Historian’s Corner

Ray Ziehm (POC)
(rzandmm@comcast.net)

PEPP PROGRAM SUMMARY

BY

Raymond Ziehm

Some seemingly small actions have had outstanding effects on the Denver Division’s growth in the space systems field. One program, the Planetary Entry Parachute Program (PEPP), in particular, exhibits how much more important some things turned out to be than originally recognized. One October day in 1966, I was assigned to a recently won minor spacecraft program from NASA Langley Research Center. The system was to be built in the Denver Second Floor Factory, with engineering located in the factory mezzanine near the top of the stairs. The program was to have two separate phases, one for several rocket launched parachute tests for the Viking Mars Lander mission, and the other for some balloon launched parachute tests. I learned I was to be the lead engineer for the balloon launched segment, whatever it was to be.

The tests were to determine the inflation and drag performance of Viking Program parachute candidates to be deployed at high velocity into the low density Mars atmosphere. The rocket launched tests would carry a simulated lander payload and were to be launched from the White Sands Missile Test Range to 120,000 feet in altitude where earth’s atmospheric density was representative of the Mars atmosphere.

The balloon launched test articles were to be carried by a helium filled balloon to the same altitude. The parachute was to be deployed into the aerodynamic instability zone behind a 15-foot diameter 120-degree conic aeroshell, representative of the planned Mars Lander vehicle entering at high velocity. After dropping from the balloon, the vehicle would use 16 small rocket motors to accelerate the aeroshell/payload assembly to a transonic velocity. The aeroshell contained a simulated payload that housed the test parachute to be mortared out from the aeroshell, and to inflate and pull the payload from the aeroshell.

When I arrived on the program, my friend Ed Nelson, a structural designer, was already there looking at a package of drawings. I learned that we were to use engineering that Langley Research Center had previously created; and that they had already built and flight tested several rocket and one balloon launched tests in 1966 that had only partial success. Our job was to build and fly four successful units.

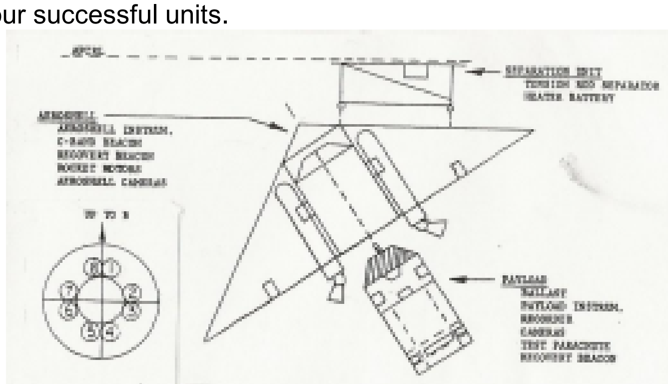

Figure 1. Balloon Launch Test Vehicle

The aeroshell/payload assembly was to be launched from the recently closed Walker Air Force Base near Roswell, New Mexico, and rise to the test altitude during its trip to the White Sands Test Range where the powered flight and parachute deployment would take place. After arrival at the range and the aeroshell/payload was released from the balloon, the rockets fired four seconds later to accelerate the vehicle to the desired velocity. At rocket burn-out, a mortar was to be fired to deploy the chute that would then separate the payload from the aeroshell. The aeroshell was mounted at an angle of 30 degrees from vertical to avoid hitting the balloon when the rockets fired.

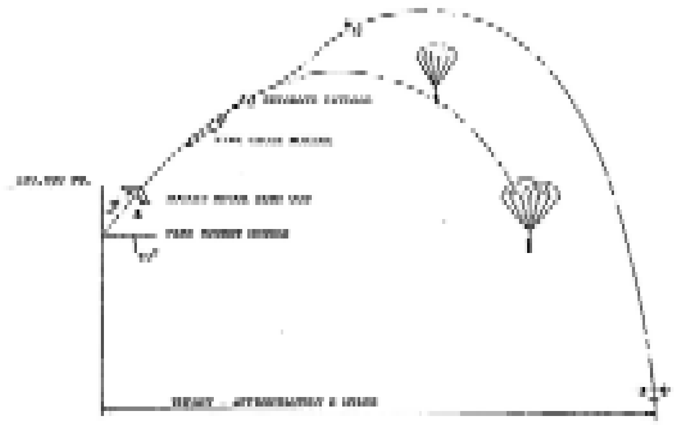

Figure 2. Mission Flight Plan

Ed and I organized the drawings and built a simple drawing tree, and it quickly became evident that there was not nearly enough engineering to build the system. Since the NASA vehicle was built in a laboratory environment, the engineering was not kept completely current. Many drawings were redlined showing how the first vehicle was actually built, and others were wrong or missing altogether.

The contract schedule required us to build and fly the four vehicles in a ten-month period, an almost unachievable task. The schedule criticality was due to the wind profile from the balloon launch site near Roswell to the White Sands Test Range. The winds in that area blow essentially from east to west during the summer, but about Labor Day they abruptly change and blow from west to east, eliminating any possibility to make the balloon flight from the Roswell launch site. Missing this opportunity would have almost a year impact on the Viking Mars Lander Program schedule.

At this time, the PEPP program was under great pressure, focused firmly on the rocket launches, and I could not get Larry Golding, our program manager, to sit down together and go over the balloon launch engineering situation. I called people in the various engineering disciplines to look over the engineering with me and scope out what had to be done. They agreed that we were in trouble. So, as a result, the following Monday morning I moved about ten engineers onto the program and they started to work. When Larry returned a few days later from one of the rocket launches at White Sands, he looked around, saw all the new people, and went into his office. Shortly thereafter the secretary said he wanted to see me. I thought, “I’m fired”.

The design group came to my support and Larry made the decision to keep all the people on board and even to bring in some others needed in specific technical areas. The customer had their people working right there with us and we eventually developed an especially good rapport.

After a few weeks, the customer asked us if we could find a way to reach a peak altitude of about 160,000 feet, with a deployment velocity in the order of Mach 1.6 at 132,000 feet altitude. This was significantly above the altitude and velocity provided by the sixteen small solid rocket motors in the original design so it was clear we had to replace them with more or larger rockets. Since development of a rocket motor was normally a three to four year program, our only path was to find an existing motor. I looked at the Solid Rocket Motor Handbook and determined that the only motor that might fit into the vehicle and provide the necessary impulse, happened to be the Titan

Staging Rocket, built by United Technology Corporation. This is a 5400 lb. thrust solid propellant motor with a burn time of 2.8 seconds. It is approximately five feet long with a body diameter of about 8 inches.

However, there is no way you can order rocket motors and have them built in time for use in a ten- month program. The situation looked bleak. I called my friend Sid Tolbert in the Propulsion Section and told him my story, and he agreed that the Titan motor was the only choice, but availability in the short time frame was certainly problematic. Sid came back the next day and said, “Have I got news for you”. He found that the Titan Program had a significant number of these motors that would soon reach the end of their shelf life and therefore become unusable, and that we could transfer them to our program. Wow, we dodged that bullet. Just a quick look at the problem indicated we would need at least six or eight of these motors on each vehicle, but when our flight analyst, Richard Moog, got on board and included the aerodynamic effects and the penalty of a nozzle cant angle adapter, later incorporated, he said it would take eight.

These rocket motors were mounted around the payload body, a central tube structure that contained the test parachute. While their shape lent itself well, one problem still existed in that these rockets fired essentially straight back in line with their geocentric axis, to where the parachute was to be deployed.

We wanted the chute to be deployed right at rocket burnout to minimize the loss of velocity due to aero drag, so some provision to avoid damaging the chute was required since solid motors often tend to spew additional flames at shutdown. Noting that the rocket motor nozzles were bolted directly onto the rocket motor case, I asked the UTC engineers if it was possible to build some sort of cant adapters to be installed between the motor case and the existing nozzles in order to reorient them and direct the motor exhaust away from the deploying parachute. The supplier said “sure”, and built, test fired, and delivered enough units for the program in record time considering the complexity of the issue.

A quick look at the likely center of gravity of the vehicle with the new rockets indicated a cant angle of about twenty five degrees might be needed, however this angle was later established at 29 degrees by Dick Moog.

Since the spacecraft had no active attitude stabilization mechanism, it would be unstable until the vehicle developed sufficient velocity during rocket burn to achieve aerodynamic stability. To accomplish this, the rocket thrust vectors had to be carefully controlled to maintain a stable flight during the early portion of the rocket burn. Film data from the NASA flight showed that significant attitude deviation during rocket motor burn was close to disaster. We developed a plan to match all motors with propellant grains from the same propellant batch to be located opposite each other around the vehicle. Also, since UTC had accurate knowledge of the exact propellant weight in each motor, motors with essentially equal propellant weights were matched to opposite positions.

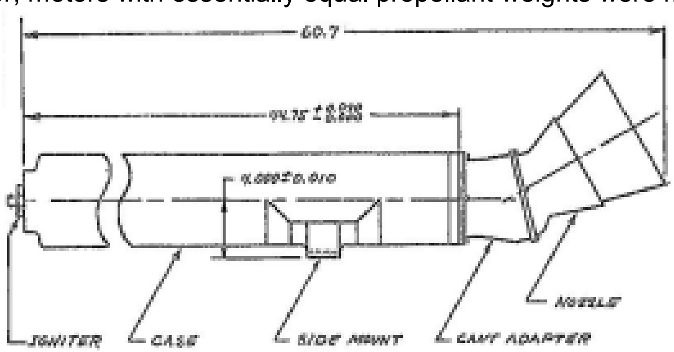

Figure 3. The Modified Solid Rocket Motor

A tool was then designed to fit into each rocket exhaust nozzle as the best representation of the thrust vector centerline such that the nozzle and cant adapter could be aligned perfectly on each motor at assembly. No one had ever seen such a tool, but it really did the trick. We then forced the center of gravity of the vehicle to the geometric center line on the dynamic balancing machine at Sandia Corporation in Albuquerque.

One part of the program was especially challenging since we had no one with significant parachute design experience. We worked with the two major parachute builders in the country and began to get a feel for what to do. We could not locate any stress data or methodology for a parachute and determined that possibly no credible analysis had ever had been done by anyone. Our aerodynamicists and stress engineers did it to the customer’s extreme pleasure. The flight data to be collected were primarily from three film cameras, accelerometers, gyros, and a tensiometer in the parachute bridle, and to be stored on a tape recorder.

(To be continued in the July STAR issue.)