Title of Investigation:

Scalable Hybrid Airship Platform for Exploration and Science (SHAPES)

Principal Investigator:

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Other In-House Members of the Team:

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External Collaborators:

Gabe Ladd (University of Maryland-Eastern Shore)

Initial Year:

FY 2004

FY 2004 Authorized Funding:

$40,000

Actual and Expected Expenditures:

$19,000 spent in FY 2004; $10,000 planned for instrument in FY 2005; $10,000 planned for testing and operations in FY 2005

Status of Investigation at End of FY 2004:

To be continued in FY 2005

Expected Completion Date:

Fall 2005

Purpose of Investigation:

Scalable Hybrid Airship Platform for Exploration and Science (SHAPES) represents the initial pathfinder platform for developing the capability to fly lightweight miniaturized Earth science payloads on a low-speed, low-altitude unmanned aerial vehicle (UAV). Our investigation answers the hard questions associated with developing an alternative technology platform—launch and recovery, stability (both sensor environment and performance), and control, while at the same time providing a usable test bed for miniaturized Earth science missions.

Our investigation includes developmental flight tests and operational science missions to demonstrate the use of the hybrid airship platform. The vehicle is 8.2 m (27 ft.) in length. It has a wingspan of 6.1 m (20 ft.) and an inflated envelope of about 1.5 m (5 ft) in diameter. The prototype design can carry a 2.5 kg (5.5 lb) scientific payload. The initial prototype vehicle uses electric propulsion, battery power, and a remote-control system. Wallops Flight Facility's (WFF) range assets are available to conduct flight tests, including WFF restricted airspace (R6604) and the new UAV runway on Wallops Island. The initial science instrumentation for the SHAPES pathfinder mission is an Infrared (IR) Video/High Resolution Digital Imaging package used for studying coastal waterways. Other potential users for the platform include a micro-spectrometer being developed to study ocean color and a package employing a gas analyzer and a sonic anemometer to study atmospheric fluxes.

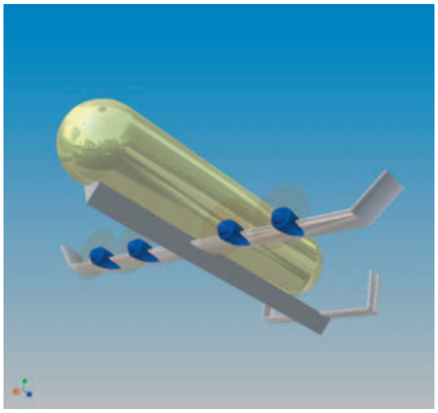

Figure 1. Parametric model of SHAPES prototype

Remote sensing is an area that has many applications in the low-altitude, low-speed arena, and is an essential component of coastal-zone research. In addition, initial studies have suggested that the hybrid airship design may be the optimum vehicle for planetary missions. This project addresses an area of platform research for Earth Science not currently being explored. While UAV platforms are an increasing area of development for both NASA and the Department of Defense, the hybrid airship concept remains a largely unexplored configuration. Previous ventures involving hybrid airships, primarily based in Europe, have focused on high-altitude, heavy-lift applications. This low-cost development effort not only provides immediate access for miniaturized Earth science sensors and instrumentation, but also serves as a proving ground for larger coastal-zone applications and planetary operational concepts.

With this project, the operational ground and flight safety risks present the most significant challenge to the success of the project; however, operational success with UAV operations at WFF have been proven in recent years, especially with the advent of the UAV runway at Wallops Island.

FY 2004 Accomplishments:

The design optimization process accomplished in early 2004 included the rescaling of the initial prototype conceptual design. This was as a result of increased fidelity of the calculations for the vehicle's aerodynamics, mass distribution, and structural optimization. One of the key variables in the hybrid vehicle design continues to be the relationship between aerodynamic lift and buoyant lift, and the corresponding interactions between the flight structures responsible for the two sets of forces generated on the structure.

Following the detailed design of the SHAPES vehicle, the Mechanical Systems Branch (Code 548) confirmed the structural integrity of the primary truss. Once we were able to order the appropriate materials to construct the truss framework, fabrication and assembly of the main vehicle truss and other key subassemblies began during the summer of 2004, with the help of two students. One student was a DDF summer intern and the other was a Summer High School Apprentice Research Program (SHARP) student. Delays in completing the analysis, due to competing project priorities with analysis personnel, led to delays in specifying fabrication materials. As a result, fabrication and assembly fell several months behind schedule.

Figure 2. Prototype truss assembly

Procurements, totaling approximately $19,000, have been completed for most of the subsystems associated with the prototype vehicle, including the propulsion elements, Lithium polymer batteries, control system hardware, lifting envelopes, carbon sensor and data logger hardware, and the previously mentioned structural materials. Remaining FY 2004 funds will be used to buy an IR imager and to cover WFF range costs, including safety analysis and range operations.

Planned Future Work:

We will be updating the parametric model of the SHAPES prototype during FY 2005 to look at mass distributions and to attempt to correlate the assumed load distributions used in the structural analysis.

Wing and tail subsystems, which are major fabrication tasks, will begin in late spring 2005 and run through summer 2005. Systems integration will begin in late summer 2005. Discussions about safety and range operations at Wallops Island will begin in spring 2005.

Summary:

The innovative elements in this proposal include those associated with assessing—via real prototyping—the aerodynamics of hybrid lift vehicles. Little work has been done on hybrid platforms of this type. This project is unique in that its current suborbital prototyping effort has almost direct application to planetary exploration tasks. The "payoff" to NASA, and specifically to the Goddard Space Flight Center, is that this initial work could position us to be competitive in future exploration proposals that we have not previously seen as relevant.

The criteria for success of this initial prototype ultimately depend on the flight demonstration of this negatively buoyant hybrid lift vehicle. In particular, we will be evaluating flight control issues, structural optimization, and key design parameters. In addition, examination of the effectiveness of the vehicle as a platform for the onboard instruments, the IR imager and CO_2 sensor, is just as important as the technology pathfinder objectives of SHAPES. Technical risk factors include issues with flight control and possibly untenable vehicle performance characteristics. Given that the SHAPES prototype is a fully operable UAV, safety risks also exist, which, by necessity, we must address in this initial effort.