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SOUNDING ROCKET SS-520: ITS CAPABILITIES AS A CUBESAT LAUNCH VEHICLE

Abstract

This paper discusses SS-520's capabilities as a dedicated CubeSat launcher. SS-520 is a two-stage solid-motor rocket with spin stabilization, which was developed originally as a sounding rocket by JAXA. The first and second launch of SS-520 was demonstrated in 1998 and 2000, respectively. After that, no launch had been scheduled for more than 10 years until SS-520-4 was launched in January 15th, 2017.

SS-520-4 was an orbital launcher that attempted to place a single 3U-sized CubeSat into a low earth orbit. SS-520-4 obtained its launch vehicle capability by installing a third stage motor in addition to the Reaction Control System (RCS) between the 1st and 2nd stages. The 3rd stage can produce acceleration close to half of the necessary Δv to reach the target orbit while the developed RCS is capable of controlling the fast-spinning (designed for 1.6 Hz) spacecraft with its excellent performance in stable response. However, SS-520-4 failed to reach the orbit due to a loss of its telemetry caused by the short circuit about 20 seconds after the lift-off. SS-520-5, which was the retry mission of SS-520-4, finally achieved successful launch carrying the 3U-sized CubeSat into orbit in February 3rd, 2018.

One of the largest features of SS-520-4/5 was its elliptic orbit, whose target altitudes of perigee and apogee were about 180 km and 1500 km, respectively. Its elliptic shape was caused by its system configuration of the single attitude control system installed only between 1st and 2nd stages and the original Δv capability of the 1st stage motor. As a result, the role of the 1st stage motor was to earn the necessary altitude of perigee while the 2nd and 3rd stage accelerated the vehicle horizontally to gain the necessary velocity for orbiting the earth. However, its launch capabilities may increase significantly if some modifications are applied to the vehicle. For instance, installing the additional attitude control system between the 2nd and 3rd stages may enable the vehicle to reach the higher altitude of perigee and increase the life time of the payload in orbit, which would be much more attractive among most spacecraft.

In this paper, SS-520's CubeSat launch capabilities are investigated beyond SS-520-4/5 launch vehicle. Its launch capabilities are analyzed for several CubeSat categories in term of its mass and size.