Using a Servo Release Mechanism to Increase Peak Altitude and to Control Descent Profile on Dual-Weather-Balloon Flights

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We have developed a robust, low-cost, low-mass servo release mechanism called “SMART” (Servo Motor Actuated Releasable Tether) for use to release rigging lines during stratospheric balloon flights. The system consists of a 6.2 gram micro servo, a plastic servo arm, a steel pin, and a body of laser-cut plywood parts. SMART is easy to install and can support and release a rigging line even when under 40 pounds of tension. This one-time servo release is actuated via a PWM signal from a microcontroller.

Being able to release rigging lines, most notably main line(s), during stratospheric weather balloon flights has a multitude of uses including flight termination to decrease the total flight time and/or to avoid undesirable trajectories or landing locations. Additionally, SMART units can be combined to with creative rigging techniques to achieve greater in-flight control of balloon-lofted vehicles such as changing ascent/descent rates, opening doors, deploying panels, etc.

As a sample application, we have used SMART mechanisms on ballooning missions lifted by dual weather balloons to regularly reach peak altitudes above 110,000 feet and also to provide either a “float” or a “slow-descent” phase, without requiring a venting mechanism. In these dual-balloon flights two identical weather balloons are symmetrically inflated to provide enough lift to achieve a reasonable ascent rate, but not inflated enough for either balloon to lift the payload stack by itself. When the main line to either balloon is released by a SMART mechanism at the desired altitude or time, the payload will either enter a float mode or begin a slow descent (depending on the inflation plan). A second SMART unit is then used to terminate the flight later by severing the main line to the second balloon, starting a standard (fast) parachute descent.

This dual-balloon-with-independent-release flight profile is particularly useful for experiments that could benefit from additional time at altitude or, in our particular case, for experiments that benefit from the sensing payload being the first thing to penetrate “undisturbed air” (on descent), thereby avoiding potential “contamination” when collecting data from within the wake of the balloon/parachute (on ascent).

Challenges with this particular dual-balloon technique, which we are working to overcome, include keeping the balloons from tangling (and hence not departing cleanly when released) and/or having one or both balloons popping early (possibly due to interactions on ascent). If releases are to be altitude-based, rather than timer-based, then having reliable gps-based (or pressure-based) altitude information is critical. Programming logic has been developed to help payloads make appropriate decisions even if altitude data is not 100% reliable and/or if the evolution of the flight does not go according to plan, such as if either balloon bursts before it was scheduled to be released. Implementation of a finite state machine based on altitude and time allows the system to make autonomous in-flight decisions. The logic includes checks for in-flight failures like premature popping of balloon(s), unexpectedly slow ascent or descent rates, inadvertently getting stuck at altitude (i.e. going into an unplanned float phase), and more. Gps fences have also been implemented to try to prevent stacks from landing in particularly wet or heavily forested locations.

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