NUSAT II
Manufacturing Design of Lightweight Satellites

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INTRODUCTION

The successful flight of NUSAT I during 1985 and 1986 encouraged the Weber State College Center for Aerospace Technology (CAST) to continue developing other small satellites. This paper focuses on the mechanical design and construction of the NUSAT II space frame.

Forty students from the Mechanical and Manufacturing Engineering Technology programs at Weber State have worked on NUSAT II since 1985. This satellite is the major part of their senior project experience. Students are responsible for the design, analysis, manufacture, assembly, documentation, and testing of the space frame. Major contributions from industry both in and out of state in terms of materials and engineering expertise make NUSAT design and manufacturing challenges a doable and realistic business adventure. Weber State faculty serve as advisors and coordinators between students and industry personnel. Even though students are expected to do as much work as possible at Weber State by themselves, outside assistance is often required from our generous industry helpers when in house resources are inadequate. As part of the project, students give periodic progress reports to the CAST team and respond to design and/or production concerns of the group. Schedules are stressed and quality work is expected. Each quarter, students are formally reviewed by Weber State faculty and industry advisors to determine their level of achievement in the project.

SCOPE

This paper deals only with the mechanical space frame portion of NUSAT II. Electronic aspects are not addressed. Details are also presented on the activation switches and the communication antenna securing system.

BASIC DESIGN

NUSAT II is an octagonal cylinder as shown in Figure 1. The satellite is approximately 19.6 inches high and 16.4 inches across the flat opposing sides of the octagon. The space frame (without electronic gear) weighs 79 pounds and contains 2950 cubic inches of interior volume. When ready for flight, NUSAT II will weigh 150 pounds. It is sized to fit inside the experimenter envelope as specified in the

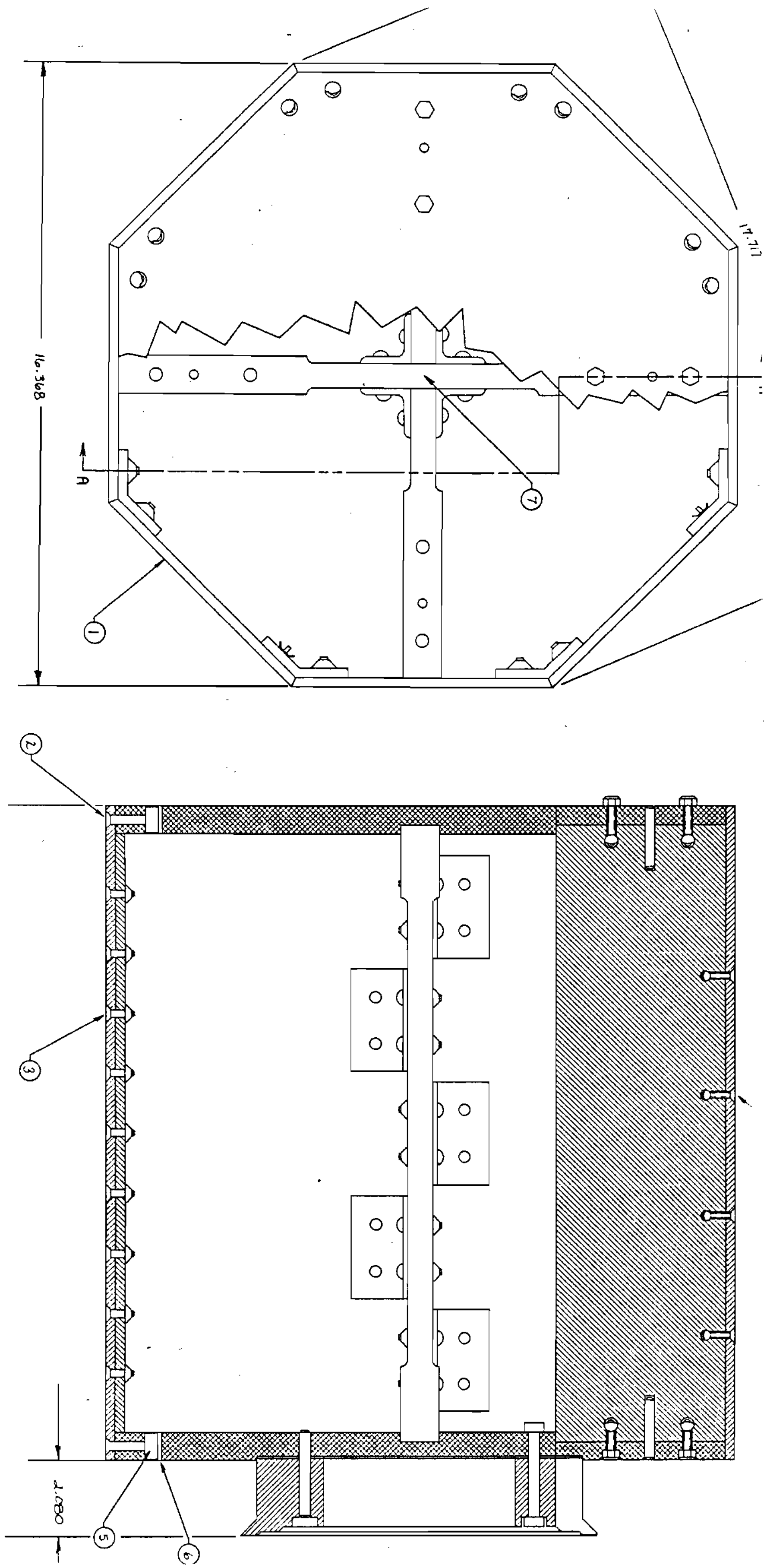


FIGURE 1

Goddard Space Flight Center GAS Satellite Ejection System Handbook. The base of the satellite employs the GAS standard Marman Plate Interface as used on the NUSAT I deployment.

The basic design criteria was driven by NASA GAS payload specifications. The structure is designed for 39 g's of static load and for 35 hertz minimum resonance vibration. The static condition was verified by students using ANSYS structural analysis software at Weber State. Vibration testing was performed and revealed significant resonance only above 45 hertz on the x and y axis and no significant resonance on the z axis.

The structure is composed of 7075-T73 aluminum structural parts and 6061-T6 non structural parts. The exploded view shown in Figure 2 reveals the Top Plate, Bottom Plate, Small Shelves, Large Shelves, and Base as the structural components. The shelves also provide suitably flat and spacious mounting surfaces for electronic components and hardware. The solar panels and associated joining pieces are non structural and are easily removed. 7075-T73 aluminum was chosen for its relatively high tensile strength and for its fracture resistance. Since 7075 alloys are about three times the cost of 6061 alloys, 6061 was chosen for its lower cost where high strength was not important.

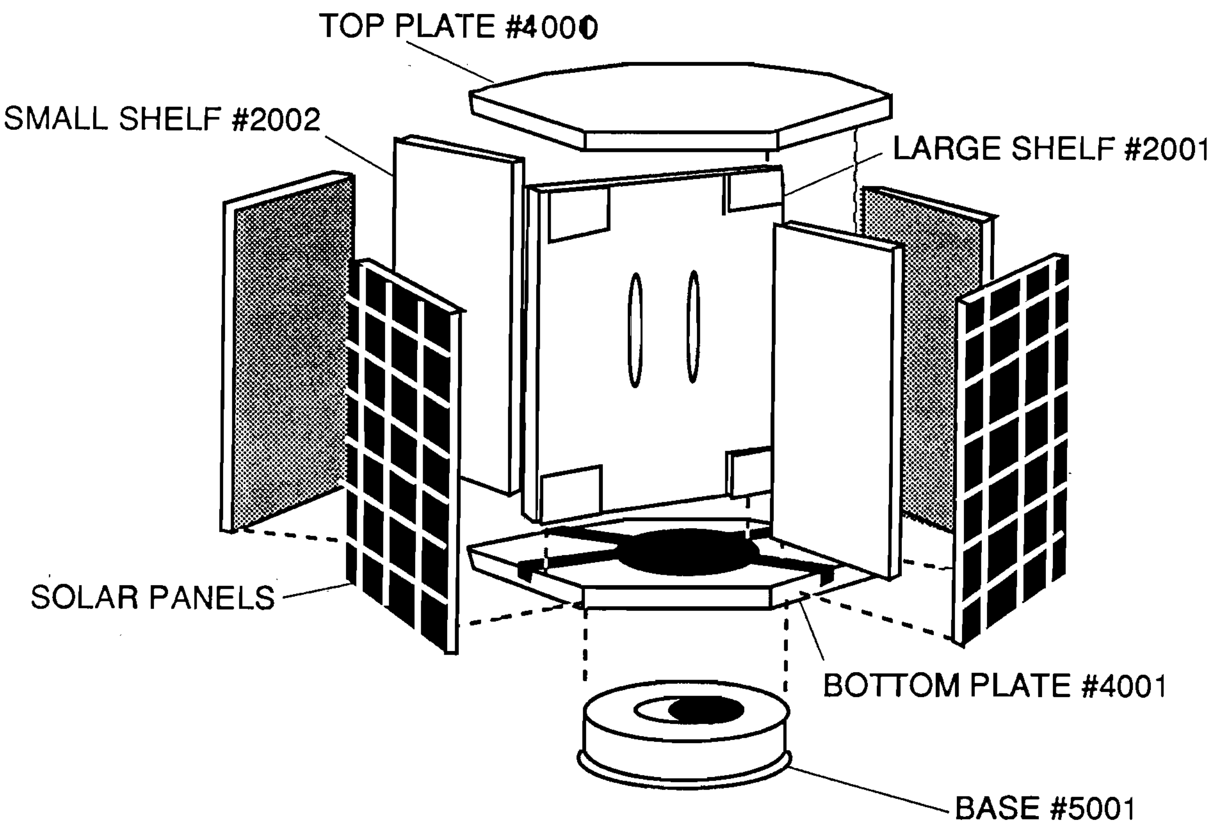
The surface of all the space frame components was chemically conversion coated using an alodine process to eliminate aluminum oxidation and ensure electrical conductivity between the components.

Fasteners used conform to NAS, MS, or AN standards. All fasteners are non magnetic thus eliminating potential electronic interference that may be found with magnetic fasteners. Main structural fasteners are A286 high strength steel alloy with non structural fasteners primarily being other stainless steel alloys.

ACTIVATION SWITCHES

The electronic operation of the satellite is activated upon separation from the launching base through the release of two parallel activation switches shown in Figure 3. Only one of the two spring loaded devices must work for NUSAT II to come to life. The technique used here is the same concept that was used on NUSAT I with the only changes being in the location on the base and the size of the plungers. When the separation takes place, springs force the plungers down and away from the micro switches thus allowing the switch to release and current to flow.

ANTENNA SECURING



EXPLODED VIEW
NUSAT II
(MAIN STRUCTURE)

FIGURE 2

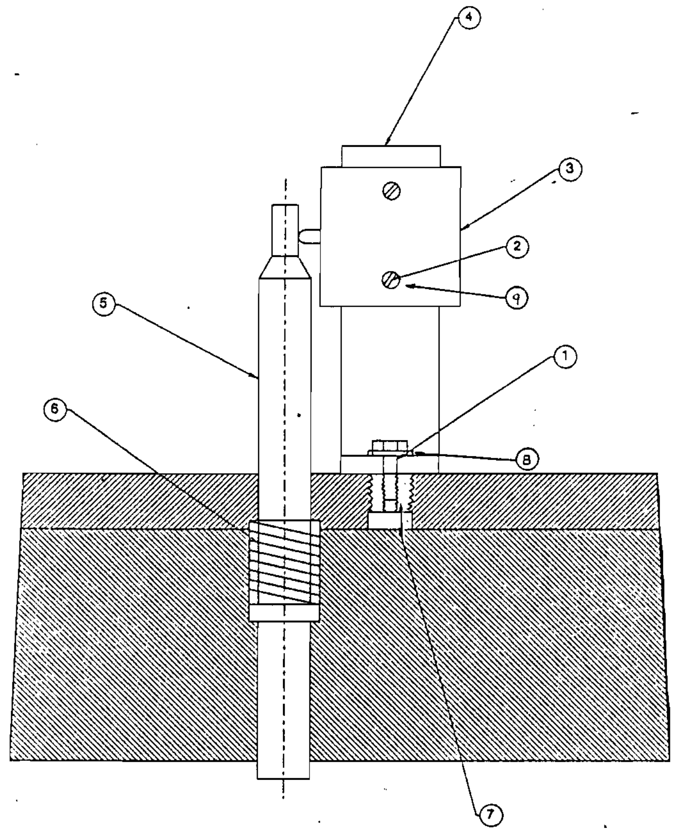


FIGURE 3

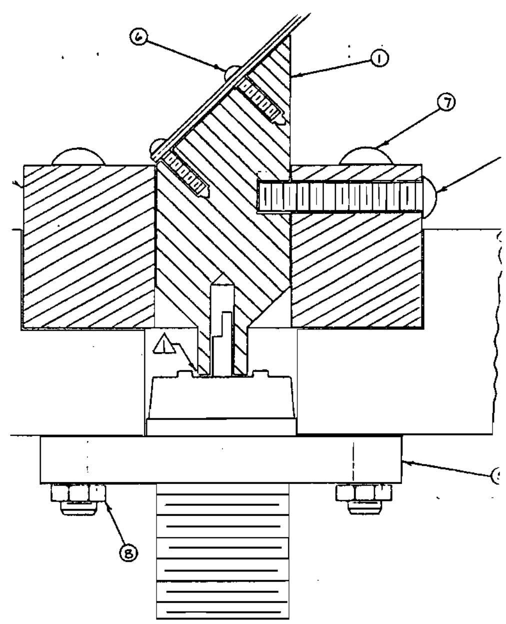


FIGURE 4

The four communication antennas are mounted on top of the satellite and are folded over and tied down during launch. A nichrome wire is used to hold them in place and is then burned to deploy the antennas. The antenna attaching feature is shown in Figure 4.

FABRICATION AND ASSEMBLY

All component parts were machined at Weber State College in the Manufacturing Engineering Technology Department. Heat treating and finishing were done by outside suppliers. Part geometry was created on a Bridgeport EZ-CAM workstation and NC code was created. This code was then post processed and downloaded to either a Bridgeport Series II CNC Milling Machine of a Hitachi Seki CNC lathe. Basic processing of the larger 7075 aluminum component parts included the following operations:

A. Procure 7075-T6 aluminum in rough cut blank sizes
B. Heat treat to the "O" condition
C. Rough machine the parts to within .050 inches of final dimensions
D. Heat treat to the T73 condition
E. Final machine
F. Alodine
G. Final inspect the parts

The intermediate heat treating steps were required to minimize distortion in the machining processes.

Assembly was accomplished using some special fixtures to properly align parts for riveting operations. Pilot rivet holes were used in some parts to establish a starting position for line drilling final rivet holes. Once assembled, the main structural components are not readily disassembled due to the use of interference fit dowel pins between the top plate and shelves, the bottom plate and shelves, and the bottom plate and the base. These pins provide positive shear fits between these parts.

DOCUMENTATION

Each student was required to provide an industry quality drawing of the assigned part. ANSI 14.5 standards were adhered to and proper engineering fits were specified. Professionals from outside industry continuously reviewed these drawings for accurate engineering detail and format. In addition, assembly drawing were created where required and a final assembly drawing was produced.

A bill of material containing all materials used in the space frame was developed and structured according to the specified assembly procedure.

Backup documentation was also compiled which included an inspection report on each structural part, certification reports on all structural material, and certification reports on all structural fasteners. Each structural part was serialized for traceability back to the supporting documentation.

NUSAT I VS. NUSAT II COMPARISON

Some problems were encountered with the NUSAT I design that were corrected with NUSAT II. First, NUSAT I was extremely difficult to access inside electrical components. The "shell half" concept allowed only small 4 inch square openings once the halves were joined together. Second, NUSAT I contained a large interior structural column which occupied a significant amount of space. Some electrical components had to be modified significantly to fit into the available space.

NUSAT II corrected the first problem by employing outer panels that can be removed two at a time thus providing ready access to inside electronics. The second problem was corrected by designing the interior shelves to serve as the primary structural components.

NUSAT II ultimately became a space frame which allowed much easier internal access and provided 33 % more interior volume. The following table summarizes the differences:

	NUSAT I	NUSAT II
Interior volume (cubic in.)	2220	2950
Weight empty (pounds)	75	79
Access areas (square in.)	16	106

ACKNOWLEDGEMENTS

The success of NUSAT II lies directly with the Weber State students and support from outside industry. Major contributors to the NUSAT II space frame include:

Affiliated Metals
Blanchard Metals
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Hill Air Force Base