

Senior Design Project: Low-Altitude Unmanned Reconnaissance Airship (LAURA)

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In today's battlefield, the ability to provide real-time, persistent intelligence, surveillance, and reconnaissance (ISR) and communication to the warfighter is essential to the Global War on Terror (GWOT). The U.S. military currently relies heavily on satellites to gain an

advantage in ISR and communication. Satellites, however, are not without their disadvantages. They are expensive to build, and the infrastructure and equipment required to place them on orbit precludes, as the situation currently exists, truly operationally responsive and persistent ISR and communication. The advent and proliferation of unmanned aerial vehicles (UAVs) have addressed the issue of responsive reconnaissance for the warfighter, but UAVs do not address the issue of long-haul communications, nor do they provide the kind of persistent ISR over an area to support asymmetric warfare and counter improvised explosive device (IED) operations.

HARVe

APL is exploring the concept of a long-endurance unmanned, untethered, lighter-than-air (LTA) vehicle operating autonomously in the stratosphere to provide real-time, persistent ISR, as well as beyond-line-of-sight communication connectivity.¹ The proposed vehicle is the High-Altitude Reconnaissance Vehicle (HARVe, Fig. 1). HARVe would be pre-packaged for deployment on a rocket or missile that could be launched by ground forces into the theater of interest. The rocket would deploy its payload just below low-Earth orbit, where HARVe would inflate and maintain its desired position over an area of interest on the ground, providing communications uplink and persistent ISR (Fig. 2).

Participating in the Whiting School of Engineering's capstone Senior Design Program, APL engineers were able to investigate some of the aspects of the HARVe concept while providing students invaluable experience in applying what they have learned in the classroom to a real engineering project. The students were tasked with creating a functional sub-scale demonstration of some key aspects of HARVe, namely: the vehicle must be LTA, provide position and attitude control, and provide real-time surveillance.



Figure 1. The HARVe concept.

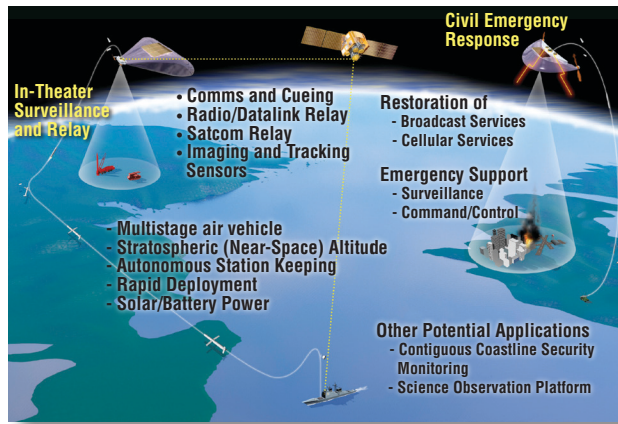


Figure 2. HARVe provides persistent ISR and communication, and it can be rapidly deployed.

LAURA

While mentored by APL engineers and JHU professors, the students were able to achieve over the course of two semesters all of the requirements of the sub-scale demonstrator. The students created concepts and analyzed the required lift, power, and dynamics of potential systems to find a balance between the goals of the project and the timeline and funding available. The result was LAURA, a Low-Altitude Unmanned Reconnaissance Airship. LAURA featured a 17-ft balloon to provide the lift necessary for the 10 lb of batteries, motors, associated electronics, and airframe to support a reconnaissance mission of 30 min to 1 h at a maximum altitude of 100 ft above sea level. The COTS autopilot (Fig. 3) that was originally intended for fixed-wing aircraft was adapted with help from APL to provide LAURA with the ability to perform waypoint following, station-keeping, and remote telemetry.² An analog video camera with an RF transmitter met the goal of providing real-time reconnaissance.

LAURA featured four motor-propellers (Fig. 4) to achieve three-axis position and two-axis attitude control. Two large 17-inch forward-facing propellers were independently controlled for forward motion as well as yaw. Two vertically mounted reversible propellers on either side of the gondola could be used for altitude adjustments as well as providing roll. A mechanism for moving the gondola along its mounting on the balloon changed the center of gravity of the airship and could provide some limited pitch control.

For further information on the work reported here, see the references below or contact john.samsundar@jhuapl.edu.

¹Samsundar, J., Jenkins, E. J., and Neradka, F. V., "A Methodology for Optimal Power Generation in High Altitude Airships Using Genetic Algorithm," Presented at the 7th International Energy Conversion Engineering Conference (IECEC), Colorado Convention Center, Denver, CO (2–5 Aug 2005).

²MicroPilot, MP2028g *Miniature UAV Autopilot*, Device Specifications (2004), <http://www.micropilot.com/pdf/mp2028g.pdf> (accessed 20 Oct 2009).

³Jackson, B., Keim, N., and Chin, M., *An Autonomously Guided, Data-Transmitting Test-Bed Blimp for the High Altitude Reconnaissance Vehicle (HARVe) Project*, The Johns Hopkins University, Baltimore, MD (2005).

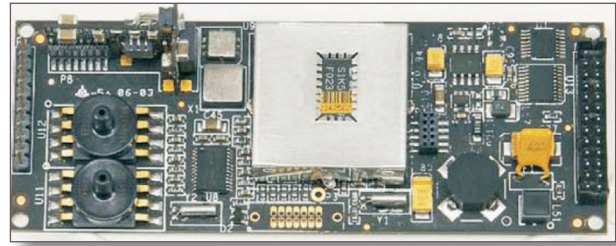


Figure 3. MicroPilot COTS autopilot with gyros, accelerometers, GPS, pressure altimeter, and flight-control processing. (Image © 2010, MicroPilot.)

During the project, the students, as mechanical engineers, faced some challenges with the electronics and programming of the autopilot, and the interaction between the APL engineers and the students proved to be beneficial to everyone involved. By working on such a multidisciplinary project, the students were able to become more well-rounded engineers, and APL was able to quickly and cheaply produce a sub-scale demonstration airship.³

Since taking delivery of LAURA, APL has had a hardware platform to experiment with aspects of guidance, navigation, and control of LTA vehicles. By studying the dynamics of LAURA, much can be learned about the way a full-scale HARVe should be designed and utilized. In short, the project was a great success.

ACKNOWLEDGMENTS: This project benefited from the participation of Mike Chin and Ben Jackson (students) and Andrew Conn (faculty member) from the JHU Department of Mechanical Engineering and of Vince Neradka from APL.



Figure 4. LAURA gondola and motor-propellers provide three-axis position and three-axis attitude control.