VII. Balloon Recovery Systems

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Abstract

The increased reliability of the scrim reinforced plastic balloon is offset by its higher costs. To reduce the per flight cost, two systems are being developed to recover balloons after mission completion, so that they can be reused. One system is used where tandem balloons are employed, the other system is designed to be used with the standard single balloon.

Now that we are able to build more reliable balloons, we are searching for ways to reduce the attendant costs without losing the reliability we have worked so hard to achieve.

AFCRL made its first attempt to reduce costs of the GT-12 scrim balloons by initiating a contract with the Schjeldahl Company to take a hard look at all aspects of manufacturing. The results of that contract were very encouraging. The cost of a 3.2×10^6 GT-12 balloon, for example, was reduced from \$54,000 to about \$32,000.

The advent of the Flying Thread Loom, described by Mr. Korn, shows even further savings. The loom cannot duplicate the GT-12 scrim pattern, but it can generate patterns that we expect to be as good.

Since we now can expect less expensive balloon materials, it is apparent that if these balloons could somehow be recovered and reused a further saving could be realized.

About 1961, Vitro Laboratories and Schjeldahl Co. did incorporate a balloon recovery sleeve into the tandem balloon system being developed for the Stratoscope series*. The sleeve was used in March of 1962 on a Stratoscope test flight launched from Hope, Arkansas. However, it appeared that air became trapped in the balloon, keeping it sufficiently inflated to prevent the ensleevement of the balloon. The system was later discarded.

Since tandem balloon systems are becoming more popular, AFCRL initiated the development of the tandem balloon recovery system. Figure 1 shows the different stages of flight. At launch, the recovery sleeve is rolled up and stored around the metal transfer duct between the two balloons. It is held in place in a protective wrap by a metal clamp. Release is made by an explosive bolt either upon reception of the proper radio command signal or by a preset aneroid.

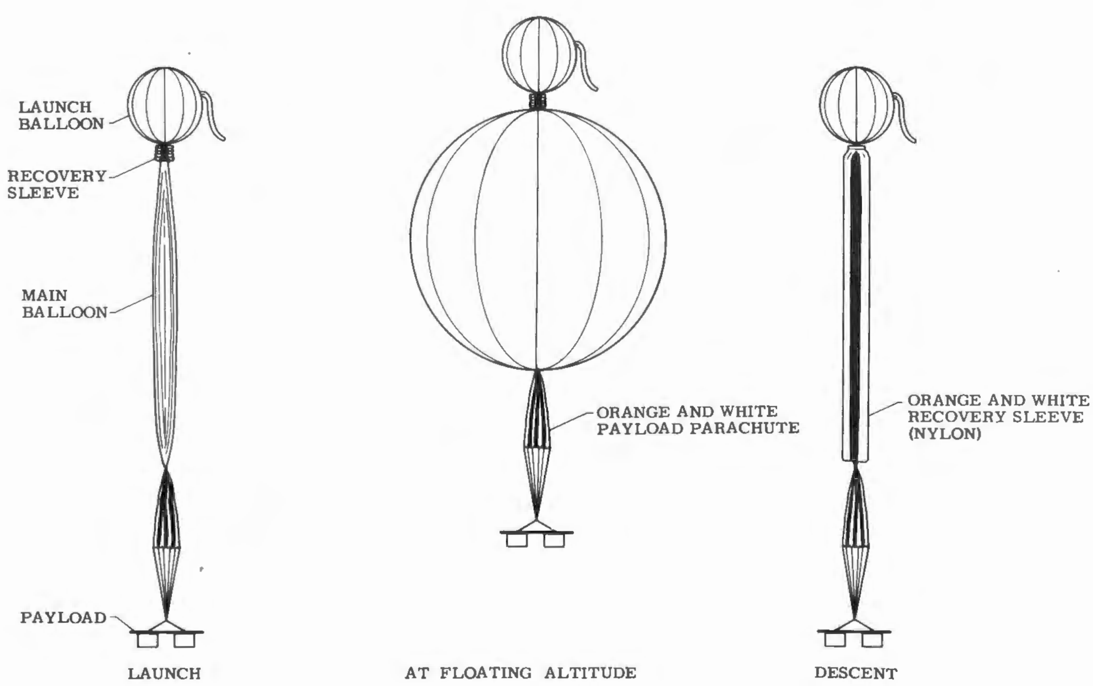

Figure 1. Tandem Recovery System

The sleeve for this development is being made of 2.2 oz/sq yd rip-stop nylon. A link chain sewn into the bottom hem of the sleeve gives it sufficient weight to roll down the full length of the balloon. The length of the sleeve is dependent upon the length of the balloon. The diameter of the sleeve is dependent upon a bulk factor at the maximum diameter of the balloon.

After the scientific mission has been completed, the valve (or valves) in the top of the launch balloon is opened and the balloons begin to descend. A descent rate is established which will bring the balloons down in the best location at a reasonable impact velocity, and then the valve is closed. The remaining gas in the main balloon begins to compress and work its way back into the launch balloon. At approximately 10,000 ft the sleeve is released and proceeds to roll down the deflated balloon. The balloons continue to descend to the ground, and at impact a switch is triggered that opens three deflate ducts in the top of the launch balloon, thus releasing the remainder of the gas. The balloons and payload lie out over the ground to await the recovery crews.

The recovery equipment for the 1.6×10^6 cu ft balloon weighs about 80 lb; this includes the nylon sleeve, live cutters, etc.

The single balloon recovery system works quite differently from the tandem system in that the sleeve goes up the balloon. This is shown in Figure 2. This system makes use of a secondary parachute that is attached to the top of the recovery sleeve.

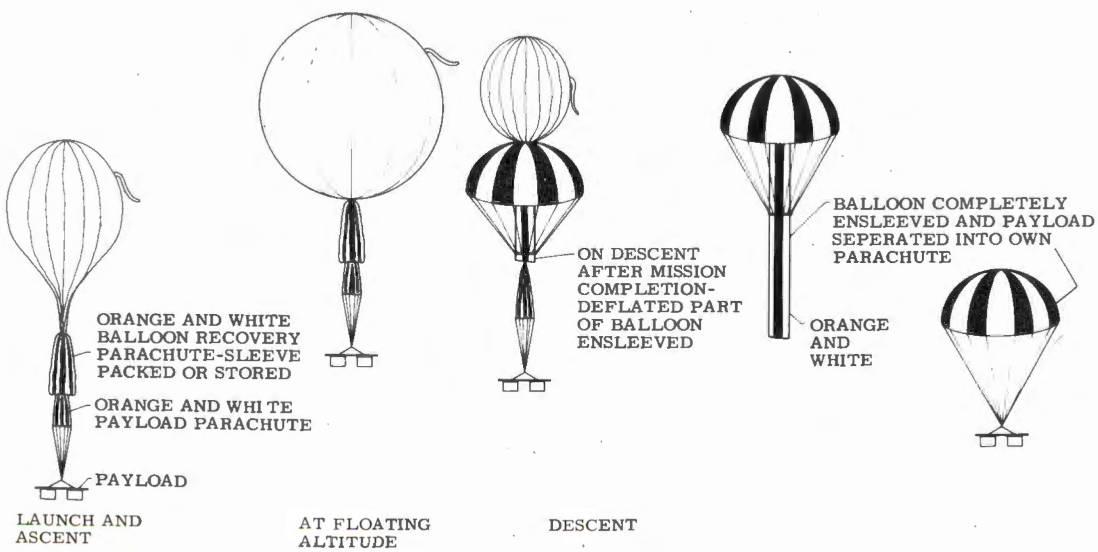

Figure 2. Single Balloon Recovery System

During launching of the balloon, the recovery rig is positioned below the base of the balloon and around the top of the payload-recovery chute. The top of the payload parachute is attached to the base of the balloon through the termination device in the normal manner. Also attached to the base of the balloon is a tubular aluminum structure, about 12 ft long, that is intended to support another tubular aluminum framework in the shape of an inverted truncated cone or funnel. This framework becomes part of the recovery parachute. The apex of the parachute is laced around the large opening of the framework to give the shroud lines of the recovery parachute something to pull against. The recovery parachute has to be large enough to support the weight of the balloon and to provide a reasonable impact velocity.

This system was used with the GT-99 balloon that weighs 580 lb; therefore, a 46.5-ft-diam chute was chosen. Auxiliary shroud lines, 8 ft long, were sewn into the canopy at a predetermined distance down from the apex of the canopy. The other ends of the shroud lines were tied to the bottom of the tubular framework, effectively forming a small parachute around a metal cylinder. The original shroud lines, 34 ft long, were cut off at 22 ft and tied to a metal ring laced into the sleeve about 24 ft from the apex of the parachute.

After completion of the scientific mission, the valve in the top of the balloon is locked open. Keeping a tight gas bubble is the key to the successful recovery of a Mylar-scrim balloon. Our first flight with the GT-99 balloon was not a complete success for this reason. We suspect that the three quick-deflate ducts that were installed near the top of the balloon actually prevented the sleeve from going to the top until the ducts themselves were fully deflated.

Although the floating altitude was 97,000 ft, it so happened that the recovery phase was actually started at 55,000 ft. First, the electric valve was locked open, then the three deflate ducts were released. The balloon began to descend immediately; within 8 min the balloon had descended to 43,000 ft and the payload was automatically separated.

This automatic separation is a built-in safety feature that prevents the balloon-recovery parachute from supporting both the load of the balloon and the payload as the gas-bubble volume decreases to where it is too small to support the payload. A lanyard is fixed at one end at two-thirds the sleeve length, and to a pin in a microswitch at the other end. When the sleeve rises up to two-thirds of its length, the lanyard pulls the pin and the payload becomes separated on its own parachute.

The balloon in the May test actually impacted before the payload. We also learned from this flight that the balloon settled into the bottom 60 ft of the sleeve, making a nice tight compact package. Taking advantage of this for the second flight, we made the bottom 70 ft out of urethane-coated nylon, and the remaining or upper section of the sleeve out of light-weight nylon. The two sections are separable so that the recovery crew can handle one section at a time. The rugged lower section provides better protection for the balloon upon impact and for handling and transporting it back to the launch site.

The GT-99 balloon was repaired by Schjeldahl Co. and reflown on 27 August. Using 20 percent free lift, it took just 63 min to go from 4000 ft to 95,000 ft. The balloon floated at 93,000 ft and remained there until we were ready to try our improved recovery rig.

We chose to do away with the quick-deflate ducts and use just an electric valve for deflating the balloon.

We allowed the balloon to float across the western mountains of the White Sands Range, then started the balloon descent by locking the valve open. In just a very few minutes the balloon started down. The position of the lanyard was placed lower on the sleeve for this flight so that a smaller volume of gas would be in the balloon when the payload was released. This, then, prevented the balloon from floating or ascending.

The average rate of descent from 80,000 to 18,000 ft turned out to be about 1820 ft/min. Not knowing the position of the sleeve at any time, it was decided not to close the valve since the sleeve could cut the payload away and a bubble of gas would remain with no way to reopen the valve. The tracking aircraft flying at about 10,000 ft observed the full ensleevement of the balloon. About the same time, back at the control center we received a signal from the balloon when it was at 18,000 ft that the lanyard had been pulled. Unfortunately, the payload-separation device operated improperly and the payload never separated. The sleeve was damaged when the balloon became fully ensleeved and was forced to carry the weight of the payload as well as the balloon.

The balloon was picked up by the recovery crew in fair condition, and is on its way back to Schjeldahl Co. for a thorough inspection.

We at AFCRL feel that both of these systems, although not yet fully developed, are workable. Our objective is to complete the development and then build kits that can be stored at our launch sites for use on selected scrim-balloon flights. It is expected that the recovery kits will cost about $500 for the tandem system and nearly $1000 for the single-balloon system. We think it will be some time before there will be enough confidence gained so that a scientist will want to use a recovered balloon without having a thorough inspection made. Allowing for shipping, inspection, and refolding we estimate a savings of something less than 25 percent for a second flight of a tandem system. This appears low, but it must be remembered that no attempt is made to recover the launch balloon, so the cost of its replacement is included.

The single-balloon system appears to offer a somewhat better picture. Allowing $1000 for the recovery equipment and 15 percent of the original balloon cost for shipping, inspection, minor repairs, and refolding, the cost of the second flight would be about 15 percent of the first if the recovery equipment is reusable.

Of course, if we could expect three and four flights from a balloon using either system, the savings become very attractive.

As a by-product, the use of either system provides an excellent method of getting the balloon out of the air in a nice neat package rather than scattering it all over some farmer's field!