TERMINAL DESCENT AND LANDING SYSTEM ARCHITECTURES FOR A MARS PRECISION LANDER

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A Mars Precision Lander mission is currently being studied under ESA contract. A landing accuracy of better than 10 km is required, with a goal of 7.5km, which is significantly better than past Mars missions. A potential mission scenario considered for the precision lander is the landing of a Sample Fetch Rover. This rover would retrieve the sample cache obtained by NASA's Mars Astrobiology Explorer-Cacher (MAX-C) rover and place it in the Mars ascent vehicle within the overall Mars Sample Return mission architecture. A precise landing is non-trivial, and requires a highly accurate guided entry and likely a powered descent phase with potential hazard avoidance.

The critical terminal descent and landing phases will safely deliver the fetch rover to the Martian surface, and have been studied in detail in the first phase of the MPL contract. To protect the fetch rover, a maximum surface impact velocity of 1.5 m/s is specified, and the system must be able to land in an area with 99% areal density of 60 cm rocks and 22.5° surface slopes. A maximum horizontal wind velocity of 20 m/s and maximum vertical wind velocity of 5 m/s must be dealt with. A minimum of two egress paths must be available to the rover, and egress must be autonomous and highly reliable and robust.

A variety of architectures for the terminal descent and landing are possible and have been investigated, including:

- Legged landers
- Airbags – vented or unvented
- Crushable structures
- Dropship (Skycrane-type)
- Shell lander (Beagle-2 type)
- Parafoil/aerobot with control platform

The surface rocks and slopes strongly drive the architecture design. A hazard avoidance system is one option, otherwise the system must be able to land safely in the worst case scenario – a combination of a 60 cm rock and 22.5° slope. Self-righting mechanisms, such as jointed or extendible legs, are an option for legged landers in this case. Vented airbags are preferable to unvented airbags due to the precision landing requirement – unvented airbags can bounce for a large distance before stopping, potentially violating the precision landing requirement. The safe egress of the rover is highly interlinked with the terminal descent and landing architecture, and would require complex ramps, roll-out platforms or cranes with a legged lander or airbag system. A Dropship would enable a simple egress via a winch and cables, and would avoid the thruster plume and back pressure issues associated with Viking-type landers.

This paper will summarise the terminal descent and landing architecture concepts and trade-offs investigated in the first half of the Mars Precision Lander contract. The advantages and disadvantages of each will be outlined, particularly in regard to a precision landing, and the preferred concepts will be identified.