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ECONOMIC ANALYSIS OF REUSABLE LAUNCH VEHICLE SYSTEM

**Abstract**

In the field of aerospace transportation, extensive space activities are limited by the cost of launch vehicles. The key of reducing cost is believed to rely on reusable launch vehicle systems. Until now, only the Space Shuttle Orbiter and the first stage of Falcon 9 have achieved reusability. However, in contrast to the original intention of reducing cost, the practical use of the Space Shuttle turned out to be expensive. The last Space Shuttle Atlantis was retired in 2011. In 2017, Falcon 9 from SpaceX successfully reused its first stage. Besides, the upcoming reusable XS-1 will be tested in 2020. It will lift off vertically and land horizontally, just like the Space Shuttle. Until now, only the fee of each launch of Falcon 9 is published, while the benefits of reusable first stage remain unknown. XS-1 aims to reduce the time and the cost required to space by orders of magnitude, but the task may be challenging. In this paper, methods from commercial aircraft industry are used to consider the life-cycle-cost of reusable launch vehicles. Firstly, the cost and labor of R&D and manufacturing for Space Shuttle, Falcon 9 and XS-1 is analyzed. Secondly, the impact of technical parameters on the cost is compared, including launching and landing mode, max speed and thermal protection requirements. Finally, taking operating cost and disposal cost into account, the life-cycle-cost of the three reusable launch vehicle system is estimated. It is shown that without complex thermal protection system, Falcon 9 and XS-1 can significantly reduce the cost, compared with the Space Shuttle. However, it is also noteworthy that although reusable launch vehicles may reduce the manufacture cost, the operating cost, including fees for launching / landing sites and TT&C systems, will still be an important part of life-cycle-cost. The study helps to evaluate the value of developing reusable launch vehicle systems in China.