To: Consulting Team, U.N.L. Space Project
From: Fred Algood, Project Director
Subject: NASA Inquiry

We have received the following inquiry from NASA concerning an orbiting satellite. I am assigning your team the task of investigating the inquiry and writing up a report that addresses all of their questions and concerns.

An Orbiting Satellite
A NASA satellite orbits the earth every 90 minutes. During an orbit, the satellite's electric power comes either from the solar array wings, when these are illuminated by the sun, or from batteries. The batteries discharge whenever the satellite uses more electricity than the solar array can provide or whenever the satellite is in the shadow of the earth (where the solar array cannot be used). If the batteries are overused, however, they can be damaged. You are to determine whether the batteries could be damaged in either of the following two operations. You are told that the battery capacity is 50 ampere-hours. If the total battery discharge does not exceed 40% of battery capacity, the batteries will not be damaged.

A) Operation 1 is performed by the satellite while orbiting the earth. At the beginning of a given 90-minute orbit, the satellite performs a 15-minute maneuver which requires more current than the solar array can deliver, causing the batteries to discharge. The maneuver causes a sinusoidally varying battery discharge of period 30 minutes with a maximum discharge of ten amperes at 7.5 minutes. For the next 45 minutes the solar array meets the total satellite current demand, and the batteries do not discharge. During the last 30 minutes, the satellite is in the shadow of the earth and the batteries supply the total demand of 30 amperes.
   1. The battery current in amperes is a function of time. Plot the function, showing the current in amperes as a function of time for the 90-minute orbit. Write a formul(s) for the battery current function.
   2. Is there ever a time during an orbit when the battery is in danger of being damaged because of excessive discharge? If yes, when does it occur?
   3. Calculate the total battery discharge, in units of ampere-hours, for the 90-minute orbit for Operation 1.
   4. What is your recommendation regarding the advisability of Operation 1?

B) Operation 2 is simulated at NASA's laboratory in Houston. The following graph was produced by the Laboratory simulation of the current demands on the battery during the 90-minute orbit required for Operation 2.
   1. Calculate the total battery discharge, in units of ampere-hours, for the 90-minute orbit for Operation 2.
   2. What is your recommendation regarding the advisability of Operation 2?
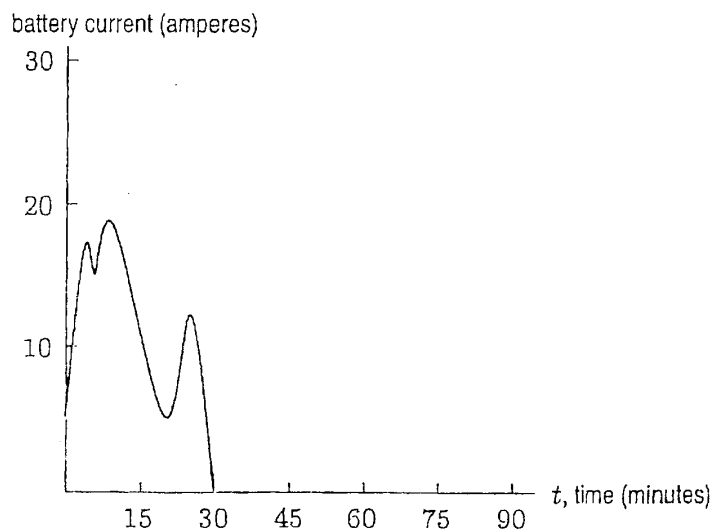
Battery discharge simulation graph for Operation 2