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FEASIBILITY STUDY AND DEVELOPMENT STATUS OF TRANSFORMABLE SPACECRAFT

Abstract

Transformable spacecraft under development in our research group is an innovative system that consists of several structural components, such as panels, connected together by joints driven by internal force actuators, e.g. electric motor drive system. The spacecraft can change its structure significantly by driving installed actuators and achieve simultaneous realization of attitude control based on non-holonomic motion, hereinafter called "non-holonomic attitude control", and transformation to arbitrary shape, which is the most important feature of the Transformable spacecraft. Nonholonomic attitude control is achieved by repeatedly driving different joints in proper sequence. Furthermore, the panel drive sequence is determined to meet the requirements of the final shape as well as the final attitude of the spacecraft. Such the most important feature can open up new spacecraft concept.

Such simultaneous realization of attitude and shape leads to following three associated features. The first is that "change of the shape enables the multiple functions by switching modes". The second is "orbit control and keeping by controlling the solar radiation pressure on the spacecraft by change of spacecraft structure, and it is achieved without fuel consumption". In this project, Transformable spacecraft will be put into a small artificial halo orbit around SEL2, and engineering and science mission will be performed. The third is "passive cooling of mission equipment achieved by appropriate panel configuration as shielding of sunlight". As a result, disturbance due to refrigerator is eliminated, which leads to attitude control without disturbance because non-holonomic attitude control also does not yield disturbance. This study analyzes the feasibility of Transformable spacecraft which demonstrates above special features in orbit, and shows the study status of key technologies for the system and subsystems as listed below: - Numerical analysis shows the feasibility of the orbit keeping and non-holonomic attitude control strategy by proposed method. - Panel structure and panel drive system which bring out the feature of Transformable spacecraft are developed and evaluated by numerical analysis and experiment. - Heat transfer characteristics of the developed joint between panels are evaluated by thermal vacuum testing and feasibility of the passive cooling of the Transformable space craft is studied. - An experimental device is being developed in order to demonstrate non-holonomic attitude control using a small robot on the International Space Station. - Communication system is analyzed to evaluate the influence of the panel configuration on antenna pattern characteristics. - A system are studied which realizes two different observation functions, interferometry and Fourier-transform spectroscopy, by fully utilizing the special feature of Transformable spacecraft.