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CANFIELD MECHANISM FOR THRUSTER POINTING APPLICATIONS IN ORBIT TRANSFER VEHICLE

Abstract

This paper focuses on design of a Thruster pointing Mechanism for an Orbital Transfer Vehicle (OTV) being developed as a rideshare deployer at Bellatrix Aerospace. OTV's passenger satellites can be of various form factors and mass, and deploying them can lead to large shifts in the Centre of Gravity (CG) of the Vehicle. With such offsets in CG, continuous thrusting manoeuvres would induce large moments on the OTV that would be difficult to counter using on-board actuators, necessitating a use of Thruster Pointing Mechanism (TPM) for thrust vectoring

Conventionally, 2-axis systems consisting of rotary actuators are used in thruster pointing mechanisms. These mechanisms have various limitations, such as low payload-to-weight ratio, limited workspace, high volume and have a single point failure in case of actuators. To overcome these limitations, the Carpal wrist mechanism (Canfield mechanism) was identified as a reliable solution.

Initially developed for ground applications, the Canfield Mechanism is being modified for in-space applications by Bellatrix for its Electric thrusters. The Carpal mechanism consists of a base plate, and a distal plate connected by three legs with 5 Degrees of Freedom (DoF) which in turn, gives the overall mechanism 3 DoF. Such a mechanism has a large hemispherical workspace and a better reliability as compared to conventional 2 DoF systems. The proposed mechanism will cater to an array of manoeuvring challenges in space logistics. This mechanism can also be suitably modified to cater to other applications including precise pointing of antennas, payloads, and robotic arm wrists.

The paper identifies TPM design requirements derived from Thrust vectoring requirements of the OTV. The mechanism was sized to cater to Bellatrix's electric thrusters. Resistance force considerations in flexible propellant feed lines are also included as a part of the actuation system design. The mechanism was modelled using 3D CAD techniques and was subjected to kinematic and dynamic analyses, the methodology and results of which are included in the paper. The control system design involved selection of actuator assembly, sensors and controllers, and design of control algorithms. A concept verification model has been developed by 3D printing the mechanism and integrated with the control system which would be further iterated for Engineering Model development before an integrated testing is carried out with the Electric Thruster.