

SPACE TRANSPORTATION SOLUTIONS AND INNOVATIONS SYMPOSIUM (D2)
Upper Stages, Space Transfer, Entry and Landing Systems (3)

Author: Mr. Zhaohui Wang
Beihang University, China, jltx1990@163.com

Dr. Ming Xu
Beihang University, China, xuming@buaa.edu.cn

Dr. Lei Jin
Beihang University, China, jinleibuaa@163.com

Mr. Yanchao He
School of Astronautics, Beihang University, China, heyanchaoinzjut@163.com

ATTITUDE CONTROL OF UPPER STAGE WITH A GIMBALED THRUSTER DURING ORBIT
TRANSFER**Abstract**

In the launch mission of One-Vehicle with Multi-Satellite, the upper stage is used to deploy satellites into orbits. For the upper stage, it should transfer to the other orbit when it completes the deploy mission in one orbit. During the orbit transfer of the upper stage, the command direction of thrust vector of the gimbaled thruster (GT) is determined by the guidance system, and it should also ideally pass through the mass center of the upper stage. However, it is hard to realize in actual operation. Large disturbance torques would act on the upper stage when the thrust vector of the GT does not pass through the mass center of the upper stage. To overcome this obstruction, this paper discusses the challenging issue of the attitude control problem of the upper stage to allow the thrust vector of the GT pass through the mass center during its orbit transfer. To eliminate the effects of the thrust vector misalignments, disturbance torques produced by the thrust vector misalignments, and reaction control subsystem (RCS) thrusters, which are additional to the GT, are conventionally used. The thruster configuration presents in this paper was defined as the optimal thruster configuration by previous reference. The GT is used to control the attitude of yaw and pitch, and the orbit velocity of upper stage. The RCS thrusters in rolling direction are used to provide attitude control torque about rolling axis. The remainder of this paper is outlined as follows. First, the coupled dynamic equations of the system consists of the upper stage body, the gimbal and the GT are derived by considering the coupling between the orbit/attitude motions, the coupling between the upper stage's attitude motion and GT's gimbal motion. Next, the desired attitude of the upper stage is calculated by the position the mass center and the command direction of the thrust vector. Then, an attitude control procedure include a GT's gimbal rotation control is proposed, allowing the thrust vector of the GT passes through the mass center of the upper stage and aligns with its command direction. Finally, the numerical simulations are performed, followed by analysis and conclusions.