A PENETRATOR FOR THE JUPITER GANYMEDE ORBITER MISSION

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ABSTRACT

The Jupiter Ganymede Orbiter (JGO) forms the ESA contribution to the Europa Jupiter System Mission (EJSM), the other element of which is the Jupiter Europa Orbiter (JEO) provided by NASA. As part of the JGO studies, a Penetrator is being considered as a potential payload element for deployment on either Ganymede or Callisto.

The JGO spacecraft will provide a range of imagery and remote sensing data from a series of flybys at both Callisto and Ganymede, followed by an extended period in orbit around Ganymede. The output of this remote sensing data will provide considerable knowledge of the Jovian system, but always from afar.

Delivering a suite of instruments to the surface of Ganymede would support the remote sensing data by providing a valuable ground truth against which to calibrate Orbiter instruments, or to provide additional local data in support of derived models of Ganymede's interior structure, especially related to the existence, depth and thickness of a liquid water layer or ocean.

The challenges of providing a soft-landing onto a large, airless body are significant, and necessitate a system which is complex, and consequently has a large mass. Furthermore, the soft-lander is inherently sensitive to descent rate errors, and this can only be mitigated by adding additional hardware and redundancy.

One way to make the Lander inherently less sensitive to landing parameter errors is to increase its nominal impact velocity by an order of magnitude (or more). This increases the allowable impact rate error, and consequently the accumulated descent trajectory errors. The resulting Penetrator can carry a ruggedised suite of instruments into the surface of the moon, with minimal deformation of the shell, and shock loadings well within the capabilities of the selected instruments, and all delivered by a relatively simple, low-mass delivery system.

The mass savings of a Penetrator together with its Penetrator Delivery System (PDS) as compared to soft-landers are especially pronounced on large bodies without atmospheres such as the Jovian icy moons, where atmospheric braking cannot be employed to remove a large portion of the landing velocity. However, the mass of the PDS is not insignificant, since some complexity and considerable de-orbit impulse still remains. In the current study, where the delta-v from Ganymede circular orbit at 200km to the surface is about 2km/s, the mass of the fuel itself required to de-orbit has been shown to be about 40kg, for a nominally 15kg Penetrator element. The resulting total mass of the complete PDS and Penetrator system may thus be as high as 5-6 times the mass of the Penetrator itself.

This paper will present the mission concept that is being studied under ESA contract by a UK consortium involving Astrium (as prime contractor), Mullard Space Science Laboratory (MSSL) and QinetiQ. The key technical outcomes of the study, with respect to the system design, analysis of delivery trajectory and impact, impact modelling and planetary protection issues. In addition, the implications of this study will be assessed with respect to other future applications for penetrators in the exploration of Solar System bodies.