# Space Systems Field Exam

Consider a satellite in low Earth, circular orbit with altitude h and period T_o. The following questions pertain to the design of the power sub-system of the satellite. Assume that the power sub-system consists of a solar array with area A_{sa}, a power management and distribution element with mass m_{pd} and efficiency η_{pd}, and rechargeable batteries of mass m_{bat}. Be sure to clearly define any variables you need to derive the expressions requested. Clearly identify any insights that you have as well.

1. Assume that the orbit is such that the satellite is always illuminated by the Sun and that the demand from the other sub-systems for power is constant (i.e., constant supply, constant demand). What is the name of such an orbit and how is it achieved? Derive an expression for the total mass of the power sub-system. What are the area and mass of the solar array and mass of the batteries that corresponds to the minimum mass power sub-system?

2. Assume that the orbit is such that the satellite experiences an eclipse each orbit and the power demand is still constant (i.e., variable supply and constant demand). Also assume that the duration of the eclipse does not change between orbits. Derive expressions for the mass and area of the solar array and mass of the batteries as a function of the fraction α of the orbital period spent in eclipse.

3. Assume that the satellite is once again always illuminated during its orbit but the power demand is variable (i.e., constant supply, variable demand). The figure below shows the demand profile. Derive an expression for the mass of the power sub-system. Is there a specific combination of solar array and batteries that minimizes mass? Under what technical conditions are batteries and a solar array favored, in terms of mass, over the use of a solar array alone?
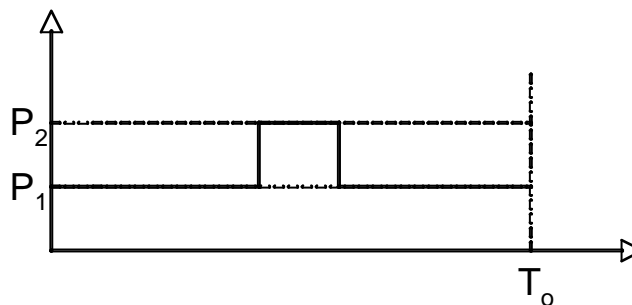
Bonus points: If the above expressions can be found as a function of orbital parameters