The 28M™ Tactical Aerostat System: Enhanced Surveillance Capabilities for a Small Tethered Aerostat

John A. Krausman[1] and Shawn T. Petersen[2]
TCOM, L.P., Columbia, MD, 21046

A requirement was identified for an economical tactical system to lift 1000 lb of electronics payload in the range of 3,000 to 5,000 ft, using an easily transportable mooring system. TCOM's range of recent designs identified a need for more height and payload capacity from a system with a small logistical footprint similar to that achieved for TCOM's smaller systems. As a result, the TCOM 28M™ Tactical Aerostat System was developed to not only fill this need, but also to provide a fully integrated system with enhanced payload capability. As a self-contained, rapidly deployable, unmanned lighter-than-air system, it provides midrange altitude capability while utilizing a mooring system mounted on a base which can be readily transported. The weathervaning mooring system features a mooring tower and uses a safe and proven 3-point concept with closehaul and nose line winches for launch and recovery. The high strength tether contains conductors for power and fiber optics for data. The characteristics of this system are presented along with altitude and payload capability.

I. Introduction

A new tethered aerostat design, known as the 28M™ Tactical Aerostat System, provides a stable platform for payloads operating in what is referred to as the mid range altitudes. The simple design concept is an outgrowth of the TCOM 15M®, 17M®, and 22M™ aerostats, collectively referred as the Tactical Class, which have been previously described[1,2]. These compact, highly-portable systems are ideal for tactical deployment and land surveillance applications. Lessons learned with the earlier systems have resulted in numerous upgrades and improvements for application to medium sized aerostats referred to as the Operational Class. For example, the 28M™ is a tactical aerostat system in the Operational Class and it can fly higher above the ground and provide improved sensor capability. The aerostat can carry payloads of over 1,000 pounds to altitudes of 3,000 - 5,000 ft. In addition, the aerostats have been deployed from relatively high pad altitudes of 5-6 thousand feet. Also, they are ideal for maritime deployments, either along the coast or directly from a vessel at sea. The 28M™ aerostat is well suited to carry a variety of payloads for numerous mission profiles. These aerostat systems have been well received by the end users in field operations.

II. System Overview

Typical payloads include radar surveillance, passive sensors and communications surveillance, electro-optical/infrared camera surveillance, and communications relay/networking. Total payload weight may range from 800 to 1,500 lbs. Available power to the payload may be customized and is typically 5 kVA for 3,000 ft altitude and 3 kVA for 5,000 ft altitude.

The aerostat flexible structure is an aerodynamically shaped nonrigid structure that uses helium as the lifting gas. It is designed to operate in 50 knot winds and to survive in 70 knot steady winds while airborne or moored in temperatures ranging from -20°C to 50°C. The 28M™ aerostat has a hull volume of 1,600 cubic meters. The empennage, or aft section, uses fins in an inverted "Y" configuration. An internal air filled ballonet is used to maintain the internal pressure during ascent and descent and a system of blowers and valves is used with the air ballonet to automatically maintain hull pressure above the outside total pressure. The rigging lines spread the load

[1] Senior Engineer, Systems Engineering Department, AIAA Associate Fellow.
[2] Senior Engineer, Aerostat Systems Design Department, AIAA Senior Member.

forces from the tether to the flexible structure material. The moored 28M™ aerostat system is shown in Fig. 1, and the aerostat after launch is shown in Fig. 2.

Aerostat avionics include a lightweight aerostat pressurization and telemetry unit to provide pressure control that operates automatically. The system features an ethernet-based telemetry via the fiber optics and it also has an onboard weather sensor station to supply data to the system. The telemetry system provides vital flight and performance parameters to the operator and the weather/flight data includes temperature, barometric pressure, wind speed, wind direction, aerostat heading and GPS location. The aerostat incorporates an optional lightning protection system (not shown in the following figures) to send discharges safely to the ground. The aerostat has a rapid deflation device that operates automatically in case of aerostat breakaway in order to bring the aerostat quickly to the ground, and batteries that allow the aerostat to be safely recovered with full telemetry in the event of power failure to the aerostat.

The 28M™ system (including CFE ground station, payloads and generators but excluding generic equipment such as site vehicles and offices) is designed to be transported in six 20-ft ISO-sized module containers, also referred to as the Twenty-foot Equivalent Unit, or TEU. It can be transported via the Palletized Load System (PLS) or via two C-17 Globemaster III or one C-5 aircraft. The required launch pad area with appropriate clearance is approximately 200 ft diameter. The system can be set up from road transport to operational using a crew of six trained persons in less than 24 hours, while some installations can be achieved in 12 hours. Launch or recovery of the aerostat in winds up to 30 knots requires a crew of two to three. Typical flight duration capability exceeds 7 days while maintaining a nominal 15% free lift, and can be up to 4 weeks, followed by a short moored period for addition of helium to the aerostat.

Figure 1. 28M™ Aerostat Moored

Figure 2. 28M™ Aerostat in Flight

III. Payloads and System Integration

The 28M™ aerostat enhances operational effectiveness by integrating Intelligence, Surveillance and Reconnaissance (ISR) Payloads and providing the data to common ground control work stations. Provision of ISR data from operating altitudes of 3,000 to 5,000 ft permits a wide range of missions from wide-area-surveillance, reconnaissance, communications and radio relay.

The ISR payloads are undergoing rapid development as new technologies are being implemented to enhance performance. The 28M™ payload mounting racks are designed to accommodate rapid changes of payloads to react to changes in missions.

A typical system diagram is shown in Fig. 3, where the airborne and ground based components are identified. Payloads shown include a radar, inertial navigation system, global positioning system, electro-optical infrared camera, and radio relay. Multiple payloads can be located at various stations on the aerostat. Also shown is the fiber optics communications and power through the tether. A typical camera and radar are shown in Fig. 4 and the telemetry and payload displays are shown in Fig. 5.

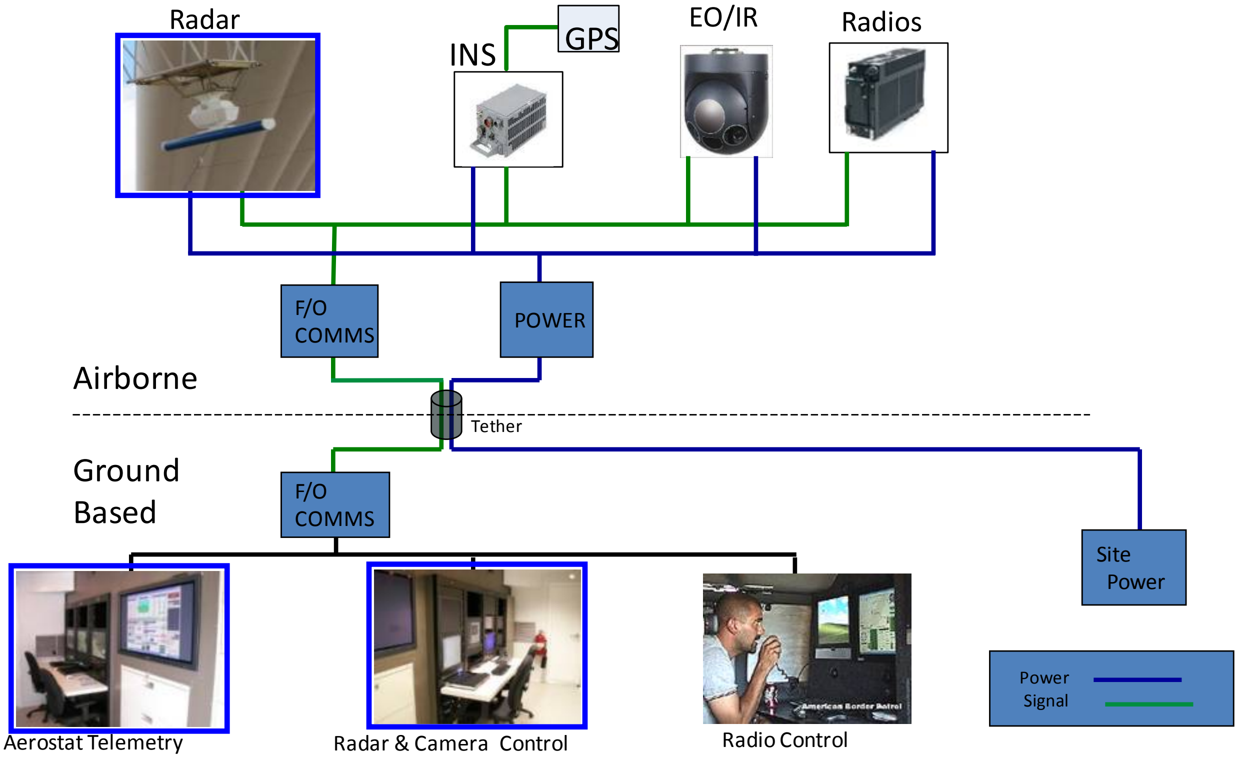

Figure 3. Typical System Integration

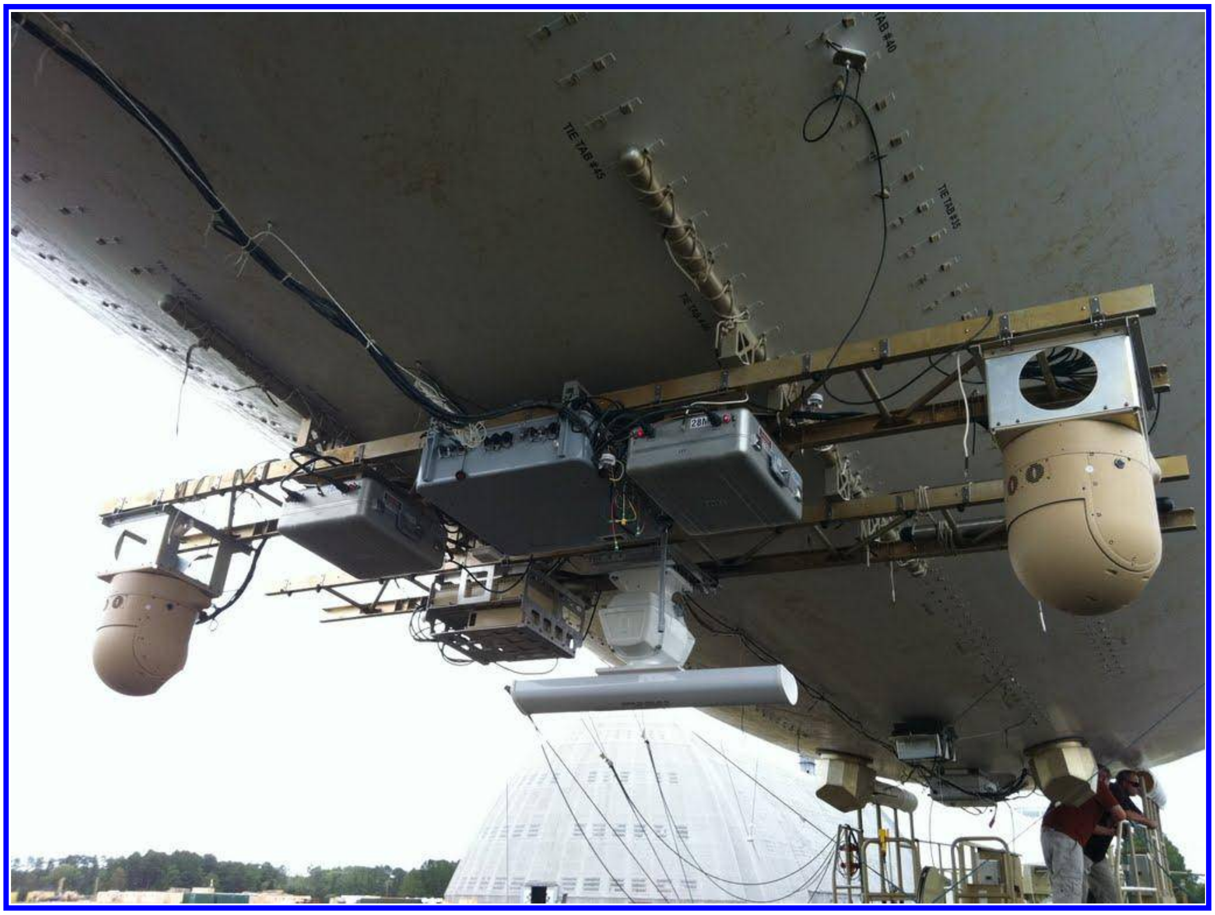

Figure 4. Cameras and Radar

Figure 5. Telemetry and Payload Displays

Payloads mounted on the underside of the 28M™ aerostat and processing and display equipment located inside a ground-based mission control shelter are tailored to accomplish the specific objectives of the customer's mission, which may be force-protection, wide-area-surveillance, communications, or a combination of objectives.

Data from the ground control shelter can be routed from the Aerostat site to Tactical Operations Centers to provide a common operating picture of the space for the remote operators. In addition to the ISR sensors an enhanced suite of airborne and ground based weather instrumentation is provided. The weather data is formatted to permit integration into military weather nets thus enabling central operators to develop a composite weather picture.

The reliability of the mission equipment has a significant impact on flight operations and is most often the chief determiner of aerostat system down-time. Integrating payloads using reliable power and signal conversion equipment designed for continuous use is critical to mission availability, as is payload system architecture. For example, system trades may result in the decision to incur a weight penalty in order to add or increase system redundancy. When airborne mission equipment fails or may require preventive maintenance, accessibility and payload mounting provisions of the 28M™ aerostat supports rapid remove-and-replace using quick-release fasteners designed to withstand thousands of cycles in harsh environments.

Flexibility of 28M™ aerostat avionics to accommodate a variety of payloads includes electronics such as modular airborne power supply units that down-convert and condition high voltage from the tether to the specific levels and quality required. The multiple fiber optic paths for payload data minimizes connections and use high quality, low-loss fiber optic rotary joints (FORJ) in both of the main rotating portions of the mooring system, the base pedestal and winch drum. Even payloads with the most demanding fiber optic attenuation budgets, such as RF-over-fiber applications, can operate at full performance without having to bypass the pedestal FORJ, a practice which previously could result in lost mission time.

The aerostat system software supports an intuitive graphical user interface. Parameters shown both graphically and numerically include aerostat pitch, roll, heading, tether tension, altitude, and helium internal pressure. Weather parameters include airborne and ground wind speed as well as direction. Numerous other parameters, including alarm events and history, can also be displayed.

Two 14 ft wide (port to starboard) racks with 7 bays each are commonly provided to mount payloads. Two bays are used by the Power Supply Units (PSUs), with the remaining 12 bays available for CFE payloads. The system can include lightweight, low-silhouette racks and also extended racks that accommodate a variety of mission-configurable payloads. Payload racks with extended structures may be used to mount payloads away from the aerostat to improve field of view, minimize interference from other on-board payloads, and aid in accessibility for maintenance. Typical installations are shown in Fig. 6. The mechanical attachments of payloads to trusses and racks are designed to minimize the remove and replace times while facilitating the safe transfer of weight from the installer to the aerostat. Individual payloads weighing more than 800 pounds are typically loaded onto the aerostat's various payload stations. Mechanical lift assist equipment is employed to reduce risk to equipment and personnel and to reduce the number of hands-on personnel required. Experience has shown this type of support equipment to be especially critical at those times when payload maintenance is required and ground wind conditions would otherwise hinder operations.

Figure 6. Payload Racks

The system operates from a commercial or similar electrical power source supplying 3-phase 460 VAC, 60 Hz or 3-phase 230/400 VAC, 50 Hz. Electrical loading of the aerostat system is characterized by short periods when peak power demand can rapidly increase, even double. This occurs during inhaul and outhaul mission phases when power is required for the winch subsystem. Operating a single generator sized to accommodate the winch peak power demand is inefficient when winches are not operating and increases corrective maintenance burdens due to wet-stacking which typically occurs when diesel generators are operated for long periods at significantly lower than their rated load. A power generation subsystem consisting of multiple, lower capacity generators connected in parallel is employed to address these concerns, as shown in Fig. 7. The generators, which have been modified to incorporate digital controls, have an operating mode that enables them to sense power demand and automatically power on and off as demand dictates. Prior to load-sharing, the generators communicate with one another to automatically synchronize at a preset voltage and frequency. The power generator subsystem includes an Ethernet interface for remote monitoring and control. The aerostat operator monitors the generator subsystem using the same software which was developed to monitor aerostat telemetry.

Figure 7. Power Generators Connected in Parallel

The Manufacturing and Flight Test Facility in Elizabeth City, NC is often used for complete integration and testing. Aerostat systems and payloads are routinely assembled, integrated, and flight tested at this location. See Fig. 8 for a typical view of the flight operations showing a large aerostat being moved out of the hangar.

Figure 8. Manufacturing and Flight Test Facility

IV. Mooring System

The mooring system uses a straightforward design that allows access to components for ease of maintenance. It uses a safe and proven three-point launch and recovery concept with nose line and port and starboard closehaul line winches. The mooring system boom pivots on the base to relieve wind loads on the aerostat, and it is damped to minimize aerostat motion while weathervaning. In addition, the mooring system base uses outriggers for added stability when deployed. The mooring system incorporates numerous safety features such as hand rails and nonskid surfaces. The main winch inhaul and outhaul rates are 180 feet per minute in normal conditions and can recover an aerostat from 3,000 ft AGL with 30 kt winds in 20 minutes. All winches are electrically driven using either 50 Hz or 60 Hz power. The main winch incorporates a level-wind feature to safely accommodate the length of tether. Total weight of the mooring system is approximately 23,500 lbs. A standard flatbed trailer and truck tractor are used to transport the mooring system to new deployment locations.

A special feature was developed with the mooring system to roll the aerostat partially or totally upside down for maintenance and battle damage repair. Temporary lines are installed on patches located on the aerostat specifically for the procedure. Maintenance operations can then be performed on the flexible structure and payloads on the sides and top of the aerostat without the use of high lift equipment and, more importantly, without increasing the exposure of the maintainer to enemy fire. A view of the aerostat rolled to the side is shown in Fig. 9 and rolled upside down is shown in Fig. 10.

Figure 9. Aerostat Rolled To Side For Maintenance

Figure 10. Aerostat Rolled Upside Down For Maintenance

V. Tether

The high strength tether contains conductors for power and fiber optics for data. Six optical fibers are used to communicate payload data between the aerostat and the ground processing station. Surrounding the power conductors and optical fibers are the Vectran® strength member layers. The outer layer consists of an ultraviolet-light-resistant polymer outer jacket to provide protection to the core from the environment. A drain is provided to reduce build-up of static electrical charge. The weight of the tether is less than 150 pounds per thousand feet with a diameter of approximately 1/2 inch. Break strength is approximately 14,000 lbs and maximum power through the tether for the aerostat electronics and payloads is 6 kW.

VI. Altitude Performance

The 28M™ aerostats were designed for operations from sea level or high mountainous terrain. The operating altitudes above ground level for a sea level pad and a 3,000 foot pad are shown in Table 1. This table shows the optimum altitude achieved for the aerostat system, which balances the need for lift with the expansion of the helium. Calculation of the optimum altitude and lift is explained in detail in a previous publication[3]. In some configurations, the altitude actually obtainable with the mooring system may be limited by the amount of tether which can be wrapped on the storage drum.

Varying the payload weights may affect the aerostat pitch angle, and provision is made for the payloads to be relocated fore or aft to achieve the proper trim. Multiple rows of tie tabs running continuously along the underside of the aerostat allow flexibility in location of the weights. The telemetry software accepts payload configurations as input as well as fixed and variable pad conditions to output the necessary tie tab locations for the payload components. This assures a more stable platform for the payloads, especially important in the case of imaging sensors.

Table 1. 28M™ Flight Performance from Sea Level and 3,000 Ft Pad (AGL)

	Payload Weight	
	850 Lb	1,250 Lb
Altitude from Sea Level Pad	5,000 Ft	3,000 Ft
Altitude from 3,000 Ft Pad	4,000 Ft	2,000 Ft

VII. Conclusion

The 28M™ Tactical Aerostat Systems have accumulated tens of thousands of hours of operation and are available for deployment with capabilities of carrying payloads of over 1,000 lbs to altitudes of 3,000 - 5,000 ft. This range is situated between the low altitudes of very small aerostats and the much higher altitudes of large aerostats. The improvements over previous small aerostats allow for higher flights above ground and also increased sensor capability while minimizing the pad size and personnel required for operation. The relocatable mooring system allows easy transportability and setup in remote areas. In addition, the 28M™ aerostat systems are capable of lifting a full suite of payloads that can readily be adjusted to meet local operational needs. Facilities are available to fully integrate the system and provide a complete turn-key solution for numerous applications.

References

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