IAF SYMPOSIUM ON SECURITY, STABILITY AND SUSTAINABILITY OF SPACE ACTIVITIES (E9)
Interactive Presentations - IAF SYMPOSIUM ON SECURITY, STABILITY AND SUSTAINABILITY OF SPACE ACTIVITIES (IP)

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ENSURING LONG-TERM SUSTAINABILITY OF OUTER SPACE ACTIVITIES DURING CHANDRAYAAN-3 MISSION

Abstract

Indian Space Research Organisation (ISRO), as a responsible space-faring agency, has always placed high importance on the safety and sustainability of outer space activities by voluntarily adopting the pertinent guidelines and best practices in its space programmes. On Aug 23, 2023, ISRO's Chandrayaan-3 mission achieved the first-ever soft landing on a hitherto unexplored South Polar region of the Moon. Besides overcoming technological challenges to achieve the remarkable feat, the Chandrayaan-3 mission also exemplifies ISRO's commitment to the sustainable use of outer space. The lift-off time of the mission was selected based on launch collision avoidance analysis (L-COLA) to ensure no close approach between any catalogued space objects and the launch vehicle LVM3 M4 during its ascent phase, the conjunction analyses also covered the initial orbital phase of the spacecraft. The cryogenic upper stage of the launch vehicle was passivated after injection. After undergoing natural orbital decay, the orbital stage re-entered the atmosphere within 5 months, limiting its long-term presence in the crowded Low Earth Orbit. During the Earth-bound phase, Space Object Proximity Analysis (SOPA) was carried out regularly for conjunction risk assessment of Chandrayaan-3. All manoeuvre plans till trans-lunar injection were screened through SOPA to rule out any post-manoeuvre close approach risk. During the lunar phase, all manoeuvre plans including lunar orbit insertion, orbit lowering, lander separation, final descent and landing profile were screened through Beyond EArth oRbit Conjunction AssessmenT (BEARCAT) to avoid any close approach to the other lunar orbiting spacecraft. To demonstrate Earth-return capability and also avoid posing any post-mission collision risks to other lunar orbiters, the propulsion module underwent lunar escape manoeuvres and was placed in a high-altitude Earth Orbit utilising the left-over fuel. Apart from sharing of ephemerides of the spacecraft with USSPACECOM and NASA for spaceflight safety, in all mission phases, transparent notifications of all major milestones were posted on the official ISRO website. The relevant space object registration for the rocket body, propulsion module, landing module, and rover was performed by IN-SPACe as the national regulatory body authorising all Indian space activities. In this paper, we describe in detail the aforementioned measures undertaken for Chandrayaan-3 mission towards the long-term sustainability of outer space activities. Considering the renewed interest in exploring Mars and the Moon, these measures pave the way for defining best practices for conducting future deep space missions in a safe, sustainable, and responsible manner.