IAF SPACE TRANSPORTATION SOLUTIONS AND INNOVATIONS SYMPOSIUM (D2)
Emerging Space Ventures, including Space Logistics and Space Safety for Sustainability (9-D6.2)

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THE DEVELOPMENT OF A REFUELLING TUG FOR SERVICING GEO SATELLITES

Abstract

In-orbit refuelling is key to achieving long-term human presence on the Moon and Mars, and to making space more sustainable. This technology will enable more efficient mission profiles, such as multi-launch missions where the main craft is launched empty and refuelled in an intermediary orbit. In-orbit refuelling will also enable mission extensions for expensive GEO satellites, as well as permitting multi-debris removal missions in LEO. A cryogenic depot with active cooling could be placed in these orbits and be used as an easily accessible long-term storage.

Due to the variety of mission profiles for in-orbit fuel storage and transfer, the use of a combination of depots and refuelling tugs will be necessary. Previous studies designing small cryogenic propellant depots for refuelling GEO satellites showed that while the upper stage of the Ariane Next can efficiently deliver propellant to GTO, it is too large to efficiently perform the transfer to GEO. Tugs are therefore necessary to transfer the propellant to GEO and between the depot and various spacecrafts.

Such a tug has to both be capable of being refuelled in orbit by the depot, and also of refuelling other crafts in GEO. As such a tug has to both be able store propellant for long durations as well as condition it for the receptor tank. The main challenge of storing cryogenic propellant comes from preventing boil-off during long term storage. The type of cooling will be determined primarily by the duration between each time the tug is refuelled.

This study first analyses in depth the typical mission profile of the tug, determining the typical ΔV requirements and mission durations. This is used to trade off various configurations and propulsion systems, to determine the necessity of active cooling of the tanks and identify the key limitations arising from both needing to be refuelled and to refuel other tanks. From this, a preliminary design for the is presented.