Development of Planetary Balloons

Debora A. Fairbrother
NASA Goddard Space Flight Center's Wallops Flight Facility
Balloon Program Office, Code 820
Wallops Island, VA 23337 USA

***Abstract* – NASA's Scientific Balloon Program provides a platform to conduct research in a near-space environment. Currently, both Earth and Space scientists utilized balloons to carry experiments in the Earth's atmosphere. Such vehicles can also be used for the exploration of planetary atmospheres. The Soviet Vega-2 mission demonstrated this for a short duration in June 1985. Since that time, technology advances will enable longer duration missions to Venus as well as to Mars. This paper presents highlights of some of the ongoing balloon technology development activities supporting the exploration of both Venus and Mars.**

I. Introduction

The use of balloons for aerial exploration dates back to 1783 when the Montgolfier brothers demonstrated the first hot air balloon. The first polyethylene balloon was flown in 1947 by Otto Winzen [1]. Since that time, balloons has been used to lift man and instruments into the stratosphere for exploration and scientific discovery. The science disciplines currently using NASA balloon platforms are: IR/Sub-mm Astrophysics, Particle Astrophysics, Gamma Ray/X-Ray Astrophysics, Geospace Sciences, Solar and Heliospheric Physical and Upper Atmosphere Research.

The extension of aerial platforms to planetary atmospheres was demonstrated in 1985 by the Soviet Union. They successfully flew two helium inflated superpressure balloons in the Venusian atmosphere as part of the VEGA-2 mission [2]. These balloons flew for nearly 2 Earth days at an altitude that ranged from 53 to 55 km which was a relatively benign operational environment. In addition, numerous studies have focused on balloons for the aerial exploration at Mars [3]. The use of planetary balloons will enable in situ atmospheric measurements, high-resolution geological, geochemical and geophysical data, and the study of atmospheric circulation.

This paper describes three of the collaborative technology development efforts that NASA's Goddard Space Flight Center's Wallops Flight Facility has been involved in to advance the future of planetary ballooning.

II. Venus

The VEGA balloons demonstrated the ability of balloons for aerial exploration. From the NRC Decadal Survey [4], the current science objectives for Venus have been documented. The top priority objectives consist of understanding the origin and evolution of Venus. This requires making highly accurate composition measurements of the atmosphere which can be done by a balloon or drop probe. The balloon has several advantages including longer duration and the ability to conduct other investigations.

To address the current science requirements, advances to the balloon system from VEGA were required. A collaborative effort was undertaken by a team of engineers from NASA Goddard's Wallops Flight Facility, the Jet Propulsion Laboratory (JPL), and ILC Dover, Inc. This team not only developed a new material that was sulfuric acid resistant, but also designed, constructed and tested a full scale prototype balloon [5].

Table 1 summarizes the final balloon design parameters of the prototype balloon. The full scale prototype balloon underwent inflation testing in the JPL Spacecraft Assembly Facility as shown in Fig. 1.

TABLE 1. Full Scale Venus Balloon Design

Diameter	5.54 m
Volume	89 m^2
Balloon Mass	25.1 kg
Nominal Float Altitude	55.5 km
Nominal Float Atmospheric Density	0.87 kg/m^3
Payload Mass	44.1 kg
Max Altitude Excursions	800 m

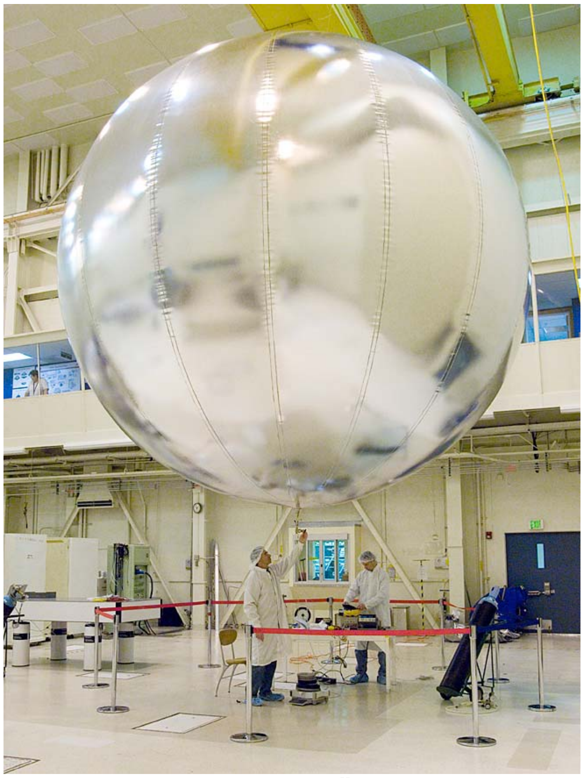

Fig 1. Prototype Venus Balloon During Testing

III. Mars

There are two balloon types under investigation for the exploration of Mars: Montgolfiere (Hot Air) and Helium Superpressure. Both designs are utilizing aerial deployment and inflation of the balloon envelope while descending in the Martian atmosphere as shown in Fig. 2. The aerial deployment and inflation of these designs is currently under investigation under funding from the NASA Mars Technology Program.

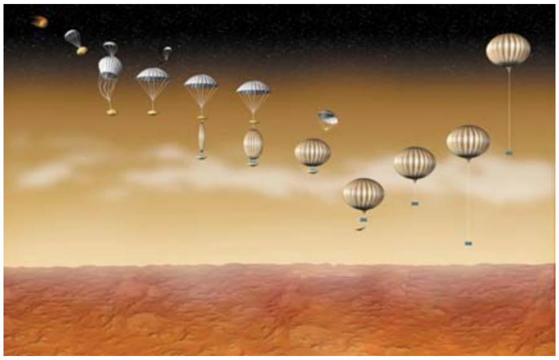

Fig 2.Depoyment and Inflation of Mars Balloon

A. Montgofliere Balloons

The Mars Montgolfiere balloon (Fig. 3) has an open bottom which allows the balloon to fill with the Martian atmosphere while descending. It is quickly heated by the sun providing the lift or buoyancy for the system. One limitation of this type of balloon is that it requires solar input for the lift and is therefore limited to flight in the polar regions during solstice when there is constant illumination.

A collaborative team of engineers from the Jet Propulsion Laboratory (JPL), NASA Goddard's Wallops Flight Facility, and Near Space Corporation as been working on the development and testing of a Montgolfiere balloon [6], [7].

The next step in the development is the aerial deployment and inflation of a 30 meter diameter Montgolfiere balloon fabricated out of a Nylon scrim reinforced Mylar film.

Fig. 3. Artist Rendition of Mars Montgolfiere Balloons

B. Helium Superpressure Balloons

The Superpressure balloon is inflated with Helium which needs to be transported to Mars in the spacecraft. There are two different designs under investigation: pumpkin and spherical shaped balloons (Fig. 4). This pressurized type of balloon can survive the diurnal (day-night) cycles encountered at the Martian mid-latitudes.

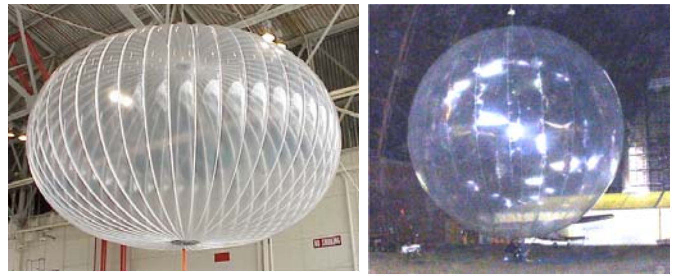

Fig 4. Pumpkin and Spherical Superpressure Balloons

A collaborative team of engineers from the Jet Propulsion Laboratory (JPL), NASA Goddard's Wallops Flight Facility, and Near Space Corporation as been working on the development and testing of a both Superpressure balloon designs [8], [9].

The next step in the development is the aerial deployment, inflation and float of a 12 meter diameter Mylar spherical balloon and 12.2 meter diameter polyethylene pumpkin balloon scheduled for late June 2007.

IV. Conclusion

It is desired that the exploration of Mars and Venus will be conducted on aerial platforms, such as balloons, in the future. The technology activities presented in this paper are critical for reducing the risk associated with these missions and increasing the Technology Readiness Level for each platform and should be continued.

Acknowledgement

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