Aircraft Systems Field Exam - 2016

Consider the design and initial sizing of a High Altitude Long Endurance (HALE) UAV to carry a 3 kg emergency response communications payload with the requirement to loiter on station for periods of up to 7 days at an altitude above 10,000 ft.

1. What secondary requirements flow down from the high level requirement above?

2. Discuss the tradeoffs between the various propulsion options for this vehicle including geographical or operational limitations.

3. Discuss how the operating altitude will impact the vehicle. What altitude ranges make sense? What secondary requirements flow down from the altitude decision?

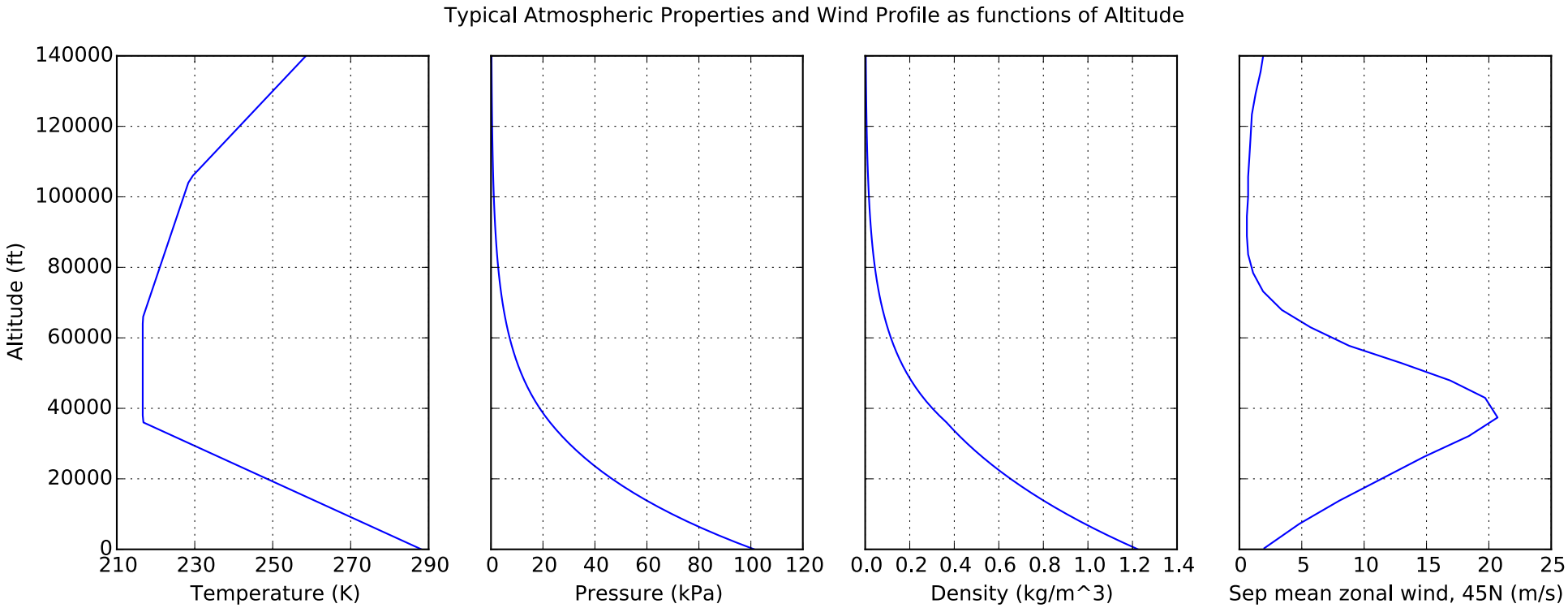
4. Assuming solar powered electric propulsion with the total mass fixed (a payload weight fraction is assumed), derive a generic expression for the ratio of loiter flight power to wing area, P/S. This expression's parameters should include CD, CL, and overall propulsive efficiency.

5. Based on the result in question 5 and making a guess of the payload fraction, make a rough estimate of the size of the vehicle (e.g. wing area).

6. Is there sufficient mass budget to carry everything in addition to the payload, cells, and batteries? i.e. Does the design close? If not, what assumptions might need to be modified to push the design towards closure?

You can assume the following technology levels: average solar cell irradiance during daylight hours of 400 W/m^2; with a conversion efficiency of 0.2; the area density of the solar cells is 1.2 kg/m^2; lithium-ion batteries with a specific energy of 140 Wh/kg.

(Notes: You may not have enough time to address all of the points above in detail but be prepared to spend a few min discussing each one. Included below is some information that you may find useful.)


Typical Atmospheric Properties and Wind Profile as functions of Altitude
Altitude (ft)
0
20000
40000
60000
80000
100000
120000
140000
210
230
250
270
290
Temperature (K)
0
20
40
60
80
100
120
Pressure (kPa)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
Density (kg/m^3)
0
5
10
15
20
25
Sep mean zonal wind, 45N (m/s)