Breakthrough in Mars Balloon Technology

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At the end of 1997, JPL initiated a the Mars Balloon Validation Program(MABVAP) to develop and validate the technology needed for a Mars balloon mission. The program drew on experiences of the previous Mars Balloon development efforts – Russian-French Mars Aerostat led by the French space agency CNES. Several NASA Centers also contributed to various stages of the test program – Langley, Ames, Lewis and Dryden. In 1999, NASA Goddard Space Flight Center, which had collaborated with JPL on earlier Mars balloon concepts prior to 1997, became a partner in MABVAP. The main focus of MABVAP was to develop and to test a viable concept for the Martian balloon that could be implemented on the small-scale dedicated or piggy-back mission.

The MABVAP was based on several principles: design compatibility with a small Mars micromission with scientifically meaningful payload; evolvability to long-duration flights and to larger sizes; and fabrication from known and proven materials. A comprehensive step-by-step test program was planned involving tests in a Mars-like environment for validation. Models simulating deployment and inflation at Mars would be validated by these Earth based tests. The program was designed to be flexible enough to be modified based on results of each step.

The major phases of the program were:

- baseline concept definition that included preliminary tests of sub-scale balloons in wind tunnel, vacuum chamber and free drop tests,
- ground and flight tests of sub-scale and full-scale balloons at hangars, vacuum chamber, and in troposphere, pull-tests of full-scale balloons,
- stratospheric deployment/inflation tests in the Martian-like environment. A number of models have been developed to better understand test results and make design changes.

Two major features – relatively small balloon and bottom inflation – contributed to ultimate success of the development. Two balloon designs were tested – 10-m spherical Mylar balloon and 500 m^3 polyethylene pumpkin balloon. After meeting milestones in the first year of the program the program experienced funding shortfalls which meant that modeling and simulation work was reduced and the costs of conducting flight tests had to radically reduced impacting reliability and to stretch out the duration of the program by an additional two years. This had its greatest impact on the stratospheric flight test program which the French experience had indicated to be the most challenging stage of development. Of nine stratospheric tests, four failed because of tow-balloon/launch failures or failures not related to the test balloon itself. The five remaining tests brought meaningful results – four with spherical balloons and one with a pumpkin balloon. In two of the spherical balloon tests, the balloon envelope ruptured on deployment. Analysis, modification of design and laboratory tests that followed these

failures resulted very recently in two successful stratospheric tests – one with spherical and another – with pumpkin balloon.

Though there is still a number of design details that should be tuned before the real mission, we believe that feasibility of the Mars Balloon concept has been proven.