# *Space Debris Mitigation Support : POLPO® Software for a Green Access to the Space*

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In the last decades, many efforts have been focused on the safeguard of the health of our Planet to limit the consequences owed to a wrong approach adopted in the past. In this context, the space debris proliferation represents a relevant issue which led to the constitution of a global forum qualified to define the international guidelines and all the legal aspects for the safe access and the peaceful use of the Outer space. These specifications must be taken into account during the planning and the design of spacecrafts and launch vehicles, with a clear impact on the companies offering access to space.

As answer to these obligations, the space companies effort aims to develop state-of-the-art simulators able to realize high-fidelity mission analysis, in order to guarantee the compliance wrt applicable safety requirements.

According with this trend, the first purpose of this work was, in its most generic definition, the development of an accurate and flexible code (*POLPO* Software) able to compute the in - orbit trajectory of spacecrafts, with the aim of assessing the risk of debris generation, due to the losses of parts or to catastrophic events, during some phases of the operative life of the spacecraft.

POLPO® (standing for *Propagatore Orbitale di Lungo Periodo Ottimizzato*) Software has been developed during a collaboration between ELV, "University of Pisa" and "La Sapienza" University of Rome; it is able to perform the orbital propagation among several bodies under the effects of the perturbations of the Space Environment.

A very accurate Space Environment model is adopted and the most relevant space perturbations are taken into account : Earth Gravity Field (EGF) Asymmetries, Atmospheric Effects, Luni-Solar Effect and Solar pressure. In particular, the flexibility, which characterizes this code, leaves to the users the possibility to choose the type and the number of the spherical harmonics, according to the Potential Theory, which are used to define the EGF. The density model of the atmosphere is defined as a function of the month, latitude and altitude. The code is also provided with a MonteCarlo task, which let to perform the De-Orbiting simulation of two bodies with scattering data in terms of initial conditions (position and velocity) , masses and drag coefficients, in order to take into account the dispersions on the initial data.

Since the choice of the considered perturbations is not defined by default and no limitations are imposed to their combination the code represents a valuable tool to deepen the understanding of the

effects of each perturbation on the considered body. It is possible to perform, for example, a simulation with only the Luni-Solar effect without taking into account the effects of the other Outer Space perturbations. This characteristic could help in the understanding of the effective influence of each perturbation on the bodies released into the Outer Space with the purpose of identifying which effects are negligible.

The high intrinsic performances of this tool make POLPO® Software an ideal tool for industrial uses, and currently, in the frame of the VEGA program , it is used for the Lifetime Analysis and the In-Orbit Collision Analysis by ELV, which, as prime contractor of VEGA Launcher, must submit the mission analysis results to the safety authority.

For "Lifetime & In-Orbit Collision Analysis" use, POLPO® is an high fidelity variable-step propagator capable of integrating with maximum accuracy the orbital parameters of orbiting bodies, spanning from the Short to the Long Period, and to check their mutual distance.

The lifetime Analysis is realized with the purpose to guarantee the indirect atmospheric reentry of the AVUM, the Upper stage of the VEGA LV, within 25 years, according to the Space Debris International Regulations.

The In-orbit Collision Analysis is realized with the purpose to exclude a potential in-Orbit collision after the P/L release. Usually, the two bodies involved in this analysis, in the ELV frame, are the AVUM and its P/L.

As further application, a safety task of POLPO® Software has been recently developed. It could be used by ELV as support for the "Far Range Analysis". As to concern this analysis, the attention is focused on the first minutes of flight, which represent the most dangerous phase for the on - ground safety, because the possible fragments, generated by a catastrophic event, could impact on a populated area. In the frame of the Far -range Analysis, the Safety task of POLPO has to be used to obtain the IP ( *Impact Point*) of the Launcher fragments, for each point of interest of the ascent trajectory of VEGA Launcher.