HISTORIANS CORNER
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PEPP PROGRAM SUMMARY

By

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(Continued from April 2018 MARS STAR issue)

The previous issue of the STAR outlined the requirements and preparation for the flight test of candidate parachutes being considered for use in the Viking Mars Lander program. This issue relates to the final preparation, the flights, and results of the program.

The test parachutes were supplied as Government Furnished Property (GFP) by the customer. They were packed into cylindrical containers by a hydraulic press that compressed them into a single mass with a density of about 42 pounds per cubic foot. The mortar was a pyrotechnic device located at the top of the container that would propel the packed chute out from the aeroshell. The tensiometer was a very late-term addition to the program. It was about a fifteen pound unit added to the parachute bridle to record chute deployment loads. The most difficult issue was to quickly find a method to support the item and the chute bridle during the high acceleration phase of the rocket motors burn, and to release it at the proper time. The method selected was to attach a bracket to the aft of the payload that mounted a folded nylon sling containing the tensiometer that was held in a closed position with a steel pin. Since NASA had used a nylon lanyard to affect an event on their flight, and time was so short, we adapted another nylon lanyard to pull the pin at the right time to free the tensiometer.

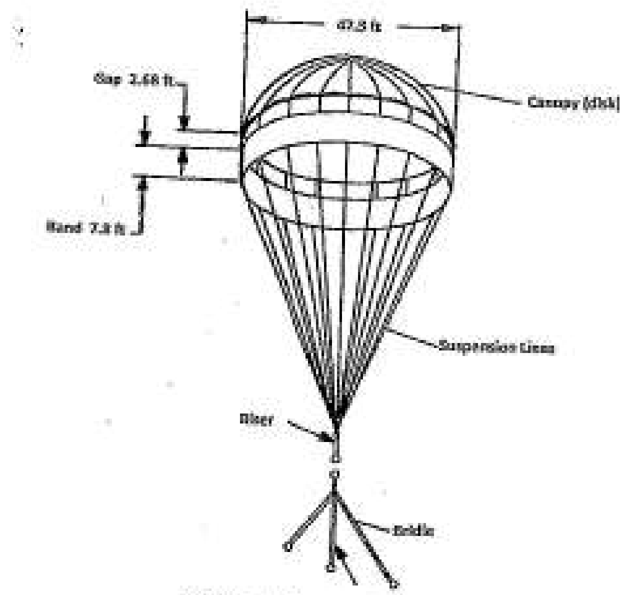

Figure 4. The DGB Parachute

Film of the chute deployment during the NASA flight had a problem due to recirculation of rocket exhaust deposited on the primary aft looking camera lens that darkened the photos so much they were seriously degraded. Just three or four weeks prior to the first launch, they asked if we could find a way to prevent that situation. It was far too late to insert another event into the flight programmer, or design and build a solenoid or ordnance operated mechanism to cover the lens and release it at the proper time. I asked Jim Ball, our structural designer, if he could quickly design a cover for the camera lens that would open at motor burn out. He designed a spring loaded, swing open door with a glass window that was triggered to open upon exit of the payload using another nylon lanyard of a calculated length.

As the flight schedule marched forward, we never found time to prepare engineering for the placement, folding, and support of the triple member parachute bridle on the payload. The support system had to hold the bridle in a safe position under the high acceleration load during rocket burn, yet be able to release it as the parachute was mortared out of the payload. We folded it in accordance with a plan developed during a visit to Langley where they had a hanger queen vehicle, just a week or so before the first launch. The idea was to hold it in position with a series of small nylon cords that together were capable of supporting the bridle and that were arranged to be easily broken, one by one, as the bridle was pulled off by the chute being mortared out. Since I was the only one who had the experience of fitting the bridle to the aft of the payload, I found myself under each vehicle, and the rocket motors, installing it immediately prior to launch. I suspect that nothing like that would be allowed today.

The balloon was a zero pressure system and at the time was the largest balloon ever flown. It consisted of a thirty foot diameter launch balloon that initially contained the helium, attached atop the main balloon that was stretched out on canvas covering the tarmac.

Figure 5. The Spacecraft on the Mobile Crane

Figure 6. Ready to launch

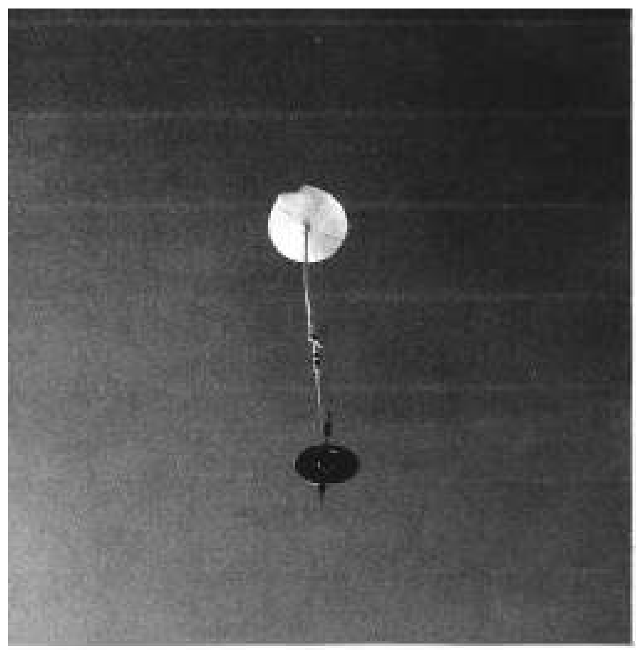

Figure 7. On the Way to White Sands

After launch as the system gained altitude and as atmospheric pressure dropped off, the helium flowed from the launch balloon into the main balloon through an open valve, thereby inflating the main balloon. The bottom of the main balloon was open to the atmosphere. When fully inflated at high altitude, the 400 foot diameter balloon was easily visible from the ground. To appreciate the size of the main balloon, compare the size of the launch balloon shown above with a volume of 200,000 cubic feet to the main balloon with a volume of 26 million cubic feet.

The three candidate chutes were: (1) a 65 foot diameter chute called a disk-gap-band (DGB) that was a large circle of material in the center, with a gap around the center circle, followed by a circumferential band outside of the gap; (2) a 55 foot diameter canopy called a ring sail that was a huge flat circle of material if laid out on the floor; and (3) a 55 foot diameter canopy in the shape of a cross.

Our flights took place in mid to late August and the winds were already becoming erratic. Air Force Cambridge Research Lab controlled the balloon launch and flight on the trip to the test range, a distance of about one hundred and sixty miles as the crow flies. About 3:00 a.m. on launch day Jack Kimpton and his test crew did final checkout and moved the vehicle out onto the tarmac, hanging on a mobile crane vehicle. After the smaller launch balloon was filled with helium and ascended to about one hundred feet, the truck crane would need to drive directly under the balloon if any ground wind was blowing to safely release the vehicle. It was a scary scene when there was a slight breeze.

Wind speed and direction measuring balloons were launched earlier to verify proper wind direction to bring the balloon to the drop zone and then a decision was made by the AFCRL meteorologist whether or not to fly.

When looking at the New Mexico map, the target area at White Sands Missile Test Range looks the size of a postage stamp on a football field relative to the trip from Roswell. Following two successful flights, on the third flight the meteorologist assessed the potential of hitting the drop zone, and cancelled the flight three days in a row. We took everything back to the hanger for another try the following day. Finally, on the 25th of August, he agreed to launch. We took the vehicle out to launch position and made final preparations for launch when a hold was called since one of the redundant flight batteries failed to activate. The batteries had been assembled by the customer and provided as GFP. Duane Newell, our electrical power engineer determined that the polarity was reversed on the activate circuit on one of the batteries. There was no way to activate the battery without a major teardown of the vehicle, which would require aborting for the day, rewiring the activate circuit, and to try again the following day.

With the weather deteriorating as it had been, and the criticality to hold the schedule, the idea of flying with all systems operating on a single battery was discussed. The customer felt it was necessary to try anything that would hold the schedule, including flying with only one functioning power system. Since it was always standard procedure to include redundant systems for all critical spacecraft functions and eliminate all possible single point failures, this was almost totally unacceptable. Larry said to me, "you decide" whether or not to fly. Our power engineer said both redundant power systems and sequence programmers had checked out fine during preflight tests, but we knew the GFP event programmer was not one we would ever have considered for use.

To fly with a single battery meant that all electrical functions such as the programmer, ordnance to fire the rockets and mortar, all cameras and instrument operations would be single string systems, with no redundancy. In the event of a failure in the single string system the test flight could yield essentially nothing, and the aeroshell, with the payload intact, would have a much higher ballistic coefficient and would suffer significant damage when it landed. In classic aerospace design, we are sometimes faced with single string systems that cannot be avoided. In these cases, the design always included significant design margins, significantly increased system testing, and use of very high reliability hardware. Finally, after some serious gut wrenching, I said "let's fly it." Almost immediately after the balloon was released and lifted the spacecraft, I said to myself, "What have I done?" and began to feel sick. We have never designed a critical space system or ordinance operated equipment with single string circuitry. No one does.

Strangely enough, as the balloon rose after launch it went straight south, and was later tracked to be in the area of Artesia, New Mexico, about forty miles south of a direct line to White Sands. Normally, after the launch we would drive to White Sands to watch the powered flight and parachute deployment and participate in the data collection and vehicle recovery. At this time the balloon appeared headed to Mexico, and everyone wondered if the mission was lost, but we drove over anyway. Upon arrival we looked up into the sky, and there was the balloon right above us in perfect position. The AFCRL folks really knew exactly what they were doing in riding the air currents to control the balloon's path. Upon a ground signal the vehicle was dropped from the balloon, four seconds later the rockets fired and three seconds after that the parachute deployed. It was another successful flight. It was the first deep breath I had taken for the last several hours.

When the films were shown after our first flight the customer was ecstatic. The glass window gradually darkened as the motors burned, and at motor burnout the door swung open giving a clear, brilliant picture of the parachute inflation. The cameras showed very stable attitude during rocket burn on all three flights, with essentially zero pitch or yaw deviation during rocket burn, and with an insignificant roll attitude change. The balance and thrust vector control plan worked well. The rocket propulsion produced a 20 G acceleration profile while achieving the desired Mach 1.6 at parachute deployment.

Well, we got the job done including many major, out-of-scope changes asked for by the customer that significantly increased the value of the program. We called the spacecraft a string, glue, and tape design, since some of the functions were initiated by lanyards attached to the payload as it exited the aeroshell, the nylon parachute and bridle, and much of the wiring attached to the structure with RTV and/or tape.

The entire program, including engineering, manufacturing, procurement, and the test and launch crew worked extremely hard, including many hours of unpaid overtime. The program was credited with achieving 100% of the test objectives on the three flights. The customer had originally contracted for four flights assuming we would have at least one failure, so after the third good flight they cancelled the fourth. Many times I exceeded my authority making significant decisions and releasing engineering without the normal reviews or checking, since manufacturing was waiting for the information, and we could not afford the time for the normal release process to unfold.

The real significance of the PEPP program for Martin Denver was the demonstrated capability to respond to the many customer requested changes and the great relationship between the program and customer personnel. Procurement (Jack Macy), and manufacturing provided outstanding support by rapidly providing the many last minute hardware items in excellent condition. Some parts and support equipment seemed to appear surprisingly soon after engineering release. The launch crew did the final installation of ordnance and cameras under difficult conditions using rudimentary ground equipment left from the earlier flight. It was the product of an entire team desire to make it happen. The same customer friends who worked with us the entire time constituted a strong vote during the Source Selection Process for the Viking Lander Program and certainly aided in our award of the main Viking contract. The parachute design that appeared best to us was the DGB; however, we did not have the complete data set. The DGB was eventually selected for the Viking missions and has also been used for many later planetary landings to this day.