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***Vertue*, a green orbital module to meet the growing demand for in-orbit operations**

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Abstract

Over the past two decades, initiatives from commercial and private actors have decentralized space, taking over governmental entities and propelling a new-born space economy, where novel economic activities and opportunities blossom aplenty. Among them, in-orbit operations are long set to disrupt the space ecosystem in a foreseeable future [1]. In the wake of this new-space momentum, the number of objects orbiting Earth is skyrocketing at a dramatic rate each year [2]. Mega constellations (Starlink, Kuiper, OneWeb already in service) are crowding an already congested low-Earth environment. In this regard, active debris removal (ADR) as part of in-orbit operations might answer the urgent call for long-term sustainability. Focusing on the geostationary belt, life-extension services by means of refuelling would maximize the return from GEO missions of a significant number of satellites which will reach EOL over the next decade. As announcements for new generation launch systems adopting a two-stage-to-orbit architecture increase, so does the need for Last Mile Delivery (LMD) services. ADR, life-extension, and LMD services represent addressable markets with expected revenues in the order of billions of USD by the half of the thirties [3]. In-space manufacturing and assembly, satellite inspection and maintenance, tugging and towing, payload download services are only another handful of possibilities in the realm of in-orbit operations, in and beyond Earth orbit [4]. Cislunar and Martian activities fostering a deep space economy are in the plan [5]. Overall, in-orbit operations are an emerging business opportunity, that anticipates an already booming market.

Finis Terrae, an innovative start-up based in Rome, is eager to seize this opportunity. An orbital propulsion module, *Vertue*, is under development to meet the demand for in-orbit operations, leveraging access to space through the Vega family of European small launchers. The present paper reviews the up-to-date space launch market analyses focusing on small lift vehicles, thereby identifying needs and suitable use cases. Within the standard of the Vega Space System— a modular evolution of Vega capable of tailoring the launcher to different missions— the *Vertue* module will enable orbital operations, providing propulsion to in-orbit servicing, Spacerider and deep space missions. The design of the module, based on advanced composite materials and a smart arrangement

of the tanks with the propulsive subsystems, results in a structural efficiency parameter up to 70% better when compared to current competitors in the market. This translates in several hundred kilograms more payload mass for the same velocity increment ΔV . The propulsive unit, a liquid rocket engine burning a green combination of propellants, may be simply disconnected and replaced, thus providing maintainability. More details about the design, the status of the project and plans of development will be provided in the final manuscript.

References

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