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INTEGRATED RIDESHARE MISSION PLANNING FOR SMALL SATELLITES USING ORBITAL TRANSFER VEHICLE

Abstract

The advancement in standardization and miniaturization of satellite components have enabled the use of Commercial off-the-shelf (COTS) components, thus enhancing the efficiency and cost-effectiveness of satellite development. Consequently, there has been a notable increase in demand for small satellite launches, which is expected to persist and expand steadily. Nevertheless, the availability of launch services to accommodate the rapidly growing number of small satellites remains constrained. While launching through a small dedicated launch vehicle appears attractive in satisfying mission requirements such as launch schedule and target orbit insertion, it still suffers from high launch costs. Alternatively, piggyback or rideshare launches present a more economical option for satellite deployment. However, they are challenged by limited launch schedule flexibility and difficulties in achieving optimal orbit placement for satellite operation. Integrating an orbital transfer vehicle(OTV) into rideshare launches offers a promising solution to mitigate these drawbacks. The OTV enables orbit transfer through either chemical or electric propulsion systems, rendering them suitable for last-mile delivery to insert small satellites into their target orbits. This allows for rideshare launches where satellites with similar launch schedules and target orbits can be grouped and launched simultaneously, effectively satisfying the requirements of each satellite. This paper proposes an integrated rideshare mission planning framework for small satellites using orbital transfer vehicles. The decision-making process involves determining the optimal launch schedule, considering factors such as the launch vehicle performance and launch cycle to send all satellites to target orbits within their launch windows at minimum cost. The problem also includes deciding which satellites will be accommodated on each launch vehicle and establishing the visiting sequence of OTVs. This problem can be viewed as a broad range of multi-vehicle routing problems(MVRP) and formulated as a combinatorial optimization problem. Due to the complexity and difficulty of the problem, this paper adopts the column generation approach, a well-established technique commonly used for the vehicle routing problem in aerospace systems. A case study is conducted to validate the problem formulation and solution procedure and analyze the advantages of using OTVs for ridesharing missions.