
Research Term: FY2000 - 2002
Research Fields: Space Utilization Technology Development
Research Categories: Phase IB Research

Research Theme: Study on Elements of Hybrid Actuator System for Vibration Isolation and Steering Control

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Summary

Objectives/Significance
Many experiments and observations in space have been conducted with satellites. Dynamic disturbances to mission payload were individually studied and controlled suitably. The Japanese Experiment Module Exposed Facility (JEM-EF) attached to the International Space Station (ISS) is strongly expected as a field for performing various space experiments and observations by utilizing space environment characteristics, such as micro-gravity and opened wide Field Of View (FOV). However, the ISS/JEM-EF has many internal disturbance sources, i.e., moving parts or crew activities, and a large tilt of the attitude. These severely affect to conduct experiment. The purpose of the study is elemental technologies to provide the quieter environment in the JEM-EF similar to previous satellites. As results of our study, these technologies will contribute to establish the system that provides vibration isolation and steering functions simultaneously and provide more effective observation/experiment conditions to the JEM-EF payloads.

Methods
It will be required that the system can satisfy many of various requirements from the JEM-EF experimental users and demonstrate the specified performance under the unique JEM-EF environment conditions. We have carried out elemental technologies study, as follows:

- We examined the preliminary mission requirements of the system by means of studying previous and/or planning satellites missions. Using these results, we estimate the system design target.
- The system must provide vibration and steering controls in low-frequency domain, and passive vibration isolation in high-frequency domain. In order to obtain dynamic
characteristics, we programmed control software and assembled the mock-up model. The mock-up consisted of a base-part, control computer (desk top PC), dummy-mass, and linear stages with passive dampers, accelerometers and displacement sensors.

- We studied the kinematics between the payload and actuators motion. We traded-off the actuators allocation within the JEM-EF payload envelope constraints and drew the accommodation concept of the system.

Results
Some knowledge shown below were obtained as our study results.

- Mission study and analysis results suggest that steering over range of some degrees would be effective for some payloads that need scanning, pointing or avoidance function.
- Through experiments using the mock-up and numerical simulations, fundamental control logics for vibration attenuation over low frequency domain and payload steering were obtained.
- We found that the appropriate actuators allocation may exist, which satisfy kinematical requirements and secure sufficient clearance within the envelope constraints.

For space experiment
Our study's goal is to demonstrate the system on the JEM-EF. Prior to the demonstration, there are some technological issues as follows:

- To verify the system performance by preparatory experiments using facilities, such as an experimental aircraft.
- To obtain technical data for evaluating degradation characteristics of materials and moving parts in space environments.
- To study the system supporting mechanism under loaded environment during launch and reboost operations.
- To evaluate accommodative capability for payloads.

Publications

Patents
- “Vibration and attitude control system for spacecraft payloads” (patent pending)