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Exploring medium gravity icy planetary bodies: an opportunity in the Inner System by landing at Ceres high latitudes

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With potentially up to 25% of its mass as H2O and current indications of a differentiated morphology, 950km-wide "dwarf planet" Ceres is holding the promise to be our closest significant icy planetary body. Ceres is within easier reach than the icy moons, allowing for the use of solar arrays and not lying inside the deep gravity well of a giant planet. As such, it would represent an ideal step stone for future in-situ exploration of other airless icy bodies of major interest such as Europa or Enceladus. But when NASA's Dawn orbits Ceres and maps it in 2015, will we be ready to undertake the next logical step: landing?

Ceres' gravity at its poles, at about one fifth of the Moon's gravity, is too large for rendezvous-like asteroid landing techniques to apply. Instead, we are there fully in the application domain of soft precision landing techniques such as the ones being developed for ESA's MoonNext mission. These latter require a spacecraft architecture akin to robotic lunar Landers or NASA's Phoenix, and differing from missions to comets and asteroids.

If Dawn confirms the icy nature of Ceres under its regolith-covered surface, the potential presence of some ice spots on the surface would call for specific attention. Such spots would indeed be highly interesting landing sites. They are more likely to lie close to the poles of Ceres where cold temperatures should prevent exposed ice from sublimating and/or may limit the thickness of the regolith layer. Also the science and instruments suite should be fitted to study a large body that has probably been or may still be geologically active: its non-negligible gravity field combined with its high volatile mass fraction would then bring Ceres closer in morphology and history to an "Enceladus" or a frozen or near-frozen "Europa" than to a rubble-pile-structured asteroid or a comet nucleus.

Thales Alenia Space and the "Laboratoire de Planétologie et Géodynamique" of the University of Nantes have carried out a preliminary assessment of a mission to Ceres high latitudes. We present here why we think an in-situ mission to the polar areas of Ceres should be of interest in the near future. We dwell on the environmental factors and challenges for a Lander, both as specificities of Ceres and as a consequence of the high latitude targeted. Factors such as day duration, fine regolith, terrain hazards, optical contrasts, thermal gradients, planetary contamination... are reviewed. We then assess how the soft precision landing technologies being developed for other missions would apply in such an environment. We present a preliminary mission analysis and a concept for the Lander, with preliminary evaluation of mass and power resources for a fixed payload or for a mini-rover. The resulting mission design combines technological maturity and a launch mass that is found compatible with the moderate cost of a Soyuz launcher.

Finally we conclude that a Ceres Polar Lander mission should be feasible, covered by automatic missions to the Moon in terms of difficulty of landing and by Dawn for the cruise. Lander missions to medium gravity bodies such as Ceres, Enceladus, Europa, Ganymede, Callisto, Iapetus, Triton… in the [0.01-0.15g] range should be accounted for in the development roadmaps of landing techniques and be considered in their return on investment. The synergies with the soft landing missions to come on Mars and Moon should then make a Ceres lander affordable for the agencies within the end of the next decade and pave the way for in-situ missions to more distant icy bodies.