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Parachute Techniques Employed in the Air-Launched Balloon System (ALBS) Development Program

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Andrew S. Carten Jr.*
Air Force Geophysics Laboratory, Hanscom AFB, Mass.
and
Michael R. Wuest†
6510th Test Wing, Edwards AFB, Calif.

Abstract

THE dual parachute array conceived at AFGL to deploy a large plastic balloon from a C-130 aircraft in flight and to extend it vertically for mid-air inflation is outlined. The test vehicle constructed by the 6511th Test Squadron at the National Parachute Test Range to verify the initial concept is described with emphasis on the special techniques employed to insure rapid opening of the top-loaded main parachute. The results of a 14-test flight program are presented. They show that the ALBS module can be safely extracted from the aircraft and that the 102-ft long balloon can be deployed in the proper manner. A follow-on test at the White Sands Missile Range is described briefly.

Contents

The Air-Launched Balloon System (ALBS) Development Program is an in-house project of the Air Force Geophysics Lab. In 1975, a key achievement was the rapid inflation of a large balloon (on the ground) using a cryogenic source.[1,2] The next step was to repeat the process in mid-air. In support of this goal an experimental lightweight dewar was constructed, and a basic midair deployment scheme was conceived. In 1976 the Air Force Flight Test Center (AFFTC) agreed to design and test a system which would simulate the proposed deployment—prior to risking the costly balloon and dewar in an actual flight test.

Because the experimental dewar was not stressed for the powerful extraction forces experienced in launching from an aircraft, it was planned that the first actual flight test of this dewar would be carried out with another balloon as the drop vehicle. Thus, the deployment techniques to be verified by AFFTC would have to apply both to the initial balloon release test and to later launches from the aircraft, using a stronger, "hardened" dewar.

The test concept was based on the operational concept shown in Fig. 1, in which the ALBS module is pulled out of a C-130 flying at 25,000 ft (7.62 km). In the operational concept, the uninflated ALBS balloon, main parachute, liquid helium dewar, and payload are stored in a module secured to the aircraft floor. The upper "drogue" parachute and its 200-ft (61-m) extension line are stored in a separate pack which, on command, is ejected into the airstream by a pendulum release mechanism. This initiates the extraction event.

The drogue parachute stabilizes the descending module after it is pulled from the aircraft. Then, the major portion of the module falls away, dragging down the suspension lines of the main parachute and causing that parachute to open, with the balloon pack riding at its apex. Next, the drag of the drogue parachute is applied to the balloon, drawing it up to full length. Inflation now commences with the gas passing through plastic tubing from the cryogenic unit at the base of the main parachute to the base of the balloon. The balloon and its 200-lb payload then rise to floating altitude, and the inflation equipment is recovered on separate parachutes.

Pretest computations[1,3] indicated that a lightweight 32-ft (9.75-m) diam ring slot drogue parachute and a 42-ft (12.8-m) diam ring sail main parachute would provide the most favorable drag characteristics. Also, the maximum value of dynamic pressure q to be expected with this array was less than 1.0, the limit chosen on the basis of balloon film strength. However, the fact that the lightweight 32-ft ring slot parachute was also to serve as the load extraction parachute soon led to a change. Early tests showed that the 32-ft parachute could not withstand the 10,000 lb (44,480 N) extraction force. It was replaced by a more rugged 28-ft (8.5-m) diam ring slot standard cargo parachute with less than ideal, but still acceptable drag and q values.

The initial AFFTC test configuration was relatively simple because parachute system performance could be verified through the use of a dummy balloon made of nylon riser material which matched the real balloon in length and weight distribution. Also, there was no requirement to separate the dummy balloon from the parachute system during these tests,

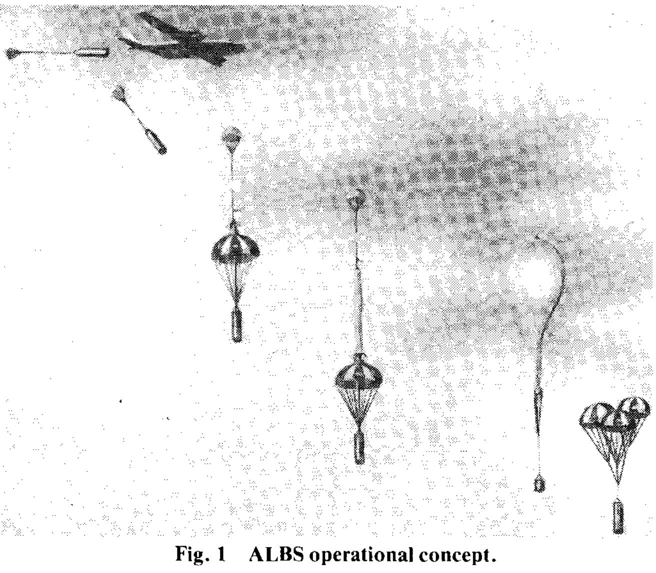

Fig. 1 ALBS operational concept.

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Index categories: Deceleration Systems; Lighter-Than-Airships; Testing, Flight and Ground.

*Balloon Systems Engineer, ALBS Project Manager, Aerospace Instrumentation Div. Member AIAA.

†Parachute Systems Test Engineer, ALBS Parachute Test Manager. Member AIAA.

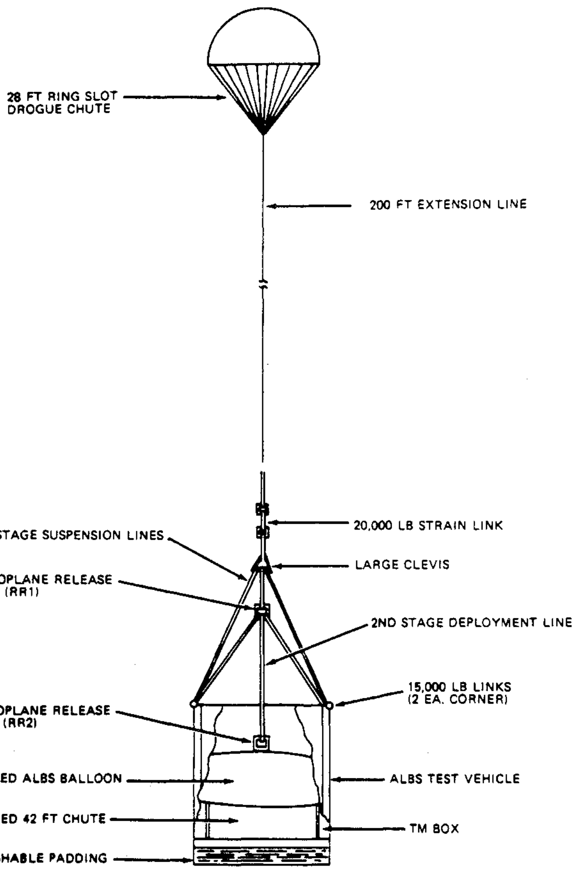

Fig. 2 Parachute system test vehicle—first-stage configuration.

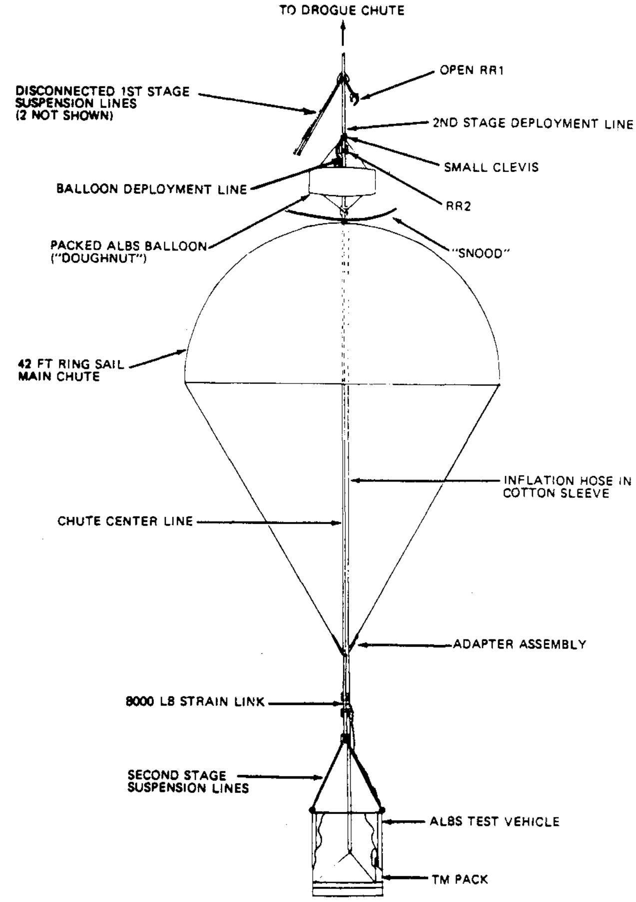

Fig. 3 Parachute system test vehicle—second state configuration.

even though this is a major requirement when the ALBS balloon is actually inflated. Later on, well into the test program, the test configuration became more complex when deployment of a real balloon was accomplished.

The test vehicle used was a cubical wooden box open at the top. Four feet (1.22-m) to a side and framed in heavy angle iron, it weighed approximately 665 lb (2958 N) empty. A heavy lead plate weighing 365 lb (1624 N) was bolted inside. (The lead ballast and the massive structural members of the box simulated the weight of the cryogenic unit and payload.) The details of loading the test vehicle and attaching it to the drogue extension line can be ascertained from Fig. 2, which shows the 1530-lb (6805-N) system descending in a vertical attitude shortly after leaving the aircraft.

Figure 3 shows the test system at the end of the second stage, with the main parachute fully open and the packed balloon positioned at its apex. This stage, initiated approximately 10 s after the module leaves the aircraft, requires about 6 s. Several major problems had to be solved to achieve successful completion of this stage. For example, there was a need for rapid pressure buildup in the main canopy to assure positive support for and proper positioning of the 200-lb balloon pack at the apex. A pull-down centerline assured this. Also, excess canopy material had to be contained temporarily during deployment of the centerline and the suspension lines. A reefed containment bag called the "snood" was used successfully here. A third problem, protecting the packed balloon and its container from the severe *g* loads developed during the deceleration of the free-falling box, was solved by selective reinforcement.

The critical third stage, in which the balloon is drawn up out of its bag, occurs 20 s after the module leaves the aircraft and requires about 7 s for completion.

The 1977 test program demonstrated that the dual parachute array performs as intended.[3,4] After the successful deployment of dummy balloons, the system was altered to accommodate a real balloon and it was deployed twice without damage to 0.0015-in. (0.0038-cm) balloon film. A partial inflation was even attempted, using compressed gas, but gas regulation problems inferred.

The planned live test of the experimental cryogenic unit, using a second baloon as the drop vehicle, was attempted in January 1978 at the White Sands Missile Range, N. Mex. Unfortunately, a mishap occurred during launch of the carrier balloon which essentially destroyed the cryogenic unit and prevented the test from being carried out.

The development program has since been reoriented around a new hardened dewar currently under construction. A follow-on AFFTC test program is underway to eliminate undesirable extraction line recoil noted in 1977 and to test the cryogenic unit recovery stage. A live test of the new system is planned for early 1980. The launch vehicle will be a C-130 aircraft flying over the White Sands Missile Range. The AFGL Balloon Detachment at Holloman AFB, N. Mex. will control the flight of the air-launched balloon.

Acknowledgment

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