Delft^{2}Mars

A low cost balloon system to map the Martian atmosphere and environment

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This feasibility study investigates the use of a small tethered balloon to perform scientific measurements on Mars. This system should be affordable within the budget of TU Delft and it has to be low-weight to be attractive as an additional instrument on a Mars mission.
Two concepts were designed which each will perform different measurements on Mars.

Rover support

In the first concept the balloon provides visual support to a Mars rover by taking high quality pictures with a camera suspended below the balloon. The balloon gives a better overview of the surface and speeds up the route determination of the rover.

Atmospheric measurements

The second concept focuses on the lower boundary layer of the Martian atmosphere. By means of small atmospheric packages distributed along the tether a local atmospheric profile is generated. Each package measures the temperature, pressure and humidity at a different altitude.

Challenge

The thin Martian atmosphere poses a big challenge; small changes in payload mass will result in large increases of balloon mass and size. The increase in size complicated the deployment as well.

General specifications

Communications	-	from the lander
Lifetime	-	90 Martian days
Power	-	from the lander
Cost	-	under □2 million
Tether length	-	100 m
Balloon gas	-	Helium

Camera concept

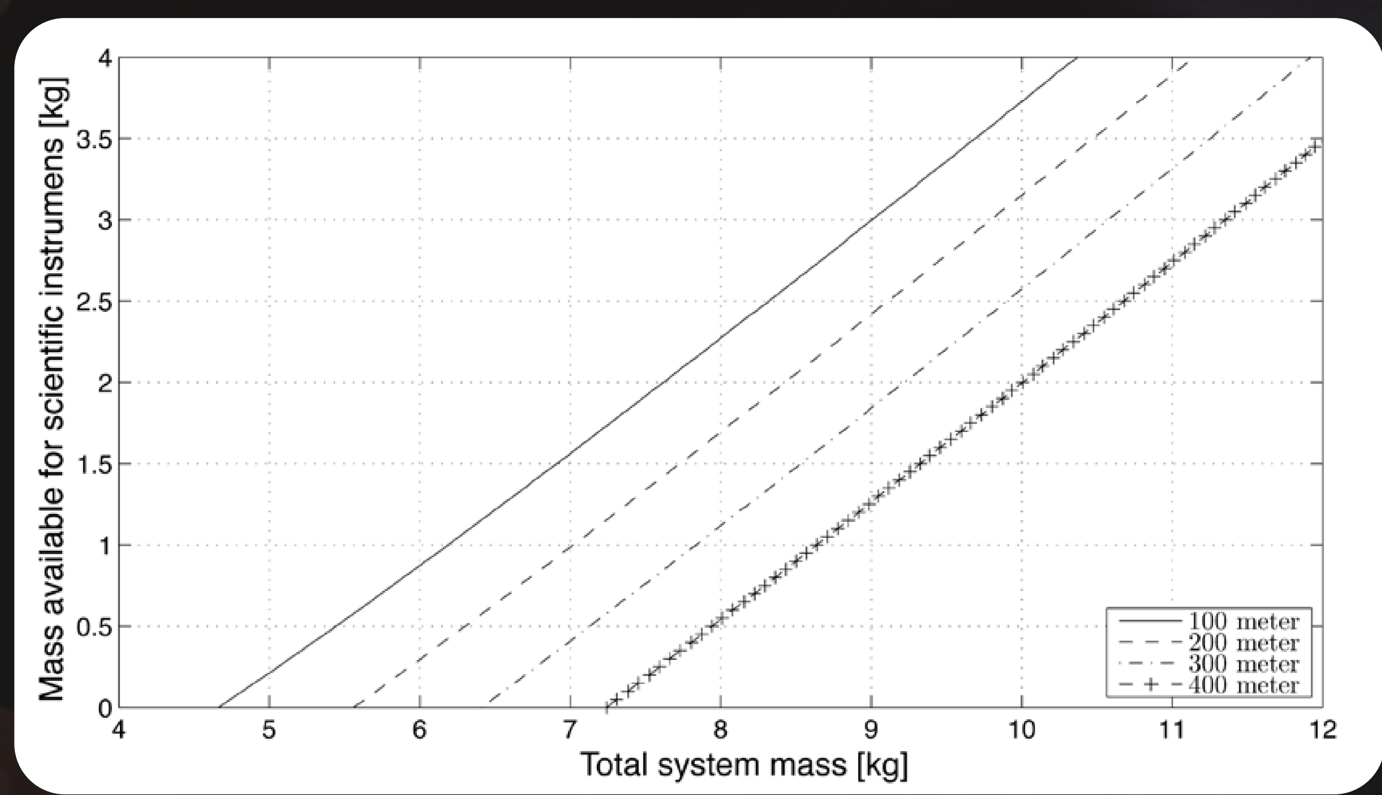
Power usage	-	2.5W active, 1.8W idle
Thermal system	-	passive and active
Resolution	-	0.09 x 0.08 m
System volume	-	15 L
System mass	-	8.3 kg

Atmopack concept

Power usage	-	15mW
Thermal system	-	absent
Resolution	-	10 packages
System volume	-	12 L
System mass	-	6.3 kg

Payload mass

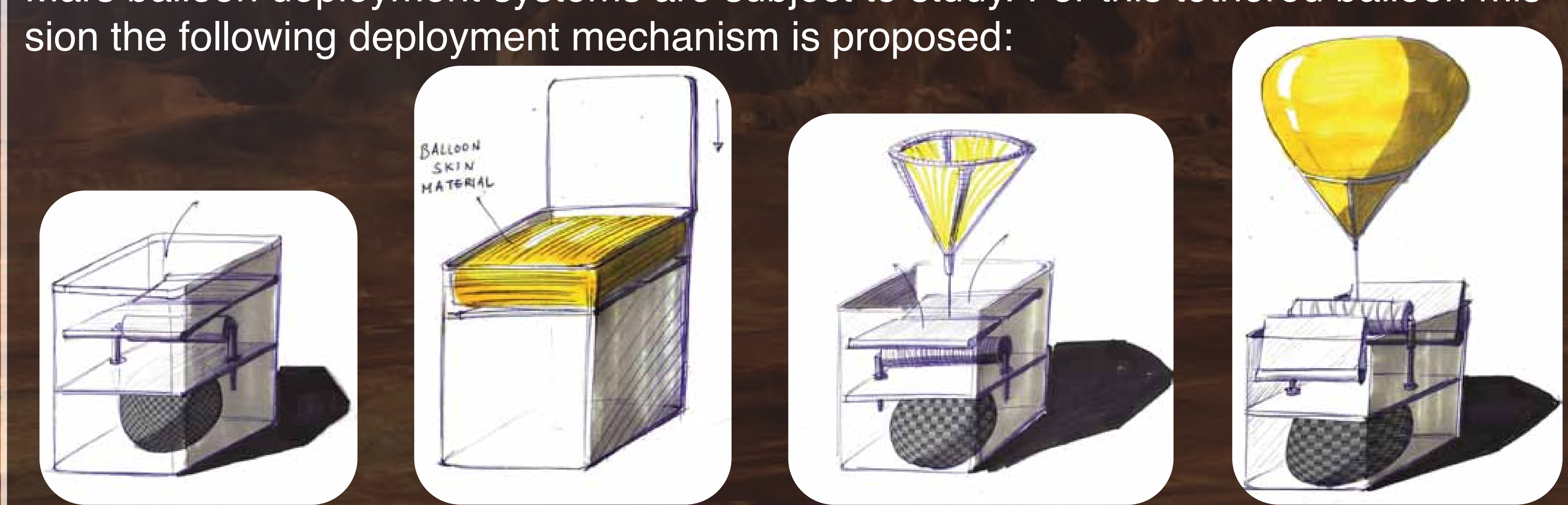
Payload mass and tether height have a significant impact on the mass of the total balloon system. Knowledge of these relations allows quick scaling for different flying payload mass. After scaling for the required flying mass the maximum allowable tether can be found.



This graph shows the relation between the payload mass and the complete mass of the system as a function of tether length for a balloon with a 6 micron LLDPE skin

Deployment

No balloon missions have been flown on Mars yet. Consequently, subsystems like Mars balloon deployment systems are subject to study. For this tethered balloon mission the following deployment mechanism is proposed:



1. The lid is opened
2. The lid slides down and the balloon starts unfolding
3. A cone is unfolded to guide the inflating balloon
4. The balloon is fully inflated and released

Testing

A weather balloon rigged with a camera was sent up to an altitude of 35 km. Here the atmospheric pressure and temperature are similar to the conditions in the Martian atmosphere.

The test showed that the suspended camera module rotates freely but that this motion does not hinder the camera performance.

Picture taken at approximately 6 km during the weather balloon test.

The background image is an artist rendering of the balloon tethered to a lander.
The image is not to scale and some elements of the design are not shown.

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