Vented Airbags: a new promising technology for Mars landers

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Since the Viking missions of NASA in 1975, the exploration of the surface of Mars represented a challenging task.
Several successful NASA missions followed the two Viking ones; in particular Pathfinder and MER robotic missions made possible to send rovers on the red planet, increasing enormously our knowledge of Mars.
Up to now, all the NASA robotic missions have used non vented airbags as landing system; when inflated, before the lander touchdown, the airbag protects the whole payload envelope, regardless the lander attitude at ground impact.
After several rebounds, nominally more than ten, the payload comes to the rest, the airbag is deflated and retracted, the landing platform is opened and finally the rover is able to move.
An innovative landing technology has been developed by Aero Sekur for the ExoMars mission of ESA, based on a vented airbag.
This new technology makes possible the deceleration of the payload, during the impact with the ground, by means of the gas compressed inside the airbag chambers, in the same way in which a non vented airbag acts, but, before the rebound of the payload, an on-board avionic system, acquiring the impact parameters (acceleration, velocity, …), is able to command the airbag valves to open, avoiding potential rebounds and guiding the lander softly onto the ground.
The algorithm implemented in the avionic software is able to cope with impact conditions, in terms of vertical and horizontal velocities, lander attitude, terrain slope and rock height, within a wide range.
The airbag shape is an hexagonal torus; each one of the six airbag chambers is controlled independently from the others, making possible to control the lander attitude during the airbag compression phase, so that the payload will land parallel to the terrain.
It is very interesting to be mentioned that the vent valve design is fully textile, making possible the folding of a valve having a diameter close to one meter.
Several drop tests, at Earth ambient conditions, have been successfully carried out, using a lander mock-up up to 600 kg and verifying most of the critical impact parameters.
LS-Dyna models have been used to verify the airbag performances and to predict the drop test behavior.
After the drop tests execution, the analytical models have been refined in order to correlate simulations and drop tests results.
The correlated models have been widely used to predict the airbag performances also at Mars ambient conditions.
In order to perform those simulations in the most accurate way, an airbag segment (one sixth of the whole airbag) was tested in a small vacuum chamber, verifying the vent valve behavior in representative Mars ambient conditions; the vent test results were implemented in the LS-Dyna models.