JOINT EUROPA MISSION (JEM). A MULTISCALE STUDY OF EUROPA TO CHARACTERIZE ITS HABITABILITY AND SEARCH FOR EXTANT LIFE. O. Prieto-Ballesteros[1], M. Blanc[2], N. André[2], J. Gómez-Elvira[1], G. Jones[3], V. Sterken[4], D. Mimoun[5], A. Masters[6], Z. Martins[6], E. Bunce[7], W. Desprats[2], P. Garnier[2], G. Choblet[8], V. Lainey[9], F. Westall[10], T. van Hoolst[11], A. Jäggi[12], L. Iess[13], A. Longobardo[14], F. Tosi[14], P. Hartogh[15], K. Stephan[16], R. Wagner[16], N. Krupp[15], J. Cooper[17], B. Bills[18], K. Hand[18], S. Vance[18], R. Lorenz[19], K. Khurana[20], S. Kempf[21], G. Colins[22], E. C. Sittler[17], K. Szegő[23], M. Wolwrck[24] and the JEM team. [1]CAB-CSIC-INTA, Spain (prietobo@cab.inta-csic.es). [2]IRAP, France (michel.blanc@irap.omp.eu). [3]MSSL/UCL, UK. [4]ISSI, Switzerland, [5]ISAE, France. [6]Imperial College, UK. [7]U. Leicester, UK. [8]U. Nantes, UK. [9]IMCCE, France. [10]CBM, France. [11]ROB, Belgium. [12]AIUB, Switzerland. [13]Univ. Roma La Sapienza, Italy. [14]IAPS, Italy. [15]MPS, Germany. [16]DLR, Germany [17]Goddard Space Flight Center, USA. [18]Jet Propulsion Laboratory, USA. [19]APL/JHU, USA. [20]UCLA, USA. [21]LASP, Univ. Colorado, USA. [22]Wheaton Colleage, USA. [23]WIGNER, Hungary. [24]IWF, Austria.

Introduction: There is a consensus in the planetary community that Europa is the closest and probably the most promising target to search for extant life in our solar system. The Galileo discovery of a sub-surface ocean likely in direct contact with a silicate floor that could be a source of the key chemical species needed for the build-up of biomolecules, the many indications that the ice shell is active and may be partly permeable to transfer materials, including elementary forms of life, and the identification of candidate thermal and chemical energy sources necessary to drive a metabolic activity, have raised great hopes that Europa is likely habitable, and strongly support a scientific plan to go there and see if it is indeed inhabited.

We propose that ESA works with NASA, which presently leads the way towards in situ exploration of Europa, to design and fly jointly an ambitious and exciting planetary mission to reach this objective. In doing so, we aim at characterizing biosignatures in the environment of Europa (surface, subsurface and exosphere), while we also want to address a more general question: how does life develop in a specific habitable environment, and what are the evolutional properties of a habitable planet or satellite and of its host planetary/satellite system which make the development of life possible.

The Jupiter Europa Mission (JEM) proposal was submitted to the ESA M5 call last October 2016, and is now under study.

Scientific goals of JEM: Our search for life there will build on the advanced understanding of this system which the missions preceding JEM in its exploration will provide: improved understanding of its origin and formation (JUNO), of its evolutionary mechanisms (JUICE) and even a preliminary comparative understanding of its habitability: while JUICE will characterize a "type IV habitat" at Ganymede, NASA's EMFM mission will provide a first characterization of a "type III habitat" at Europa, using a multiple fly-by strategy. Building on these invaluable assets, the overarching goals for JEM is:

"Understand Europa as a complex system responding to Jupiter system forcing, characterize the habitability of its potential biosphere, and search for life in its surface, sub-surface and exosphere."

We suggest to address these goals by a combination of five Priority Scientific Objectives, each with focused measurement objectives providing detailed constraints on the science payloads and on the platforms used by the mission. Our observation strategy to address them will combine three types of scientific measurement sequences: 1) measurements on a high-latitude, low-latitude Europan orbit providing a continuous and global mapping of planetary fields (magnetic and gravity) and of the neutral and charged environment during a period of three months; 2) in-situ measurements to be performed at the surface, using a soft lander operating during 35 days, focusing on the search for biosignatures at the surface and sub-surface by analytical techniques in the solid and liquid phases, and on the operation of a surface geophysical station whose measurements will ideally complement those of the orbiter; 3) and measurements of the chemical composition of the very low exosphere in search for biomolecules originating from the surface or sub-surface, to be performed near the end of the mission during the final descent phase.

The implementation of these three observation sequences will rest entirely on the combination of two science platforms equipped with the most advanced instrumentation: a soft lander to perform all scientific measurements at the surface and sub-surface at a selected landing site, and an orbiter to perform the orbital survey and descent sequences. In this concept, the orbiter will also provide for the lander the vital functions of carrier, with the objective of carrying the lander stack from the Earth to a Europan orbit on which it will release it before its descent, and of data relay during the 35 days of lander operations. Using its own instrument platform, it will in perform science operations during the relay phase on a carefully optimized halo orbit of the Europa-Jupiter system, before moving to its final Europan science orbit for three months.

Payload proposed for JEM: We derived from our science objectives a carefully selected science payload for the lander and for the orbiter.

Our proposed orbiter payload suite includes six well-proven instruments provided by European institutes in an international collaboration framework to characterize the planetary fields and the plasma, neutrals and dust environment, fitting within the allocated mass, and one additional instrument that will be considered depending on the mass margin to be identified after the assessment study. To efficiently address the radiation issue, we propose to decouple the sensor heads from the other parts of the electronics, and to group these parts in a dedicated vault, or a well-shielded location within the platform, that will facilitate radiation mitigation. Appropriate planetary protection measures corresponding to at least Planetary Protection Category IVb will be implemented to all subsystems, including the payload and the spacecraft element.

Our lander science platform is composed of a geophysical station and of two complementary astrobiology facilities dedicated to biosignature characterization experiments operating respectively in the solid and in the liquid phases. The design and development of the liquid phase laboratory, called AWL for "Astrobiology Wet Laboratory", will be a specific European contribution to the surface science platform. The two astrobiology facilities will be fed by a common articulating arm operating at the platform level that will collect the samples at the surface or sub-surface and will deliver them to the analytical facilities. We are proposing two alternative options for the deployment of AWL: inside the main platform, where it would benefit from all its infrastructure and services, or outside of it as an independent sub-platform, to be deployed with the help of the articulated arm. Further discussions between NASA and ESA will be needed to identify the best option.

Mission configuration: To fly the JEM mission, while making it affordable to the two Agencies and making JEM an appealing joint exploration venture for the two of them, we propose an innovative distribution of roles; while NASA will provide an SLS launcher, the lander stack and will cover most of the mission operations, ESA will design and provide the carrier-orbiter-relay platform. This delivery is technically possible using a safe technical approach, taking advantage of a double heritage of European developments for space exploration: the JUICE spacecraft for the JEM orbiter avionics, and an adaptation of the ORION ESM bus to the specific needs of JEM for its structure. This approach to the provision of the carrier makes it possible to propose a total contribution of ESA to JEM that fits well within the limits of an M-class mission, as required. Thanks to this approach, a joint venture of NASA and ESA to fly the first mission that will go and search for extant life outside our own planet becomes both fully credible and extremely appealing.

This way, JEM can be the next major exciting joint venture of NASA and ESA to the outer solar system, inspired by and following the unique success of Cassini-Huygens. It will provide an outstanding opportunity to preserve and develop the unique spirit of collaboration and friendship which links the European and American planetary science communities, by proposing to these two communities to work together toward one of the most exciting scientific endeavours of the XXIst century: to search for life beyond our own planet.