N76-15067

A REVOLUTIONARY AND OPERATIONAL TETHERED AEROSTAT SYSTEM ILLUSTRATING NEW LTA TECHNOLOGY

James A. Menke*

ABSTRACT: A tethered aerostat system, which demonstrates utility of LTA systems, has been in operation for about one year. It was made possible by development of a reliable tethered aerostat that is used to support broadcast equipment at an altitude of 10,000 feet. Two elements of the TCOM system, the aerostat and mooring station, both designed and manufactured by Sheldahl, are particularly relevant to the LTA Workshop. They demonstrate the feasibility of using LTA vehicles in real, operational, all-weather applications and, in addition, illustrate an advance in the overall technology base of LTA. This paper presents a description of the aerostat and the mooring station including their technical design features and demonstrated performance characteristics.

INTRODUCTION

A revolutionary new telecommunications concept has been developed that utilizes a Lighter Than Air vehicle to elevate broadcasting equipment as shown in Figure 1. It is very likely the only operational LTA system in service anywhere in the world today.

Developmental work by Sheldahl over the past five years has produced certain technological breakthroughs which enable tethered buoyant vehicles or aerostats to be employed in practical around the clock operations. Heretofore, such vehicles have been limited to short duration scientific experimental use.

* Manager, Tethered Aerostat Systems, Sheldahl, Inc., Northfield, Minnesota, U.S.A.

The world need for a tethered aerostat which will float continuously over a fixed earth location with payload carrying capacity is quite extensive. For example, developing countries around the world cannot afford elaborate conventional communication networks such as are employed in the United States that use a combination of microwave broadcasting towers, telephone wiring networks and satellites.

The advent of a practical aerostat (balloon) system enables such a country to very economically acquire effectively a two-mile high broadcasting tower, or mini-satellite which can carry electronic broadcasting and relay equipment. Such electronic equipment suspended from a single aerostat flying nearly two miles (10,000 feet) overhead,

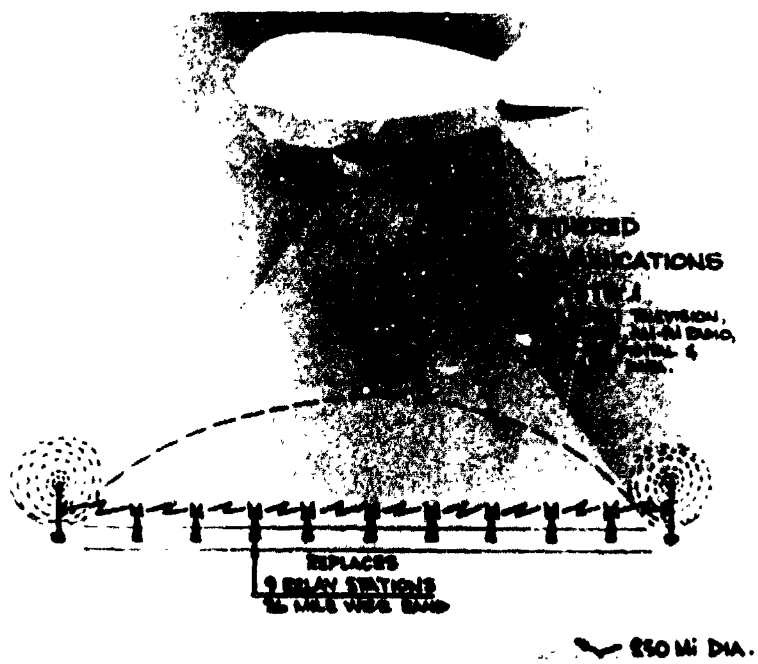

Figure 1
Tethered Communications System

can provide direct line of sight communications to an area covering 45,000 square miles. Multiple aerostat installations can extend this coverage indefinitely. Thus, a single aerostat installation can take the place of about 15 conventional microwave towers and yet offer much broader communications capability at 20 to 50 percent the cost of conventional equipment.

The TCOM Corporation, a subsidiary of the Westinghouse Electric Company, has been established to integrate and market this revolutionary telecommunications system, called the TCOM (for Tethered COMmunications) system, on a worldwide basis. At the present time, a complete demonstration system is in operation at TCOM's Grand Bahama Island facility and operational systems are being installed in the Republic of South Korea and Iran.

This paper will deal with the two major elements of the TCOM system that are particularly relevant to the LTA Workshop, that is, the aerostat and its mooring system. They demonstrate the feasibility of using LTA technology in real, operational, all-weather applications and, in addition, illustrate an advance in the overall technology base of LTA, particularly in the areas of structural design, flexible materials, and manufacturing operations.

DESCRIPTION

The aerostat and mooring station as shown in Figure 2 constitute a single system. During all phases of operation, including launch and retrieval, the aerostat and mooring station are joined and function as an inseparable system. The aerostat is flown directly from the mooring station. Both the aerostat and mooring station automatically rotate so that they are aligned with respect to the wind.

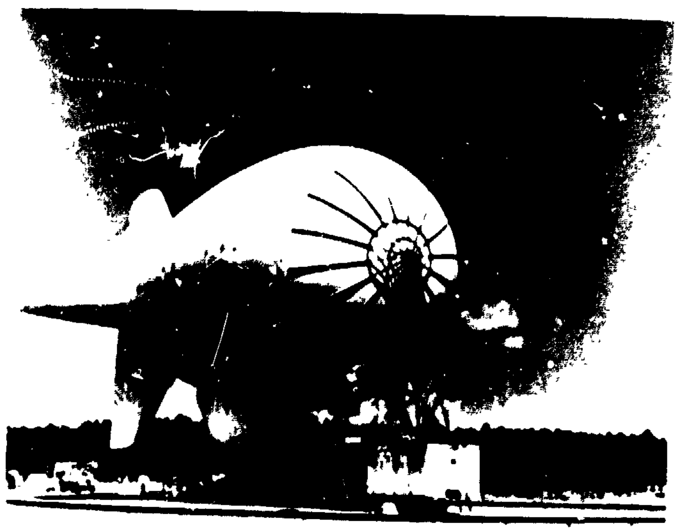

Figure 2
Moored Aerostat

Two features of the system that make the TCOM telecommunications concept economically feasible are the small crew size needed and its all-weather operating capability. Since this concept requires that the aerostat remain aloft for weeks or months at a time, a large full-time ground crew is cost prohibitive. The system, both mooring station and aerostat, also had to be designed to withstand worldwide environments, primarily winds and temperature, without hangar facilities.

Aerostat

The aerostat described herein and illustrated in Figure 3 is the Sheldahl Model CBV-250A. Specifications are presented in Figure 4. It is capable of supporting sizeable payloads at altitudes up to 15,000 feet above mean sea level. Nominal operating altitude is 10,000 feet.

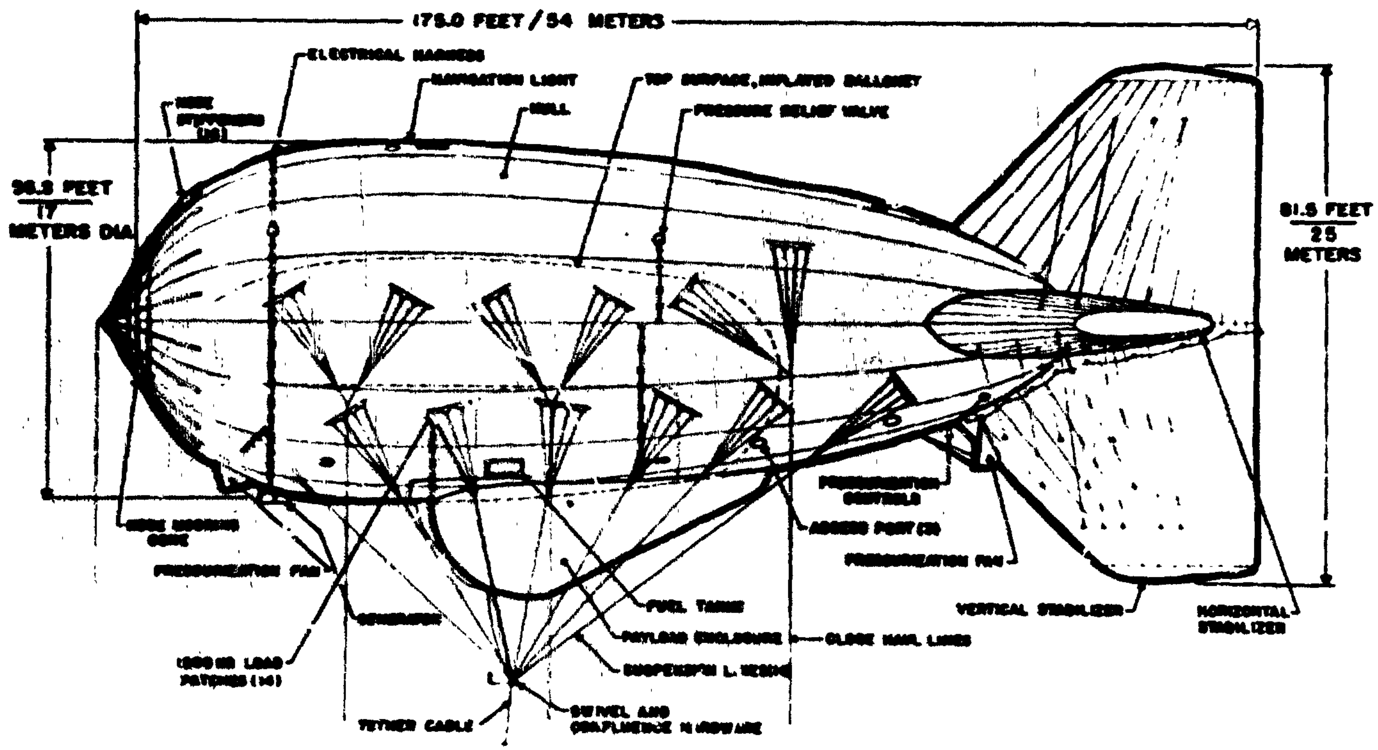

Figure 3
Sheldahl CBV-250A Aerostat

	MODEL NUMBER	
	CBV-250A	CBV-350A
WEIGHT	5,100 lbs	5,500 lbs
DIMENSIONS		
Hull Volume	267,000 cu ft	380,000 cu ft
Overall Length	175 ft	215 ft
Hull Length	148 ft	188 ft
Hull Diameter	56.8 ft	56.8 ft
Fin Span	81.5 ft	81.5 ft
Payload Enclosure Width	25 ft	25 ft
Payload Enclosure Height	15 ft	15 ft
OPERATIONAL PERFORMANCE		
Wind Speed @ MSL	90 knots	90 knots
Wind Speed @ 10,000 ft	100 knots	100 knots
Ceiling Altitude above MSL	15,000 ft	15,000 ft
LOAD CAPACITY (PAYLOAD, POWER PLANT, FUEL)		
@ 5,000 ft	7,000 lbs	12,000 lbs
@ 10,000 ft	4,000 lbs	8,000 lbs
@ 15,000 ft	1,000 lbs	4,000 lbs

Figure 4
Aerostat Specifications

The aerostat is controlled or "flown" from the ground control station. It is unmanned and can maintain its position in the immediate vicinity of the launch site for continuous flight durations approximating one week. Retrieval to ground level for refueling, helium replenishment and other maintenance can usually be accomplished within a few hours and the mission resumed. The aerostat is a highly reliable, rugged vehicle constructed to withstand very severe weather conditions. It is designed and constructed to operate safely in 85 knot winds and carry a 4,000 pound load at an altitude of 10,000 feet.

Hull pressure is maintained by a conventional ballonet design. Fans and valves are automatically cycled to force air into or out of the ballonet thereby controlling pressure to within prescribed limits.

The hull nose structure is made from a high strength aluminum alloy and is provided for docking the vehicle to the mooring station.

The main payload attachment point on the aerostat hull within the payload enclosure is capable of supporting a package weighing up to 1,500 pounds. The volume available for the payload inside the enclosure is that of a 25 foot diameter hemisphere. In addition to the main payload support structure, he underside of the aerostat has provisions for attaching other hardware such as the airborne power generator, fuel and fuel tanks. This load attachment provision extends 113 feet fore and aft on the underside of the aerostat.

Mooring Station

The mooring station is a permanent installation with primary functions to a) serve as the ground anchor for the aerostat when it is on station, and b) serve as a maintenance station for the aerostat between missions. The mooring system is shown in Figure 5.

A reasonably level area approximately 500 feet in diameter is needed to provide adequate ground clearance for the moored aerostat. A concrete pedestal is located at the center of this area to support the main winch and enclosure as well as the mast. Concrete footings are also provided for the monorail. These footings can either be a full circle of concrete or smaller footings at each rail anchor point. The mooring area need not be paved. However, gravel or some other stable surface is necessary to carry erection and maintenance equipment.

The mooring station consists of a central machinery enclosure and mast mounted on a large central bearing, a horizontal boom compression member and a circular monorail which supports the outboard boom end, flying sheave and close-haul winches that are mounted on rollers. A mechanical lock with a remote electrical release is provided at the top of the mast. Work surfaces are provided on the top deck of the machinery enclosure, on the boom and at the location of the aerostat payload when it is moored. A diesel powered main winch and an auxiliary power unit located within the machinery enclosure furnish the power required to launch and retrieve the aerostat and to moor it in the close-hauled mode. The main winch is used to control and stow the tether cable during flight operations. Three smaller winches, one at the base of the mast and two on the circular rail, provide the restraints and control during early stages of launch and during

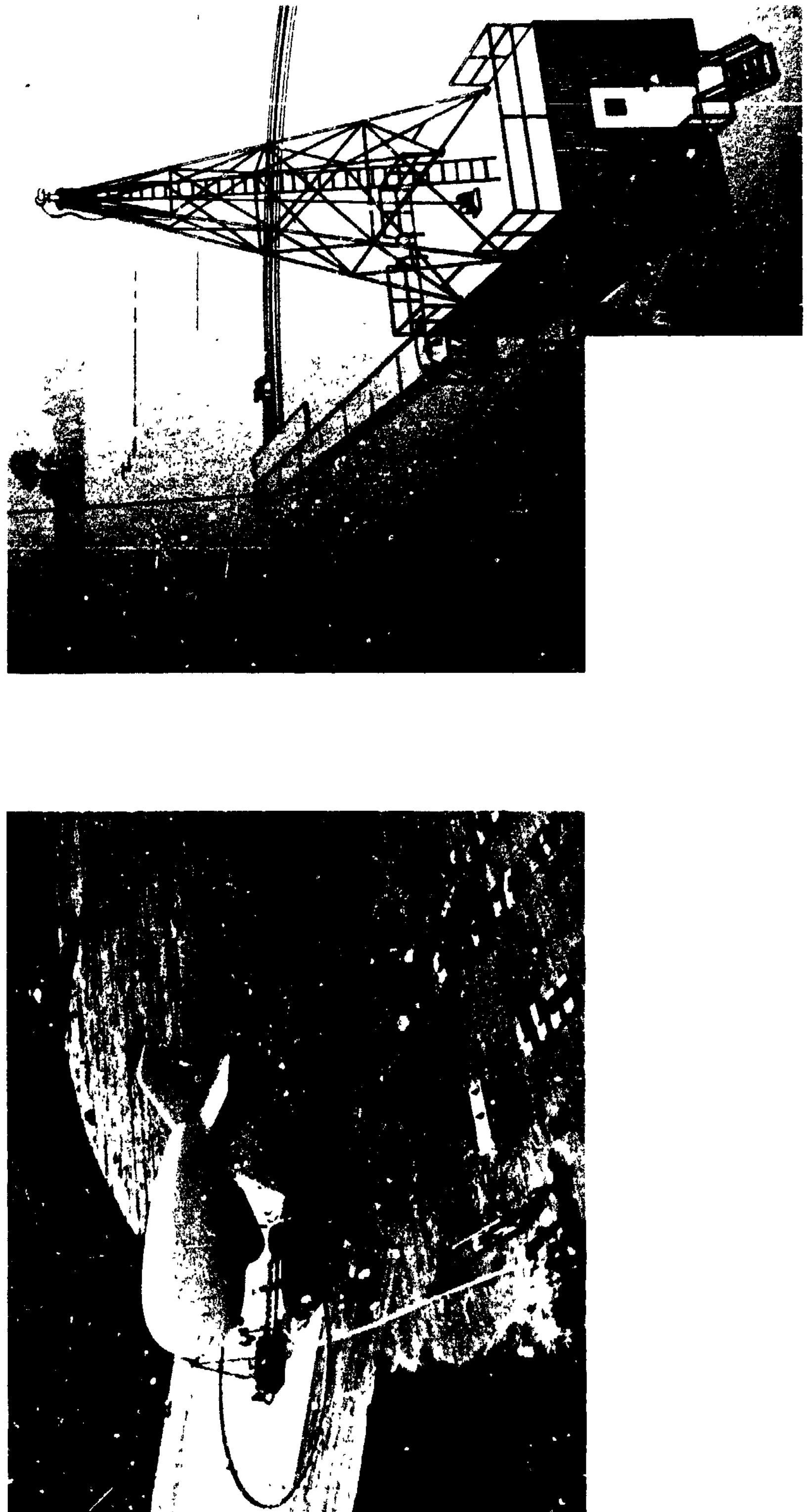

Figure 5
Mooring System

final recovery. A completely enclosed operator's cab is located on the forward side of the machinery enclosure, providing visibility to all operational areas. The specifications for this system are presented in Figure 6.

The principle feature of this design is its ability to be rotationally driven, either by the forces generated by the aerostat or externally, to align, in azimuth, with the aerostat or its tether cable. This allows a single operator to maintain the balloon in flight and only a four member crew to launch and recover the aerostat. During servicing and maintenance when moored, the crew rides with the system as it rotates into the wind thereby providing improved accessibility and greater safety and again reducing the crew size requirement.

SYSTEM PERFORMANCE

When moored the aerostat is mechanically locked to the mooring mast at the nose and secured by its suspension lines to the service platform under the aerostat payload. In this configuration, any changes in wind direction will cause a rotation of the complete system and maintain the balloon heading into the wind. It also allows the field crew to "ride" the mooring system and work without concern for shifting winds and gusts. In relatively calm weather (winds less than 15 knots), the brakes can be engaged so that heavy loads, such as the aerostat payload, can be transferred from truck to work platform.

The entire system is designed to sustain 90 knot wind loads with the aerostat in its moored mode. Thus a critical component design was that of the nose structure of the aerostat since it provides the mechanical attachment of the flexible aerostat to the rigid mooring tower. Maximum loads anticipated in 90 knot winds including dynamic loads are 26,000 pounds axial and 15,000 pound side load. The structure has been successfully tested to these values.

When the aerostat is moored, a 3 to 5 knot wind 10 degrees off the aerostat heading will cause the mooring station to realign itself into the new wind direction.

The maximum operating altitude for the aerostat is a function of aerodynamic forces on the aerostat and tether cable, helium volume at altitude, total weight aloft, and environmental factors, such as temperature and barometric pressure. The CBV-250A vehicle can attain an altitude of 15,000 feet; however, payload capability at this altitude is extremely limited. Typically, the CBV-250A is flown at 10,000 feet with a 4,000 pound load. Ascent and descent rates are approximately 200 feet per minute.

The aerostat is designed to operate in wind speeds up to 90 knots at sea level and higher speeds corresponding to a dynamic pressure of 27 pounds per square feet at higher altitudes.

Electrical power for vehicle and payload operation is supplied by either on-board rotary engines coupled to brushless generators or by using the tether cable as a conductor to transmit power from a ground source.

	MODEL NUMBER	
	18500	18600
APPLICATION	CBV-250A Aerostat	CBV-350A Aerostat
WEIGHT	95,600 lbs	99,600 lbs
DIMENSIONS		
Rail Diameter	173 ft	203 ft
Tower Height	47 ft	47 ft
Payload Service Platform	16 ft x 22 ft	16 ft x 22 ft
Machinery Enclosure	12' W x 9' H x 31' L	12' W x 9' H x 31' L
STRUCTURAL CAPABILITY		
Wind Speed (With Aerostat Moored)	90 knots	90 knots
Wind Speed (Without Aerostat)	120 knots	120 knots
Operating Temperature	-30°F to +120°F	-30°F to +120°F
Design Criteria	AISC Standards, 7th Edition	AISC Standards, 7th Edition
HYDRAULICS (Supplied by OECO)		
Main Winch		
Tether Cable Capacity	20,000 ft	20,000 ft
Maximum Pull	30,000 lbs	30,000 lbs
Maximum Line Speed	200 fpm	200 fpm
Close Haul Winches (3)		
Maximum Pull	12,000 lbs	12,000 lbs
Maximum Line Speed	140 fpm	140 fpm

Figure 6
Specification Summary, Sheldahl Aerostat Mooring System

EXPERIENCE

A total of six aerostat systems have been built and three additional systems are presently under construction. One of these systems has been in operation on Grand Bahama Island for the past 14 months providing television coverage for the outer islands.

During this initial 14 month operating period many performance features of the system have been demonstrated. For example, the aerostat has flown in 85 knot winds, in electrical storms, and in heavy rain. The aerostat has remained on station aloft continuously for five days. Highest recorded superheat has been 25 degrees Fahrenheit. Supercooling at night has been as low as 10 degrees Fahrenheit. Tests of material samples removed from the hull after 12 months indicate no significant degradation. The aerostat has been launched in ground winds gusting to 35 knots. Ease of servicing both the aerostat and payload in variable direction ground winds has verified the functionalism of the automatically rotating mooring system. Launch and recovery operations have been conducted with only a four man crew.

FUTURE PLANS

At the present time a complete system is being installed in Korea. It will be fully operational this year. Shortly thereafter, a system will be installed in Iran.

A "stretched" version of the aerostat has been designed and is currently under construction. Its configuration will be identical to the CBV-250A except that a 40 foot cylindrical section will be added at the major diameter of the hull, thereby increasing hull volume by 100,000 cubic feet. Payload capacity will be increased to 8,000 pounds at 10,000 feet altitude. The mooring system design has also been modified to accept the larger vehicle. This larger vehicle designated CBV-350A will undergo flight qualification tests early in 1975.

SUMMARY

What is the significance of this new telecommunication system development as it relates to airships? Materials and technology, of course, are common to both. Further, based on experience with tethered aerostats, it is the opinion of this author that airships can be designed and constructed to operate as reliably as conventional aircraft. However, one of the more pertinent questions that must be answered is: "Will the airship solve a problem or provide a service more economically than other transportation systems?" There are, of course many other issues and influences that must be considered, such as energy consumption, government subsidies, etc.. but the key issue should be one of economics. The telecommunication system is viable mainly because the service it provides is done at a fraction of what it would cost if provided by other more conventional means. In like manner, if objective studies show that airships could solve a problem or provide a service at lower costs when compared to other solutions, then and only then would there be any merit in their development.