A LANDING PLATFORM WITH ROBOTIC SELF-LEVELING CAPABILITY R. Buchwald1, 2, 1German Aerospace Center (DLR), Institute of Space Systems, Robert Hooke-Str. 7., 28359 Bremen, Germany, robert.buchwald@dlr.de, 2Airbus Defence & Space, Airbusallee 1, 28199 Bremen, Germany, robert.buchwald@astrium.eds.net

Introduction: One of the most challenging tasks of a successful robotic sample return mission to Mars is the safe and precise landing of a rover or a re-ascent stage on the surface. Besides landing systems with landing legs, different types of airbag systems or the sky crane concept have successfully been used in the past. Airbags can properly attenuate the landing shock but cannot avoid uncontrolled roll over during the touch down phase and do not guarantee a sufficient precision. The highly complex sky crane system concept allows the precise direct delivery of a rover in challenging terrain, but the according very low touch-down velocities are hard to be achieved using European technology only. Landing systems with landing legs have a much simpler design with a great heritage and are able to land with the same precision but the distance of the rover to the ground after landing imposes challenges for the egress.

In the frame of the German national Triple-A and Triple-A follow-on projects1 [2], an alternative robotic concept based on a landing system with landing legs has been developed.

System concept description: During Mars atmospheric entry, the legs are folded at the side of the platform in order to fit in the capsule. During the parachute phase and after heat shield separation, the legs are deployed and latched in their landing position by a robotic deployment arm. The landing legs attenuate the landing shock and provide sufficient landing stability during touchdown. After touchdown, the primary latching bracket is released and the robotic arm allows to lower the platform to the ground for a simplified rover egress or to level the platform in the gravitational field in order to provide an adequate launch base for an ascent stage.

System development: The development of hardware and numerical models has been accompanied by intensive breadboarding activities. Within the applied bottom up test and verification approach [1], the complexity and level of integration is successively increased on the side of the physical and virtual test mockup in parallel, providing the highest level of traceability and correlation possible. Some of the performed tests are for example dedicated shock absorber material tests under different environmental conditions, footpad to soil interaction tests, shock absorber assembly friction and performance tests and single leg drop tests.

System demonstration:

The final system demonstration test campaign has been split into two parts - the touchdown system demonstration and the robotic system demonstration. The touchdown system has been demonstrated within a small series of drop tests under Earth gravity using a terrestrial full scale demonstrator of the Mars landing platform. The tests have been performed on soft soil as well as on an inclined rigid plane with one or more footpads being blocked by artificial obstacles.

The robotic system demonstration tests have been performed with the same full scale demonstrator under 3/8g on the Landing and Mobility Test Facility (LAMA) of the DLR Institute of Space Systems in Bremen [3]. The reduced gravitational environment is provided by active weight off-loading using a KUKA KR500 commercial off the shelf industrial robot.

References:

[1] Buchwald, R. etal; Stepwise development testing and technology demonstration of a landing system with landing legs; Proc. of the 60th German Aeronautical Congress, Sept. 2011, Bremen, Germany

[2] Buchwald, R. etal; A concept for the autonomous landing shock attenuation, self-leveling and lowering of a robotic landing platform; 10th International Planetary Probes Workshop, 2013, San Jose, USA


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