

AIR FORCE CAMBRIDGE RESEARCH LABORATORIES BALLOON OPERATIONS

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ABSTRACT

AFCRL scientific ballooning is unique in the Air Force and provides the only Department of Defense in-house capability. A general information base is provided to familiarize the reader with the Air Force organization, research efforts, facilities and balloon flight operations.

INTRODUCTION

The USAF Balloon Program is managed by the Aerospace Instrumentation Laboratory, one of nine Air Force Cambridge Research Laboratories, located at L. G. Hanscom Field, Bedford, Massachusetts. The Aerospace Instrumentation Laboratory is composed of a balloon group and a sounding rocket group. The primary mission of the balloon group is to support the research, development, test and evaluation and operational needs of our sister laboratories in AFCRL and of other elements of the Air Force. Our other objective is to extend the capabilities and versatility of balloons as atmospheric platforms. To carry out this mix of research and operational work, the balloon group of ninety-two people consists of physicists, meteorologists, engineers, and operationally trained personnel.

I will touch only briefly on our research efforts since the topic of this paper is concerned with our balloon operations. The research can be characterized by the following work efforts:

(1) Free Balloons - materials studies directed primarily towards increasing the load-carrying and altitude capabilities of polyethylene balloons.

(2) Tethered Balloons - development of improved tethered balloon cables, improved balloon designs and materials, and studies of balloon dynamics.

(3) Powered Balloons - advanced systems design, power source studies and flight test of prototype models.

(4) Air Launched Balloons - studies of systems launched from aircraft and rockets.

(5) Climatological studies - flight dispersion and operational analyses for proposed programs.

(6) Instrumentation and Tracking - development of navigational systems and command and control instrumentation.

Balloon flight operations conducted at our permanent launch sites located at Holloman AFB, New Mexico and Chico, California utilize and evaluate the research and development products of the balloon group. Thus, there is a closed loop between theory, development, and application, providing the setting wherein theory can be quickly tested and future research needs readily identified.

BALLOON FLIGHT OPERATIONS

As mentioned in the introduction, our mission is first to support Air Force needs. We also provide balloon flight support to other Dept. of Defense agencies and government organizations. Within the latter category, for example, the AFCRL has acquired the responsibility of providing support to the Atomic Energy Commission's Ash Can project, for which about 30 flights per year are conducted. Flights are made from New Mexico, California, Alaska and Panama. The Panama and Alaskan series are conducted once a year. With the impending retirement of the WB-57 aircraft, the Ash Can project will be expanded to include additional air sampling flights within the 40,000 to 60,000 ft (1.2×10^4 to 1.8×10^4 m) altitude range.

Measurements are made of Carbon 14 and radioactive particulate concentrations. After the samplers have performed their functions the payloads are separated from the balloons and aeri ally recovered by C-130 aircraft. We are working to extend the present capability of snatching payloads of 450 lbs (2.0×10^3 N) to loads on the order of 700-1200 lbs (3.1×10^3 to 5.4×10^3 N). In order to do this, a new recovery parachute system is under development. We expect that prototype systems will be tested this summer. The advantages of air snatching the balloon payloads are obvious because terminations may occur over water, jungles or the arctic tundra. Since we have been involved in the Ash Can program, the aircrews have not failed to bring a payload home.

NASA has frequently utilized AFCRL balloon flight support. The Planetary Entry Parachute Program, PEPP, and the Balloon Launched Decelerator Test Program, BLDT, for the Viking Program, were major balloon programs conducted for NASA during the past few years. This past year we concluded a balloon-borne laser flight series for NASA-Goddard which provided data on the atmospheric effects on laser beams transmitted from a balloon at 90,000 ft (2.7×10^4 m) to a receiver on the ground.

In summary, in regard to whom balloon flight support is given, first priority is to the Air Force, followed by organizations which have programs from which the Air Force may derive benefit. For example, the NASA PEPP and BLDT programs resulted in the development of new, heavy-payload balloon capabilities which can be directly utilized in Air Force systems testing.

The Air Force has on occasion been accused of being the prime polluter of the lower stratosphere and of doing little to determine the effects on air quality of its aircraft operating at these altitudes. In the balloon sampling program the Air Force is presently doing something about this problem. In the next few years the balloon group and other AFCRL scientists will be engaged in stratospheric pollution research, building on the results of the recent CIAP, Climatic Impact Assessment Program. In particular, we will be conducting balloon flights for AFCRL's Aeronomy Laboratory to obtain data on chemical reactions resulting from jet aircraft emissions in the lower stratosphere.

FACILITIES

Permanent AFCRL balloon launch facilities are located at Holloman AFB, New Mexico and at Chico, California. Both locations also have a remote operations capability for performing flights wherever a need may exist. The balloon launch facility at Holloman AFB has access to the use of precision radar, optical instrumentation, telemetry, and restricted airspace on the White Sands Missile Range. Nuclear blast simulations, high altitude prototype parachute tests, hardware evaluation, high altitude tethered balloon operations--any test involving free-fall can be conducted by the Holloman facility. Each launch site has a completely equipped and staffed weather station, machine shop, instrumentation laboratory, parachute shop, and a small environmental test chamber. The Holloman facility has the use of an environmental test facility with a working volume of 8x8x11 ft (2.4x2.4x3.4m), an altitude range from sea level to 225,000 ft (6.86x10⁴m), and a temperature range of minus 100°F to plus 200°F (minus 73.3°C to 93.3°C).

TETHERED BALLOON FACILITY

AFCRL first became involved in tethered balloon operations when it provided support to NASA's testing of the Surveyor lunar lander. Subsequently, the immediate and potential capabilities of tethered balloons became better appreciated and it became obvious that a permanent facility was essential for these operations. Consequently, Fair Site was established on White Sands Missile Range solely for the purpose of supporting tethered balloon operations. The criteria for the selection of this site were that it should:

- (1) be capable of routinely handling payloads of 500 pounds (2.2x10³N) or more to altitudes in excess of 10,000 feet (3.1x10³m) above ground.
- (2) be unencumbered by other programs.
- (3) be in a restricted air space area to permit flight durations of hours to weeks, and
- (4) be suitable for future expansion, to accommodate development testing and operations of tethered systems of much greater payload altitude capabilities.

Fair Site is located in the northwest corner of restricted area, R-567-B, on the White Sands Missile Range. It is approximately 70 land miles (1.1x10⁵m) from Holloman AFB. Here, there is no restriction upon the flight altitude of tethered balloons. Meteorological conditions have been investigated fully, and the climatology indicates a good year-round flight capability.

The site has the advantage of a fully instrumented range to provide data essential for interpreting the results of many scientific experiments flown on tethered balloon systems. Position data for our tethered balloon flights can be obtained using either FPS-16 radars or cinetheodolites or both. If radar is used, a position display can be set up at the Balloon Control Center at Holloman AFB or at some Range Control Station. Velocities, accelerations and balloon altitude data can be

obtained from both cinetheodolites and on-board instrumentation. Data reduction is provided through WSMR. In addition to the cinetheodolites and radars, facilities for receiving a wide variety of telemetered data are available.

The heart of the tethered balloon facility is the permanently fixed winch which has the following capabilities:

- (1) Line pull capabilities of 30,000 pounds ($1.3 \times 10^5 \text{N.}$) maximum at a maximum speed of 200 feet (61 m.) per minute;
- (2) Line pull capabilities of 6,000 pounds ($2.7 \times 10^4 \text{N.}$) at line speeds of 1,000 feet ($3 \times 10^2 \text{m.}$) per minute;
- (3) Variable speed control in each of the above modes;
- (4) Fail-safe brake system;
- (5) Interchangeable sheave and capstan shoes;
- (6) Drum capacity to 30,000 feet ($9.1 \times 10^3 \text{m.}$) of $\frac{1}{2}$ -inch ($1.3 \times 10^{-2} \text{m.}$) diameter line;
- (7) The capability of accommodating line sizes from 3/8-inch through 3/4-inch diameter ($9.5 \times 10^{-3} \text{m}$ through $1.9 \times 10^{-2} \text{m.}$).
- (8) Level wind system capable of storing 3/8-inch through 3/4-inch diameter ($9.5 \times 10^{-3} \text{m.}$ through $1.9 \times 10^{-2} \text{m.}$) line sizes uniformly on the winch drum, and adjustable for these line sizes with 1/16-inch ($1.6 \times 10^{-3} \text{m.}$) variation in diameter.
- (9) Instrumentation consists of a line-load measuring device, line-footage counting device, line-speed and direction measuring device.
- (10) Other instruments include those items necessary to monitor the operation of the power source and the hydraulic drive system.

FILMS OF AFCRL BALLOON OPERATIONS

In closing, I will show a short film which gives a general view of some of the equipment we use in our balloon operations and the retrieval of an Ash Can payload by C-130 aircraft over Panama.

DISCUSSION SUMMARY — PAPER 3.2

In answer to questions about expected cost and performance of a tethered balloon operating at 60,000 ft, the development cost was estimated at \$750,000. The French already have flown a 250-pound tethered balloon this high. The possibility of flying a 500-pound device at 90,000 ft was considered good if money were available.

SPECIAL PANEL DISCUSSION ON LONG DURATION BALLOONING

DISCUSSION SUMMARY — PAPER 3.3

Panelists: Dr. Ricker and Dr. Lewin of M.I.T., Mr. Pavey, Mr. Snider and Mr. Shipley of NCAR.

During the panel discussion on long duration balloon flights several points were covered. These points included the importance, effectiveness and some details of such systems, a proposed NCAR program to develop required capabilities and finally the current funding situation.

Two types of long duration balloon systems were considered. One approach uses a zero pressure balloon launched in Europe and recovered after 5-8 days in the United States. The second system would involve launching a superpressure balloon from Australia that would circumnavigate the globe during flights lasting several months.

It was stressed that development of these systems is the important next step in scientific ballooning. The basic advantage of course, is the increased observing time afforded by these long flights. Satellites and balloon-borne instruments were compared to illustrate this time advantage. The sensitivity in many investigations improves as the square root of the observing time available. Therefore, long duration balloon flights are perhaps 10-20 times more sensitive than one day flights, but satellites are perhaps only twice as sensitive as long duration balloon flights. It was estimated that satellites cost one hundred times more per pound than balloon-borne instruments. Therefore, balloon-borne investigations are more cost effective.

During discussion it was pointed out that although the trans-atlantic flights are not as long as the flights around the southern globe there are compensating factors. The most important is the much larger payload capability of the zero pressure trans-atlantic flight. This payload makes possible larger instrument apertures. Since sensitivity depends on aperture, this compensates for the shorter flight duration.

Other advantages of long duration balloon flights were noted. Opportunities to fly instruments on balloons are far more numerous than opportunities for satellite flights. The lead time for balloon-borne investigations is short. Therefore, research concepts can be pursued at a satisfactorily rapid pace. In addition, instrumentation changes required to meet new requirements are possible through most of a balloon flight program.

There was some discussion concerned with dangers to air traffic. Since these balloons float well above commercial air corridors, the only times of concern are during launch and recovery. Safety measures to cover these periods have been well developed during conventional balloon programs. Furthermore most of the long duration flights are planned for far south latitudes where air traffic is very light.

NCAR summarized a proposal to the National Science Foundation covering the development of a long duration balloon flight program. The instrument considered would weigh 400-500 pounds and float at 130,000 feet. During discussion various estimates were made of the fraction of this weight available for the scientific instrumentation. These estimates varied from 80-300 pounds. It was felt that this size payload represented a useful and practical first step. The program would cover a two year period and would include both balloon development and test flights. As part of the balloon development, NCAR will analyze the various aspects of the dynamics of mylar balloons. Other balloon materials and balloons will be developed by U.S. companies under contract. There are five (5) test flights included in the program. Three (3) will be in the United States and two (2) in Australia.

Estimates of the costs involved in future research flights were presented. These estimates were based on a projected program including fifteen (15) flights per year. Superpressure balloons suitable for long duration flights will cost about \$50,000 each. Operations costs including launch, tracking, recovery, and operation of four (4) ground stations were estimated at \$75,000 for the fifteen (15) flights. Cost of the flight control electronics was not included since it is expected to be recovered.

Some of the general aspects of the present funding situation were discussed. NASA provides some support for research and development, but not enough to fund the two (2) year development program. Most of the NASA funding is for operations costs involved in current research flights.

For this development project to proceed it must have National Science Foundation funding. There has been an endorsement of the project by the National Academy of Sciences. The problem is that the required funding is in competition with other research programs and with current balloon operations funding.