

Research on the Design Method of Modular Structure for Satellites

SONG Wei-Xu

Department of structure and thermal control
Shanghai Engineering Center for Microsatellites
Shanghai, China, 13761066803
Songweixu108@126.com

LI Chun-Peng

Department of business
Shanghai Engineering Center for Microsatellites
Shanghai, China

ZHANG Ke-ke

Department of overall technical
Shanghai Engineering Center for Microsatellites
Shanghai, China,

SU Rui-Feng

Department of overall technical
Shanghai Engineering Center for Microsatellites
Shanghai, China

Abstract—In order to achieve rapid injection of micro-nano satellites, based on the analysis of latest related research result, a conception that truss structure is applied to the modular structure design of micro-nano satellite is presented, and a detailed approach using ball joint and rod as load-carrying structure and its specific design examples are given. The result shows that the truss structure can realize the standardization of the mechanical interface to complete the modular structure design of the micro-nano satellites.

Keywords- Modularization; truss structure; ball joints

I. INTRODUCTION

With the development of space technology, dependence on space systems is becoming increasingly serious. The desire of protecting and rebuilding space system in case of war or natural disaster is more and more urgent among countries. Traditional satellite manufacturing often takes several months even years, therefore, how to quickly assemble the satellites and take them into orbit gets more and more attention of world space powers

To reduce costs and achieve the target of launching on demand and quick response, the modular design of satellite is crucial. The conception of modular design of satellite is that integrate the parts which have same performance demand into one module, and make the structure of each module fit for standardized interface, to ensure that any modules with each other match on the mechanical and electrical, all the modules constitute a satellite. In recent years, there is lots of research in terms of the performance definition and design complexity of the of the modular satellite^[1-5]. The results show that the complexity of modular design is mainly reflected in the interface design, the interface must ensure data communication as well as transfer and exchange of mechanical and electrical energy between the modules, so the standardized design of the module interface becomes crucial. Standardized design and modular structure design of the satellite module mechanical interface is one of the key technologies of the study. Research in this area at domestic and overseas made a lot of significant

progress in recent years. Program SCOUT (the Small, Smart Spacecraft for Observation and Utility, Tasks) funded by the U.S. Department of Defense, and program FEBSS funded by the Air Force Research Laboratory (the The Flexible and the Extensible Bus for the Small Satellites), both of which using the SMART (Space Maintenance and Repair Technique) platform, shaping the satellite body as hexagonal octahedron whose modules are connected by prism and standardized interfaces get typical achievement in the research of modular structure design of satellite platform^[6].

However, this standardized interface design only ensure satellite module extend in one aspect, to increase the flexibility of the satellite module extension requires further study.

II. APPLY THE TRUSS STRUCTURE TO THE DESIGN OF THE MODULARIZATION STRUCTURE

In this paper, in order to increase the flexibility of satellite module extension, a truss structure with ball joint interface is used as the main satellite structure. The 18-hole fetlock joint which we choose, make the module realize multi-directional extension through the connection between the holes on fetlock joint and rod. What's more, truss structure has the advantage of light weight, good technology, flexibility and easy to assemble, etc.

The modular design concept is applied to the design of micro-nano satellites. The micro-nano satellite body is a cuboid, which consists of several cubes with standard interface, shown in Figure 1. The cube module has standard interfaces, can achieve extension of satellite functions by increasing modules if needed.

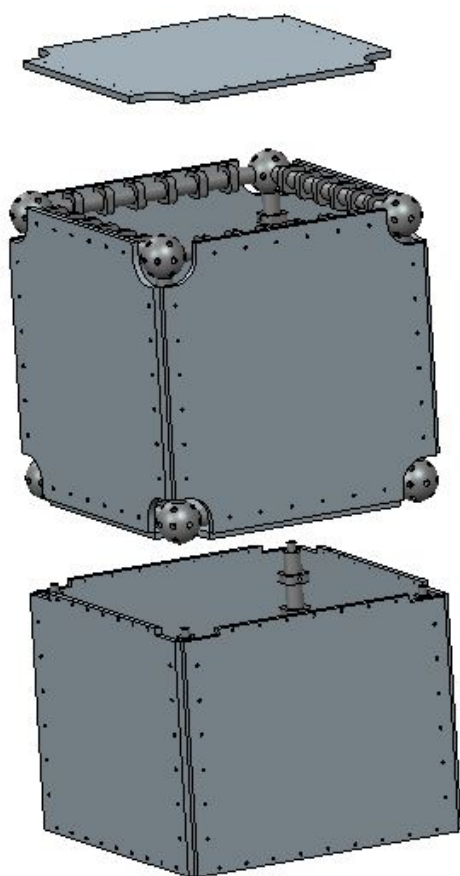


Figure1. The shape and structure of satellite

Due to the use of the 18-holes ball joints, the truss structure mentioned in this article has the function of multi-directional extension, which can also be used in integrating several modules into one micro-satellite, shown in Figure 2.

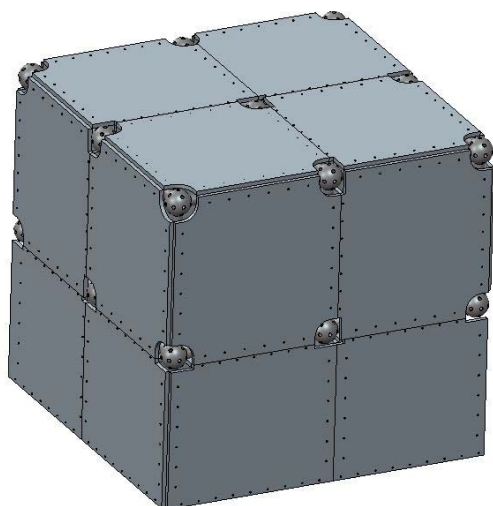


Figure2. The shape and structure of Micro-sat

III. DESIGN OF THE INTERFACE FOR THE MODULE

The structure for each module of the satellite consists of three basic components: plates, connecting rods and ball joints, and eight rods are connected together by the four ball joints to form a cube structure as shown in Figure 3. There are 18 screw holes on each ball joint, by which to connect with each connecting rod. There are eight connecting rods which have bosses, and five polish rods which connecting between the two ball joints on the diagonal section on each surface of the module, in order to maintain the stability of the entire module structure. Plate is designed to support the internal components of the module structurally, and provide support for the required stiffness and strength for the the full weight of components contained in the module, and to maintain the requirements of frequency.

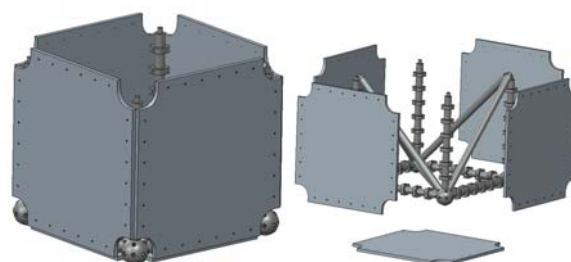


Figure 3. The diagram of the structure for single module

Ball joints and connecting rods provide a major load-bearing path for the assembling of the satellite. Each module is connected to another mainly through the screw holes below the four ball joints in the four corners connecting to the double-screw bolt. The screw fastening between the side plate and the connecting rod is to assist the main load-bearing path, make the module locking with each other, which improve the shear strength of junction, and strengthen the integrity of the shell as shown in Figure 4.

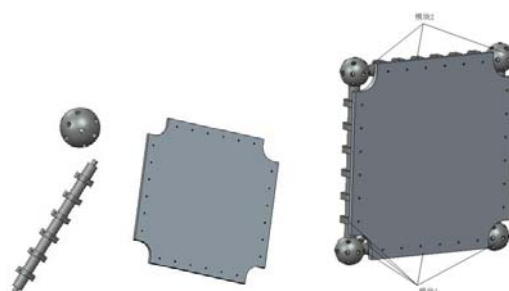


Figure4. The diagram of the structure for the joint between each module

In consideration of the connecting between the satellite and the adapter of rocket, the baseplate of the bottom module in satellite is different from the baseplate of the standard modules. In order to effectively load the the force of the entire satellite to the adapter, one “*” type force bearing frame with a ring in the centre is embedded in the baseplate connecting between the rocket and the satellite phase as shown in Figure 5.

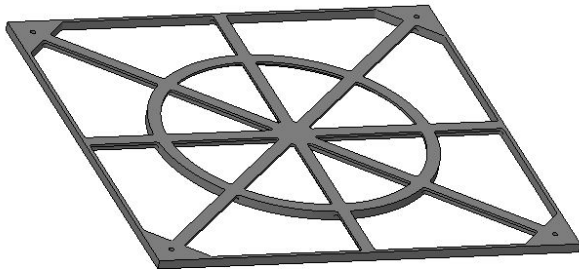


Figure5. The force bearing frame of baseplate

IV. CONCLUSIONS AND RECOMMENDATIONS

And the development and launch of the satellite system long guide and cycle time caused by the restrictive environment of the techniques and strategies to track response deployment capability, modular technology to ensure that demand performance of the module as spares at any time take, when required, within a few days, they quickly assembled and launched to respond to the crisis. Truss structure proposed in this paper can achieve the standardization of the module interface, ball joints can also improve the flexibility of module extensions can complete the modular design of the satellite, and

ultimately for mass production, reduce costs significantly, shorten the development cycle. However, the detailed design of the entire truss structure and structural optimization work remains to be depth.

REFERENCES

- [1] Philip Davies,etc. A Modular Design for Rapid Responsive Telecons and Navigation Missions[J]. 2nd Responsive Space Conference, Los Angeles, CA:2004, AIAA2004-3003.
- [2] Trevor Sorensen, etc. KUTESAT-2, A Student Nanosatellite Mission for Testing Rapid-Response Small Satellite Technologies in Low Earth Orbit[J]. 3rd Responsive Space Conference, Los Angeles, CA:2005, AIAA2005-3002.
- [3] Norman C.,etc. Standardization to Optimize Integration and Testing[J]. 3rd Responsive Space Conference, Los Angeles, CA:2005, AIAA2005-4005.
- [4] Robert M.Button,etc. Future Concepts for Modular,Intelligent Aerospace Power System[J]. 2nd International Energy Conversion Engineering Conference, Providence, Rhode Island:2004, AIAA2004-5730.
- [5] Jim L,etc. Space Plug-and-Play Avionics[J].3rd Responsive Space Conference, Los Angeles, CA:2005,AIAA2005-5001.
- [6] Scott A, etc. AeroAstro's SMARTBTM: A Low-cost Modular Approach Enabling Responsive Space Missions[J]. 3rd Responsive Space Conference, Los Angeles, CA:2005, AIAA2005-3003.