Entry, Deployment and Science of Planetary Balloons

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Balloons can be effective platform to study *in situ* planets with atmospheres. Venus, Mars and Saturn moon Titan are the primary candidates. Passive balloons could serve as effective wind tracers to study the atmospheric circulation. They can carry instruments benefiting from close proximity to the surface: camera (on Mars and Titan), radar, magnetometer, neutron spectrometer, radiometers. Atmospheric structure instruments, acoustic and electromagnetic monitors are other candidates for surveying the planetary meteorology and environment. Balloons can deliver surface probes and relay data from them. Powered blimps on Titan and Venus can reach practically any desired destination to conduct detailed studies. On Titan they may deploy and retrieve surface packages and soil samples.

There are no major differences in the balloon design (except for material used) between the planetary and terrestrial balloons. Aerial deployment and inflation is the main – and the least understood - feature that is specific for planetary balloons. Several lump-mass models that were developed to simulate balloon deployment process clarified the basic factors but did not provided confident estimates of forces. Process of inflation when the descending parachute-balloon-gondola system is subjected to non-stationary aerodynamic forces is described even in fewer details.

VEGA balloons overcame problems with the "brutal force" method being made of robust heavy Teflon fabric. In modern environment fight for mass efficiency does not allow to use this method even for Venus and Titan. However, Venus and Titan have deep and dense atmospheres and even small (several meters in diameter) balloons can carry substantial payloads. Deployment and inflation of efficient thin-film balloons has been demonstrated successfully in Venus-like environment of the Earth troposphere. Moreover recently we demonstrated deployment and inflation of a blimp-shaped balloon of the size comparable to the Titan's blimp.

In case of Mars with its several millibar atmosphere the "brutal force" is inapplicable completely: Mars balloons have to be big (more than 10 m diameter) and light (i.e. made of thin film) to carry even a several kilogram payloads. Their deployment and inflation was considered (and correctly) as a major risk factor that effectively cancelled the Russian-French Mars Aerostat project and prevented selection of many Mars balloon proposals. Efforts of JPL in partnership with Goddard, other NASA Centers and industry resulted recently in the first successful stratospheric demonstration of deployment of the Mars balloon prototypes. Several video demonstrations of the tests and results of simulations of balloon trajectory during entry, deployment and inflation as well as simulation of balloon deployment process are presented.