fixed altitude at cruise $h_{cruise} \leftarrow 5000$ ft
6. Fixed altitude at station $h_{station} \leftarrow 1.5 \times 10^4$ ft
7. Fixed avionics $Vol_{avionics} \leftarrow 0.125$ ft³ $W_{avionics} \leftarrow 8$ lbf
8. Fixed climb rate $h_{dot} \leftarrow 125 \frac{\text{ft}}{\text{min}}$
9. Fixed time to get on station $t_{cruise} \leq 1$ day
10. Constant wind speed during loiter $V_{wind} \leftarrow 25$ m/s
11. Fuselage fineness ratio $fr \leftarrow 3.5$
12. Power during climb/cruise $P_{avn} \leftarrow 40$ watts
13. Power during loiter $P_{avn} \leftarrow 50$ watts

Performance Curves

The following curves are performance curves. They assume that the weight of the aircraft is fixed. All of the above assumptions hold.

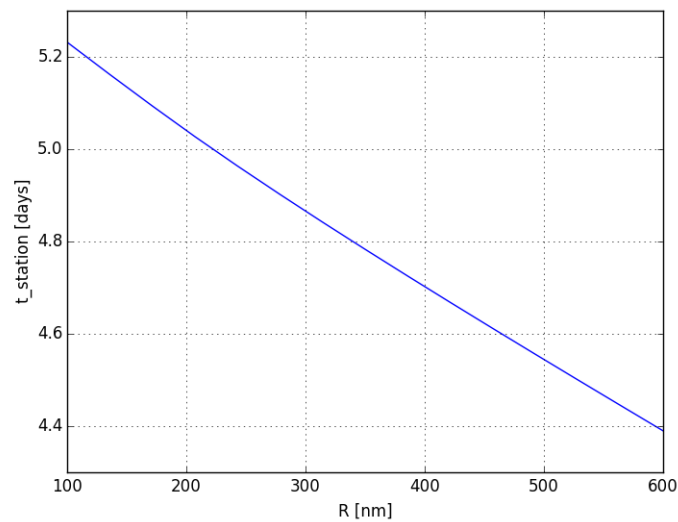


Figure 1: Time on station vs R . Assumes fixed weight of $MTOW = 87$ [lbf].

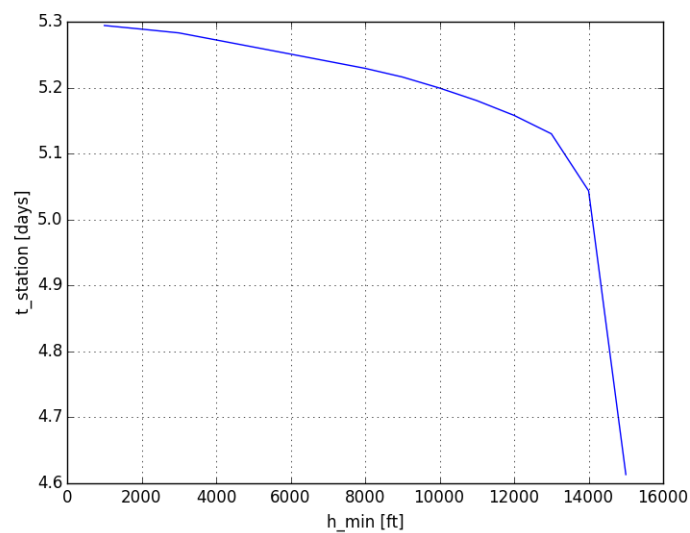


Figure 2: Time on station vs cruise altitude. Assumes fixed weight of $MTOW = 87$ [lbf].

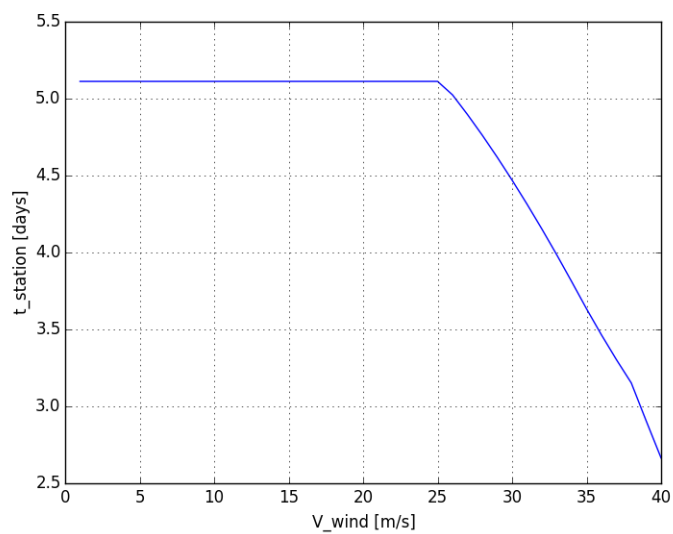


Figure 3: Time on station vs wind velocity. Assumes fixed weight of $MTOW = 87$ [lbf].

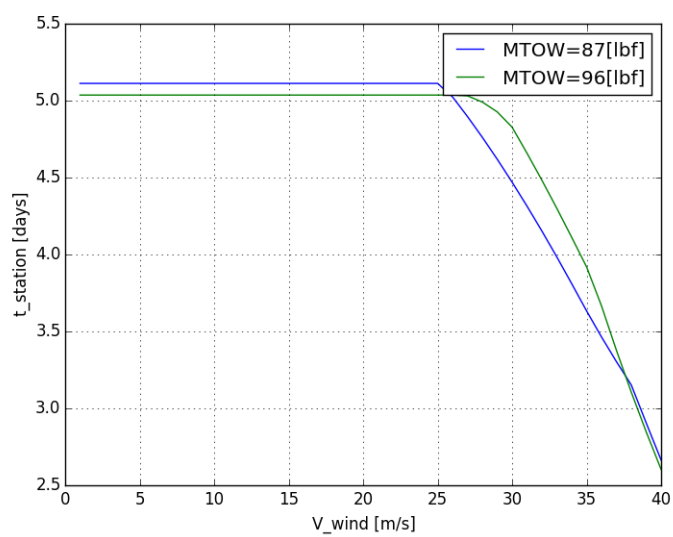


Figure 4: Time on station vs wind velocity.

Solution

Cost

83.13 [lbf]

AR : 27.87		Aspect ratio
A_{capcent} : 9.979e-05	[m**2]	Cap area at center
C_{D-fuse} : 0.003734		fueslage drag
C_{f-fuse} : 0.006756		Fuselage skin friction coefficient
F : 1633	[N]	Load on wings
LoverA : 5.225	[lbf/ft**2]	Wing loading
MTOW : 83.13	[lbf]	max take off weight
M_cent : 1310	[N*m]	Center bending moment
P_{cap} : 4.74e+04	[N]	Cap load
S : 15.91	[ft**2]	wing area
S_{fuse} : 7.994	[ft**2]	Fuselage surface area
Vol_{cap} : 0.0002135	[m**3]	Cap volume
Vol_{fuel} : 0.02653	[m**3]	Fuel Volume
Vol_{fuse} : 0.04423	[m**3]	fuselage volume
W_{cent} : 73.41	[lbf]	Center aircraft weight
W_{fuel-tot} : 42.13	[lbf]	total fuel weight
W_{fuse} : 4.284	[lbf]	fuselage weight
W_{wing} : 7.514	[lbf]	Total wing structural weight
W_{zfw} : 41	[lbf]	Zero fuel weight
\delta_{tip} : 4.211	[ft]	Tip deflection
\rho_{sl} : 1.225	[kg/m**3]	density at sea level
b : 21.06	[ft]	Span
c : 0.7556	[ft]	Wing chord
h_{spar} : 0.02764	[m]	Spar height
l_{cent} : 2.675	[ft]	center fuselage length
l_{fuse} : 3.316	[ft]	fuselage length
m_{cap} : 0.3757	[kg]	Cap mass
m_{fuse} : 0.7427	[kg]	fuselage mass
m_{skin} : 2.956	[kg]	Skin mass
w_{cap} : 5.524	[in]	Spar cap width
w_{cent} : 0.7642	[ft]	center fuselage width
\vec{BSFC} : [0.507 0.681 0.507 0.649 ...]	[lb/hp/hr]	brake specific fu
\vec{C_D} : [0.0304 0.0131 0.0299 0.0274 ...]		Drag coefficient
\vec{C_L} : [1.08 0.498 1.06 0.991 ...]		Lift coefficient
\vec{L_factor} : [0.188 0.189 0.518 0.518 ...]		Max shaft power loss fa
\vec{P_{shaft-max}} : [2.38 2.37 1.41 1.41 ...]	[hp]	Max shaft power at
\vec{P_{shaft}} : [2.38 0.66 1.41 0.448 ...]	[hp]	Shaft power
\vec{RPM} : [8.44e+03 5.82e+03 8.44e+03 6.1e+03 ...]	[rpm]	Engine operating RP
\vec{Re_{fuse}} : [1.49e+06 2.18e+06 1.24e+06 1.24e+06 ...]		fuselage Reynolds numbe
\vec{Re} : [3.38e+05 4.97e+05 2.83e+05 2.83e+05 ...]		Reynolds number
\vec{T} : [9.54 2.16 4.74 2.1 ...]	[lbf]	Thrust
\vec{V} : [20.9 30.7 25 25 ...]	[m/s]	cruise speed
\vec{W_{end}} : [82.8 81.4 80.6 71.6 ...]	[lbf]	segment-end weight
\vec{W_{fuel}} : [0.288 1.4 0.83 9.06 ...]	[lbf]	segment-fuel weight
\vec{\eta_{prop}} : [0.5 0.6 0.5 0.7 ...]		propulsive efficiency
\vec{\rho} : [1.05 1.05 0.738 0.738 ...]	[kg/m**3]	air density
\vec{c_{dp}} : [0.0117 0.00622 0.012 0.0112 ...]		wing profile drag coeff

```

\vec{h_{dot}} : [ 357      148      ]      [ft/min]      Climb rate
      \vec{h} : [ 5e+03      5e+03      1.5e+04      1.5e+04      ... ] [ft]      altitude
      \vec{t} : [ 0.00973      0.126      0.047      1.2      ... ] [day]      time per flight seg
      \vec{z_{bre}} : [ 0.0034      0.0167      0.01      0.117      ... ]      breguet coefficient

```

Constants

```

      BSFC_{min} : 0.32      [kg/hr/kW] Minimum BSFC
      C_{L-max} : 1.5      Maximum lift coefficient
      E_{cap} : 2e+07      [pound_force_per_square_inch] Youngs modulus of CF cap
      FuelOilFrac : 0.98      Fuel-oil fraction
      K_{fuse} : 1.1      Fuselage form factor
      N_{Max} : 5      Load factor
      P_{shaft-maxMSL} : 2.93      [hp] Max shaft power at MSL
      R : 200      [nmi] range to station
      RPM_{max} : 9000      [rpm] Maximum RPM
      R_{cruise} : 180      [nmi] range to station during climb
      Re_{ref} : 3e+05      Reference Re for cdp
      V_{wind} : 25      [m/s] wind speed
      Vol_{avionics} : 0.125      [ft**3] Avionics volume
      Vol_{pay} : 0.5      [ft**3] Payload volume
      W_{avionics} : 8      [lbf] Avionics weight
      W_{eng-tot} : 6      [lbf] Installed engine weight
      W_{pay} : 10      [lbf] Payload weight
      W_{skid} : 3      [lbf] skid weight
      \delta_{tip-max} : 0.2      max tip deflection ratio
      \eta_{prop-climb} : 0.5      propulsive efficiency in climb
      \eta_{prop-cruise} : 0.6      propulsive efficiency in cruise
      \eta_{prop-loiter} : 0.7      propulsive efficiency in loiter
      \mu : 1.5e-05      [N*s/m**2] Dynamic viscosity
      \rho_{cap} : 1.76      [g/cm**3] Density of CF cap
      \rho_{fuel} : 6.01      [lbf/liquid_gallon] density of 100LL
      \rho_{skin} : 0.1      [g/cm**2] Wing Skin Density
      \sigma_{cap} : 4.75e+08      [Pa] Cap stress
      \tau : 0.12      Airfoil thickness ratio
      e : 0.9      Spanwise efficiency
      fr : 3.5      fineness ratio fuselage
      g : 9.81      [m/s**2] Gravitational acceleration
      h_{min} : 5000      [ft] minimum cruise altitude
      h_{station} : 1.5e+04      [ft] minimum altitude at station
      k_{2-fuse} : 5.938      fuselage form factor 2
      k_{1-fuse} : 2.858      fuselage form factor 1
      m_{rib} : 1.2      [kg] rib mass
      m_{tail} : 1      [kg] tail mass
      t_{cap} : 0.028      [in] Spar cap thickness
      t_{cruise} : 1      [day] time to station
      t_{station} : 6      [day] time on station

```