PAPER TITLE: Montgolfiere Balloon Aerobots for Jupiter's Atmosphere
AUTHORS: Jack A. Jones and Matt Heun
AFFILIATION: Jet Propulsion Laboratory, California Institute of Technology

ABSTRACT

Up to now, the only practical means to explore the planetary atmospheres of the outer gaseous planets has been to send in single descent probes, such as was done on the Jupiter Galileo probe on December 7, 1995. For other bodies, such as Venus and Titan (a moon of Saturn), controlled ascent/descent balloon aerobots have been proposed. The technology for this type of aerobot uses phase change fluids, heated by the lower atmosphere and condensed at altitude, to control buoyancy. This system has been successfull] y tested in the Earth's atmosphere in a series of tests known as the Altitude Control Experiments. Recent studies, however, have shown this system to be far too heavy for missions to the outer planet atmospheres, which consist of > 80% hydrogen, and thus require very large hydrogen quantities for payload buoyancy. Even a simple hydrogen-filled balloon would require over 1000 kg of delivered system payload mass for a small, 10 kg science payload.

These same JPL studies have shown that a very promising, lightweight balloon system using a combination of solar heating and lower planetary radiation heating, appears quite feasible for Jupiter, The technology is based on a modification of a design that was demonstrated by a series of thirty infrared Montgolfiere (hot air) balloons flown by the French CNES in the Earth's stratosphere in the 1980s. In the French design, the balloons' upper surfaces were aluminized to minimize radiant heat loss to space, while the balloons' inside upper surfaces were blackened to absorb radiation heat from the lower, warmer Earth. The resulting radiant heating of the balloons' internal air allowed missions with 50 kg payloads that lasted up to sixty days and encircled the globe twice.

Recent analysis at JPL has shown that a similar technology appears very relevant for missions to Jupiter, as well as possibly to the other giant gas planets of Saturn, Uranus, and Neptune. For Jupiter, a simple radiant Montgolfiere balloon would have a system mass of about 300 kg for a 10 kg payload. When combined with solar heating during the. Jovian five hour clay, however, the balloon total system mass is reduced to only about 100 kg. Heating during the five hour night is accomplished by a combination of lower planetary radiant heating and isentropic compression of the balloons internal gas as the balloon descends from a daytime altitude of 0.1 bar to a nighttime altitude of about 0.2 bar. Data from the cloud levels (below 0.3 bar) could be obtained by means of lightweight sondes, long thin tethers, or various acoustic experiments for deep atmosphere analysis.

Data from the Galileo probe of Jupiter (December, 1995) was used to update thermal models of the Jupiter atmospheric thermal environment, Modeling thus far suggests that a balloon of about SO meter diameter would be required for a 10 kg payload. The material would be a thin, high strength polymer, such as PBO, with a lightweight strengthening scrim material. A one-tenth scale size balloon (5 meter diameter) will be tested for deployment, filling, and solar radiant heating characteristics in the Earth's atmosphere.

The technology described herein represents an entire new class of low-cost, light-weight, aerobot spacecraft, and it is the lightest weight technology that is known to be viable to conduct in-depth, long-life studies of the atmosphere of Jupiter and possibly of the other giant gas planets in our solar system (Saturn, Uranus, and Neptune). Mission life is expected to be months long since the ambient gas balloon is virtually unaffected by gas permeation leaks, small holes, or envelope imperfections.