11th AIAA Aviation Technology, Integration, and Operations (ATIO) Conference, including the AIA
20 - 22 September 2011, Virginia Beach, VA

AIAA 2011-7069

The 22M Class Aerostat: Increased Capabilities for the Small Tethered Aerostat Surveillance System

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A requirement has been established to lift an electronics payload in the range of 3,000 to 5,000 ft, using an easily transportable mooring system. Existing transportable helium-filled tethered aerostat systems are not large enough and the larger aerostat systems are not easily transported and have more significant logistical requirements. As a result, the TCOM 22M class aerostat systems were developed to not only fill this need, but also to provide a fully integrated system with enhanced payload capability. As self-contained, rapidly deployable, unmanned lighter-than-air systems, they provide low to 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 these systems are presented along with altitude and payload capability charts for a specific aerostat, the 22M™.

I. Introduction

THE new group of tethered aerostats, known as the 22M class, provides a stable platform for payloads operating in what is referred to as the low to mid range altitudes. The simple design concept is an outgrowth of the TCOM 15M® and 17M® aerostats, which have been previously described[1]. Lessons learned with these systems in the theater of operations have resulted in numerous upgrades and improvements. For example, the aerostat can fly higher above small arms fire and provide improved sensor capability. The 22M class aerostat can carry payloads of several hundred 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. The 22M class of aerostats are well suited to carry a variety of payloads for numerous mission profiles. These aerostat systems have been well received by the US war-fighters operating in hostile territories.

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 300 to 800 lbs, and available power to the payload is in the range of 2 to 5 kVA.

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 excess of 70 knot steady winds while airborne or moored. The 22M class aerostats have hull volumes in the range of 800 to 1600 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. The rigging lines spread the load forces from the tether to the flexible structure material. The moored 22M™ 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 telemetry system provides vital flight and performance parameters to the operator. One of the aerostat systems features an ethernet-based telemetry via the fiber optics and it also has an onboard weather

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sensor station to supply data to the system. The aerostats have a rapid deflation device that operates automatically in case of aerostat breakaway, and batteries that allow the aerostat to be safely recovered with full telemetry in the event of power failure to the aerostat.

The system is packed in ISO module containers which can be transported by C-17 aircraft. Some containers can also be transported by helicopter, depending on the weight. The required launch pad area is approximately 200 ft diameter. The system can be set up and made operational in six hours using a crew of six persons, while launch or recovery of the aerostat requires a crew of two to three. Typical flight duration capability exceeds 7 days while maintaining a nominal 15% free lift, followed by a short moored period for addition of helium to the aerostat.

Figure 1. 22M™ Aerostat Moored

Figure 2. 22M™ Aerostat in Flight

III. Payloads and System Integration

The prime purpose of the 22M class aerostat is to enhance the operational effectiveness of US armed forces 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 force-protection, 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 22M class 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 also 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.

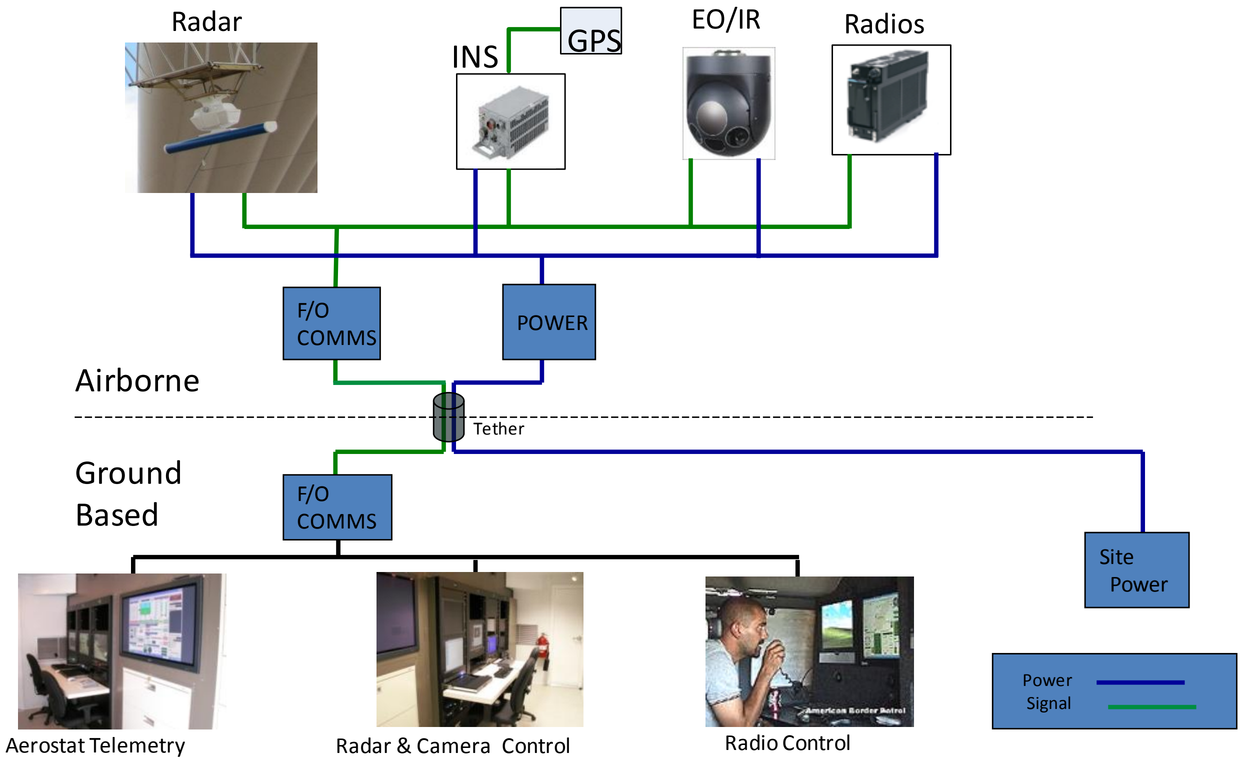

Figure 3. Typical System Integration

Figure 4. Camera and Radar

Figure 5. Telemetry and Payload Displays

Payloads mounted on the underside of the 22M class 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 pay 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 22M class aerostats support rapid remove-and-replace using quick-release fasteners designed to withstand thousands of cycles in harsh environments.

Flexibility of 22M class 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 resulted in lost mission time.

The aerostat system software supports an intuitive graphical user interface. Parameters shown both graphically and numerically include aerostat pitch, roll, 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.

The system can be configured with lightweight, low-silhouette racks and also extended racks that accommodate a variety of mission-configurable payloads. Payload racks with deep structures may be used to mount payloads away from the aerostat to improve field of view 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 200 pounds are typically loaded onto the aerostat's various payload stations. Specially designed 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

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

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. In addition, one version of 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 range from 100 and 180 feet per minute. All winches are electrically driven using either 50 Hz or 60 Hz power. Total weight of the mooring system ranges from 13,500 lbs, which can be configured for helicopter transport, to approximately 23,500 lbs. A standard flatbed trailer and truck tractor are used to transport the mooring system to new deployment locations.

V. Tether

The high strength tether contains conductors for power and fiber optics for data. The various performance capabilities of the 22M class systems require that the tethers have a range of components such as number and size of conductors and also amount of strength members. Up to 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 a polymer outer jacket to provide protection to the core from the environment. The weight of the tether ranges from 95 to 140 pounds per thousand feet with a diameter of approximately 1/2 inch. Break strength ranges from 7000 to 14,000 lbs and maximum power through the tether is 3 to 6 kW.

VI. Altitude Performance

The 22M class aerostats were designed for operations from high mountainous terrain. The operating altitude above ground level of a specific aerostat, the 22M™ from a 3000 ft pad, is shown in Table 1. Even better performance is achieved from lower pad altitudes. From sea level, the 22M™ performance would increase 1100 ft AGL for the same payload weights. Alternatively, additional payload weight could be added for the sea level cases to achieve the same altitudes above ground level as shown for the high pad case.

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[2]. Temperatures shown are seasonal temperatures and do not represent daily fluctuations. Altitudes obtainable with the mooring system may be limited based on the amount of tether which can be wrapped on the storage drum.

Varying the payload weights may affect the aerostat pitch angle, and thus the payloads can be relocated fore or aft to achieve the proper trim. Tie tabs running along the underside of the aerostat allow flexibility in location of payloads. This assures a more stable platform for the payloads, especially in the case of imaging sensors.

Table 1. 22M™ Flight Performance from a 3000 ft Pad (Ft AGL)

Pad Temp (°F)	Payload Weight (Lbs)		
	500	400	300
80	1400 Ft	2100 Ft	2900 Ft
100	1200 Ft	1900 Ft	2700 Ft

VII. Conclusion

The 22M class of aerostat systems have accumulated thousands of hours of operational deployment and are now available as new tethered air vehicles capable of carrying payloads of 300-800 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 flight above hostile arms fire and also increased sensor capability. The relocatable mooring system allows easy transportability and setup in remote areas. In addition, the 22M class of aerostat systems are capable of lifting a full suite of payloads. The system is fully integrated and provides a complete turn-key solution for numerous military and commercial applications.

Acknowledgments

The authors thank Michael E. Potts, TCOM Senior Systems Engineer, for assistance with the payload sections.

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