

# Steerable-Parachute Design and Testing

Statement of Project

16.621

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## **Introduction**

In 1997, the U.S. Air Force Science Advisory board identified a need to improve the accuracy of airdrops in a report titled “Summary Report: New World Vistas, Air and Space Power for the 21st Century.”<sup>1</sup> Cargo parachutes currently being used by the military and humanitarian organizations to deliver payloads such as food, ammunition and equipment are essentially ‘dumb.’ Once a parachute is dropped from an aircraft, there is no way to control its flight path, which is highly dependent on meteorological conditions. Thus one method for improving the accuracy of airdrops involves adding control systems to unmanned parachutes in order to improve control over their flight paths.

The potential value of developing control systems, for use with unmanned cargo parachutes in order to improve accuracy of cargo drops, is illustrated by the fact that the U.S. Army, the U.S. Air Force, and major industry leaders such as The Boeing Company and Vertigo Incorporated have teamed up to develop a parachute control system known as the Affordable Guided Airdrop System (AGAS).<sup>2</sup>

AGAS uses a commercially available GPS receiver and a magnetic compass as navigational sensors, and pneumatic muscle actuators consisting of braided-fiber tubes to pull on the parachute's rigging lines in order to displace it. Before AGAS, attempts to improve unmanned parachute control focused on developing more expensive parafoil systems.

Since their discovery by William Beuhler at the U.S. Naval Ordnance Laboratory in 1961,<sup>3</sup> nickel titanium shape memory alloys (NiTiNol) have been employed in a wide variety of applications from decreasing vibrations in turbine fan blades to use as artificial muscle fibers. However, one potential application that has yet to be explored involves using the properties of NiTiNol to control parachutes. Pulse width modulation can be

used to pass varying amounts of electrical current through NiTiInol wires in order to change their lengths.<sup>4</sup> Therefore we are proposing to attempt to use electrical current-heated NiTiInol wires to develop a parachute control system similar to AGAS.

### **Hypothesis**

An unmanned cargo parachute with rigging lines made of NiTiInol shape memory alloys can be steered by changing the lengths of those lines.

### **Objective**

The main objective is to analytically and experimentally assess what degree of control can be achieved by shortening the shape-memory alloy rigging lines of a parachute.

### **Statement of Work**

The following tasks shall be performed as part of 16.621

- ?? Develop simple models or use existing ones to define degrees of parachute controllability based on it being able to perform certain maneuvers at particular speeds or within a particular time period
- ?? Perform an order of magnitude analysis in order to size a scale parachute that can be dropped under controlled conditions (e.g. inside Johnson Athletic Center)
- ?? Design experimental procedures and determine the specific equipment needed

The following tasks shall be performed as part of 16.622

- ?? Construct the scale parachute

- ?? Equip the parachute with a simple control system, a car or motorcycle battery and relays to handle power, an accelerometer, a camera, and other equipment selected during 16.621
- ?? Perform first set of drop tests without using control system and record data as the 'control' of the experiment
- ?? Perform subsequent tests to determine the controllability of the scale parachute by varying different parameters one at a time
- ?? Analyze the resulting data and record findings
- ?? Throw a party Caltech-style to celebrate the successful outcome of the project

### **Success Criteria**

The project shall be regarded as a success if we can assess to what degree an unmanned cargo parachute with NiTiNol shape memory alloy rigging lines can be steered by changing the lengths of those lines.

### **Conclusion**

By drawing from the recently acquired knowledge on unmanned parachute control from AGAS and the many successes of NiTiNol applications in the past, we hope to develop a system to control unmanned cargo parachutes. This system would be similar to AGAS, but would provide an alternate means of meeting the same goal by using different actuators. The potential advantages of producing this cargo parachute control system include increases in airdrop accuracy, which translates to lower amounts of cargo damage or loss.

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## References

<sup>1</sup> “Summary Report: New World Vistas, Air and Space Power for the 21st Century,”

USAF Science Advisory Board, 1997.

<sup>2</sup> Dellicker, S., Benney, R., and Brown, G., “Guidance and Control for Flat-Circular Parachutes,” *Journal of Aircraft*, Vol. 38, No. 5, 2001, pp. 809-817.

<sup>3</sup> “The History of Nitinol,” Images SI Inc., Staten Island, NY.

[<http://www.imagesco.com/articles/nitinol/02.html>. Accessed 10/3/02.]

<sup>4</sup> “Nitinol Technical Information,” Shape Memory Applications, Inc., San Jose, CA.

[<http://www.sma-inc.com/information.html>. Accessed 10/2/02.]