MARCOPOLO-R: NEAR EARTH ASTEROID SAMPLE RETURN MISSION IN ASSESSMENT STUDY PHASE OF ESA M3-CLASS MISSIONS. P. Michel[1], M.A. Barucci[2], A. Cheng[3], H. Böhnhardt[4], J.R. Brucato[5], E. Dotto[6], P. Ehrenfreund[7],I.A. Franchi[8], S.F. Green[8], L.-M. Lara[9], B. Marty[10], and D. Koschny[11], [1]Lagrange Laboratory, Univ. Nice, CNRS, Côte d'Azur Observatory, B.P. 4229, 06304 Nice Cedex 4, France (michelp@oca.eu), [2]LESIA-Obs. Paris, F, [3]JHU-APL, Maryland, USA, [4]MPS, Katlenburg-Lindau, D, [5]INAF-Obs. Arcetri, I, [6]INAF-Obs. Roma, I, [7]Univ. Leiden, NL, [8]Open Univ., Milton Keynes, UK, [9]IAA-CSIC, Granada, E, [10]CRPG, Nancy, F, [11]ESTEC, ESA, NL.

Introduction: MarcoPolo-R is a sample return mission to a primitive Near-Earth Asteroid (NEA) selected in February 2011 for the Assessment Study Phase at ESA in the framework of ESA's Cosmic Vision 2 program. MarcoPolo-R is a European-led mission with a proposed NASA contribution. MarcoPolo-R will rendezvous with a unique kind of target, a primitive binary NEA, scientifically characterize it at multiple scales, and return a unique pristine sample to Earth unaltered by the atmospheric entry process or terrestrial weathering.

The MarcoPolo-R proposal is based on the previous Marco Polo mission study [1], which was selected for the Assessment Phase of ESA's Cosmic Vision 1 program in 2007. Its scientific rationale was highly ranked by ESA committees but it was not selected for the Definition Phase in 2010 because the estimated costs were higher than the allotted amount for an M class mission. The aim of the new Assessment Study is to reduce the cost of the mission while maintaining its high science level.

Scientific requirements: The main goal of the MarcoPolo-R mission is to return unaltered primitive NEA material for detailed analysis in ground-based laboratories. The limited sampling provided through collection of meteorites does not offer the most primitive material available in near-Earth space. More primitive material, having experienced less alteration on the asteroid, will be more friable and would not survive atmospheric entry in any discernible amount.

MarcoPolo-R will allow the analysis of some of the most primitive asteroid material in ground-based laboratories and the study of the formation of the solar system and its planets, the characterization of an NEA as a representative of a primitive solar system body, and will contribute to the field of astrobiology. The sample will provide a legacy for future generations of scientists with the potential for application of new analysis techniques and instrumentations.

Target selection: The baseline target of MarcoPolo-R is the primitive binary NEA (175706) 1996 FG3, which offers a very efficient operational and technical mission profile. A binary target also provides enhanced science return: the choice of this target will allow new investigations to be performed more easily compared to a single object, and also enables investigations of the fascinating geology and geophysics of asteroids that are impossible to obtain from a single object. Moreover, sample return from a binary would bring us crucial information: i) that may allow discrimination between the proposed formation mechanisms of binary systems, ii) about the internal composition of the progenitor (as part of the surface of the primary may well correspond to some material that was located in the interior of the progenitor; Fig. 1).

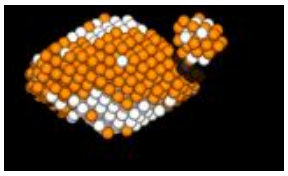

Figure 1: *Image of a simulation of binary formation by YORP spin-up; orange particles were originally located at the surface of the progenitor while white particles were originally below the surface. It can be seen that the pole of the primary is essentially composed of white, initially sub-surface, particles [2].*

Mission Profile: Several missions have been already studied internally by ESA with two launch windows, in 2021 and 2022, and sample return in 2027 and 2029. Once at the NEA, a number of potential sampling sites (up to 5) are characterized by remote sensing measurements. The spacecraft will then attempt to sample surface material (order of 100g) on the most suitable site. Several options of the sampling acquisition system are under study at ESA. A sample mechanism is also under study at NASA.

Conclusion: The large international interest for sample return missions to primitive asteroids is demonstrated by recent selections of main space agencies. NASA selected the mission OSIRIS-REx in the program New Frontiers for launch in 2016 (return in 2023), while the mission Hayabusa 2 is now in phase B at JAXA for launch in 2014 (return in 2020). Given the diversity of the targeted objects and the different sampling strategies adopted by different missions, different kinds and amounts of material will be sampled. It is important that several sample return missions are sent to different objects using different sampling approaches, so that we can enhance our knowledge on the diversity of primitive bodies.

References: [1] The Marco Polo Science Team (2009), ESA/SRE(2009)3 Marco Polo, ESA Publi. Division. [2] Walsh K. J. et al. (2008) Nature 454, 188.