STANDARD GAS HARDWARE

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ABSTRACT

The Sierra College Space Technology Program is currently building their third GAS payload in addition to a small satellite. The project is supported by an ARPA/TRP grant. One aspect of the grant is the design of standard hardware for GAS payloads. A standard structure has been designed and work is progressing on a standard battery box and computer.

INTRODUCTION

Under the direction of Michael Dobeck, Sierra College has successfully flown two GAS payloads aboard the Space Transportation System. Many lessons were learned about the difficulties of building GAS payloads. Considerable time and effort were expended in the design, analysis, and safety-approval process for the structure, battery box, and computer. It was clear that the building of a payload would be greatly simplified if standard flight-qualified hardware existed, and the documentation or actual hardware was readily available. Researchers could then be relieved of much of the work of building a payload and freed to concentrate on developing their experiments. With this in mind, Michael Dobeck wrote a successful grant proposal for Sierra College in the Summer of 1993. One of the major components of the ARPA/TRP grant is the design, construction, and flight qualification of a standard structure, battery box, and computer for GAS experiments. This paper will discuss the progress Sierra College has made toward the development of standard GAS hardware.

PROGRAM HISTORY

Payload G-399

A short overview of the Sierra College Space Technology Program is in order to provide some background for the work currently in progress. The first Sierra GAS payload, G-399, was begun under the direction of Michael Dobeck in 1990. Aerojet

[1] The work described in this paper is supported by an ARPA/TRP grant. The grant is managed through the NASA management office at the Jet Propulsion Laboratory in Pasadena, California. The grant number is NAG7-1.

Corporation donated the services of one of their structural engineers, P. J. Krusi, to design an internal structure for the five cubic foot payload. Three shelves were required for the planned experiments, and Mr. Krusi connected the shelves with four tubular columns to form the structure. Figure one shows the basic design.

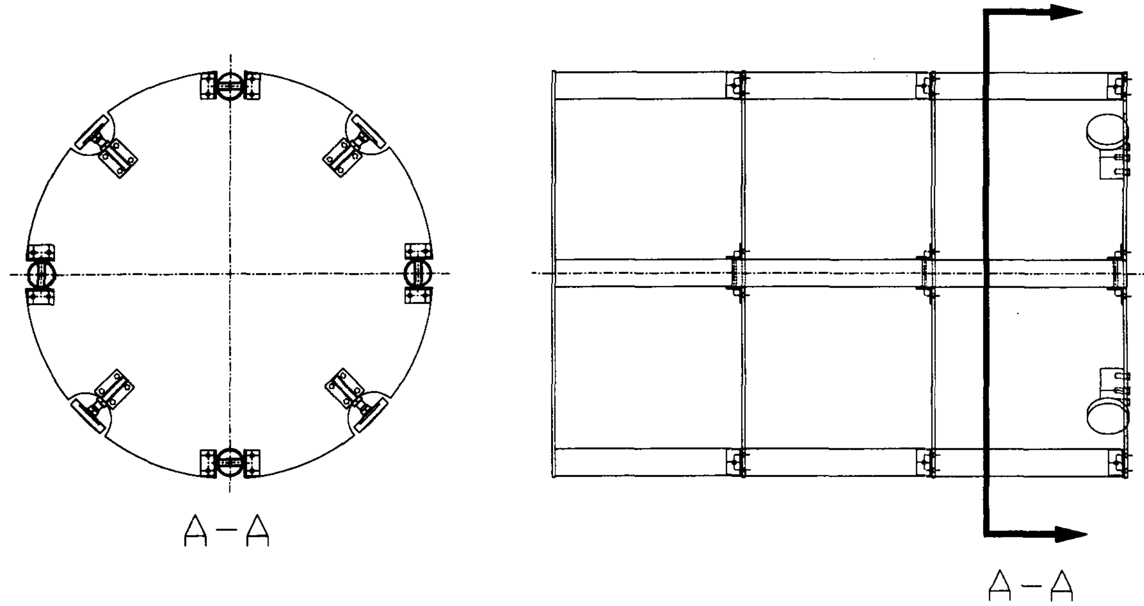

Figure 1: The G-399 internal structure

The columns were built with round tubing to maximize the strength-to-weight ratio of the structure. Small crush tubes were welded through the columns for added strength at the attachment points for the shelves. Four snubbers were required on the bottom shelf to prevent possible deflection of the structure into the walls of the GAS canister.

The design was very successful in meeting the objectives of light weight, high strength, and minimal intrusion into the available canister volume. However, integrating the experiment hardware with the structure revealed a shortcoming of the design -- it was difficult to assemble and disassemble. Additionally, there were some difficulties that arose in the manufacturing process. The welding of the crush tubes in the thin-walled columns required a highly skilled welder, and the welds had to be x-rayed to demonstrate their quality. Nevertheless, the project was completed in three years, flew in June of 1993 aboard the Shuttle Endeavour, and the structure performed flawlessly.

Payload G-178

While G-399 sat in Florida awaiting launch, work had already begun back at Sierra on the second GAS payload, G-178. At the G-399 integration other GAS experiments were observed that were professionally built with budgets into the millions of dollars. Borrowing ideas from those payloads, a new design was worked out for the internal structure. Designed for a 2.5 cubic foot payload, the structure was built with eight I-shaped machined columns that bolted to the outermost holes in the GAS experimenter's mounting plate (EMP). The complete structure was created with a milling machine, requiring no welding or x-raying. The columns were formed by segments bolted between the shelves (not passing through the shelves), so assembly and disassembly were much more simple than with G-399. Constructed over a hectic eighteen week period, G-178 flew in September of 1994 aboard Discovery.

ARPA TRP Grant

The decision to build G-178 as quickly as possible was brought about by the arrival of a higher priority project. After the flight of G-399, Michael Dobeck wrote a proposal for Sierra College for an ARPA/TRP grant in the area of manufacturing engineering education. The grant was awarded in November of 1993.

The ARPA grant, which is managed by the NASA management office at the Jet Propulsion Laboratory in Pasadena, California, has three major goals. The first of these goals is the creation of a multi-track Space Technology degree and transfer program. Students earning a heavily interdisciplinary Space Technology degree will use a project as the focus of their studies. The project forms the second goal of the grant: the design, implementation and flight of a microsatellite. The satellite will use a spectrograph to measure the ozone layer and take digital images to characterize the target area. The final goal of the grant is the subject of this paper: the creation of standard flight qualified GAS hardware including a support structure, computer, and battery box. This standard hardware will allow other schools or industry users to create Space Shuttle experiments with greatly reduced difficulty.

THE STANDARD STRUCTURE

Design Goals

The goals of the design for the standard structure were fairly simple: minimize weight, maximize usable volume, manufacture without welding, allow easy assembly and disassembly, and provide some flexibility in configurations. The design process was essentially an optimization of the G-178 structure.

Description

The standard structure uses I-shaped columns like G-178, but the number of columns was reduced from eight to six. The columns were also reduced in weight by increasing their thickness slightly while changing their cross-section from a solid rectangle to an I-beam. A pictorial view of the standard structure is shown as figure two.

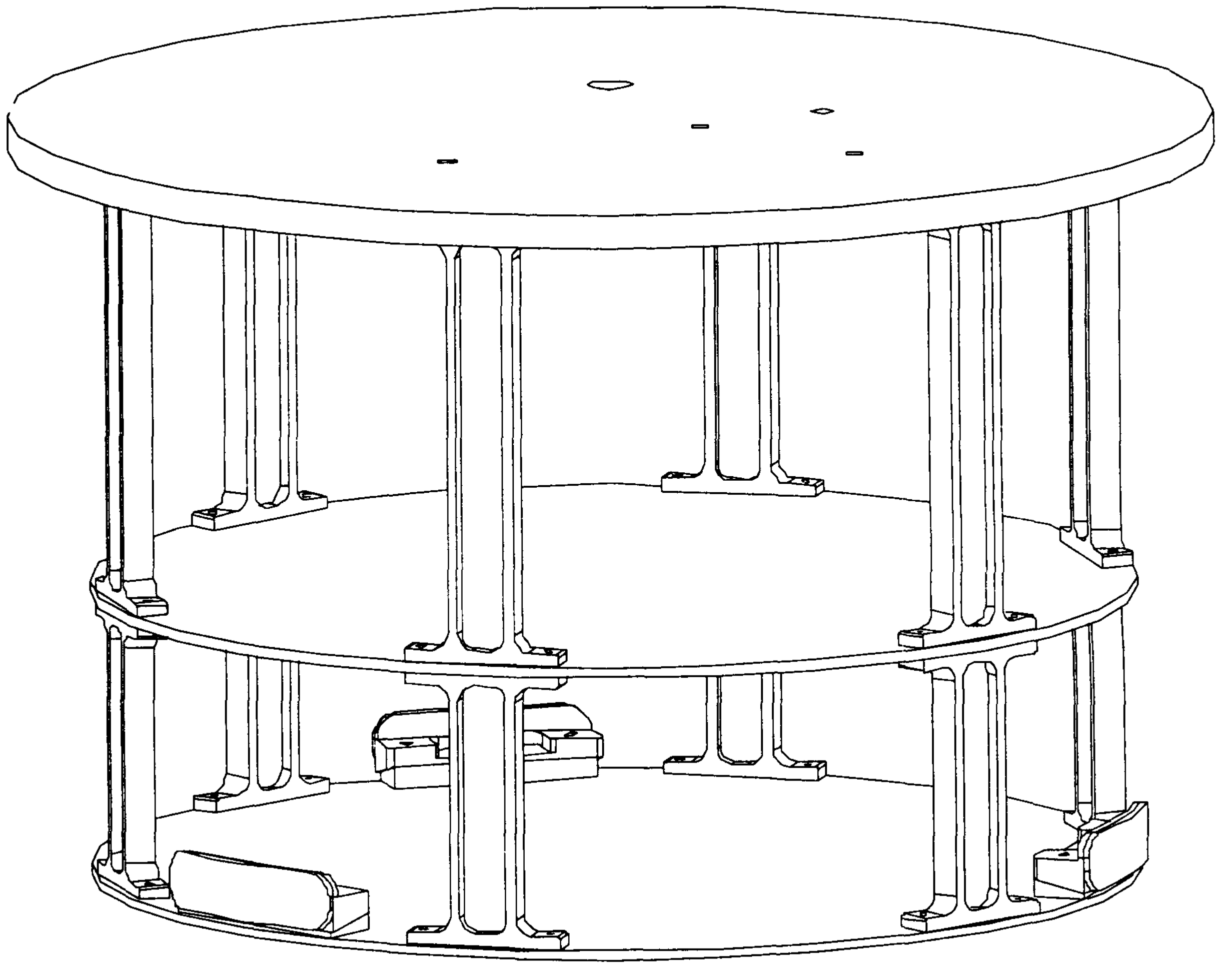

Figure 2: The standard 2.5 cubic foot GAS structure

The use of six columns also allowed for the easy placement of three snubbers. NASA requires the snubbers unless it can be proven through analysis that the structure will not deflect into the GAS canister. It was determined that a standard structure built with enough stiffness to eliminate snubbers would simply weigh too much. The optimal solution was to use the minimum number of snubbers, which is three.

The snubber design is shown pictorially in figure three. The design requirements were as follows: the contact area with the canister of each snubber be at least four square inches, the adjustment mechanism be accessible from below the structure, and a positive locking mechanism be used. Further design goals were to minimize the weight of the snubbers and their footprint. Minimizing the amount that the snubbers intrude into the shelf space maximizes the space available for experiments.

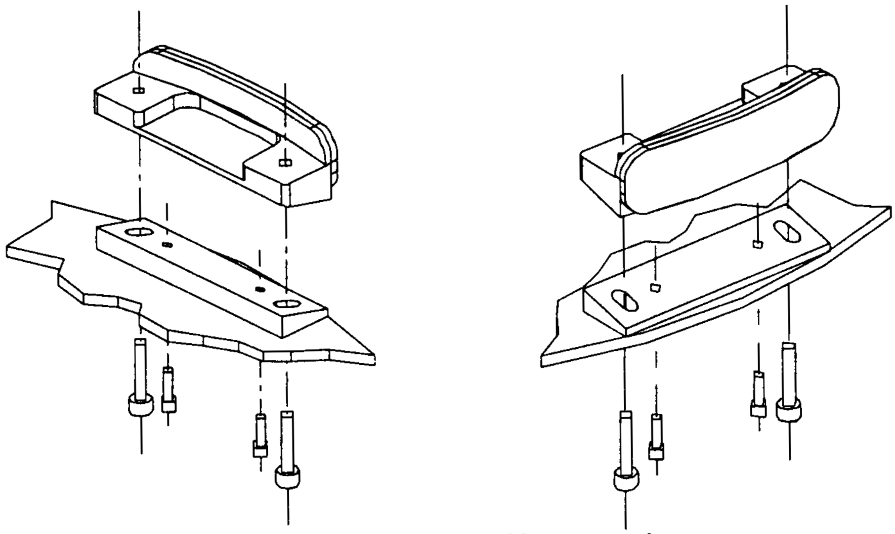

Figure 3: The standard GAS structure snubber -- two views

The design places the snubber on an inclined block that is first bolted to the shelf. The block and the shelf have two matching slots milled in them through which bolts pass from below the shelf up into threaded locking inserts in the snubber. As the bolts are tightened the snubber moves down the inclined plane of the block and out towards the wall of the GAS canister. Once the snubbers are adjusted out against the walls of the canister and the bolts are torqued, a positive lock is achieved because movement of the snubber inward would require movement up the inclined plane, which would stretch the torqued mounting bolts. The snubber design provides for an easy adjustment procedure from below, and, as can be seen in figure 4, a minimal amount of shelf space is used.

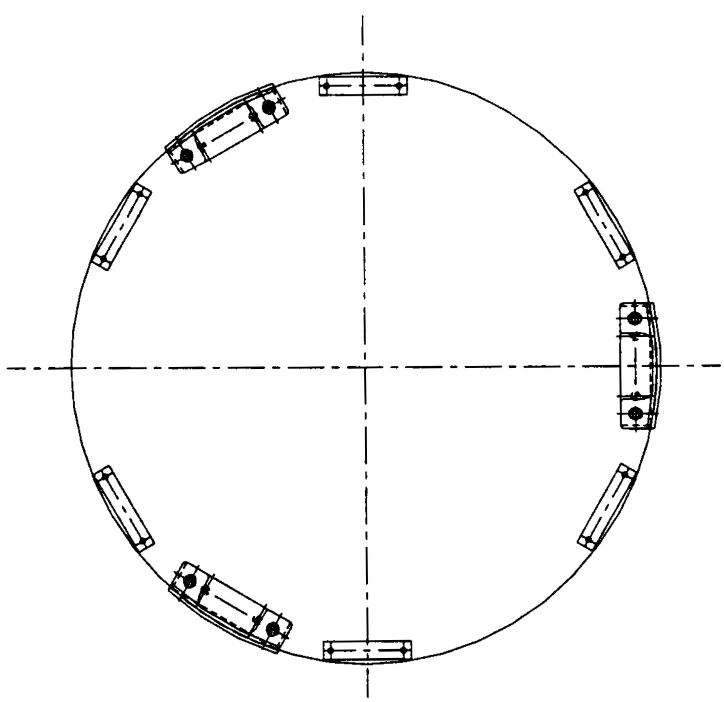

Figure 4: the layout of columns and snubbbers on the bottom shelf

The standard GAS structure was also designed with modularity in mind. The goal was to be able to substitute different length columns within the GAS canister envelope to achieve different configurations with respect to the number of shelves and the spacing between them. Two prototype designs have been built for 2.5 cubic foot structures, as shown in figure five. Preliminary finite element analysis has indicated that these configurations are more than adequate under static loads, and dynamic modeling was in progress as this paper was being written. These configurations will be doubled in length and analyzed as potential five cubic foot structures. If the design passes dynamic analysis, a large number of configuration options will be available by selecting different length columns.

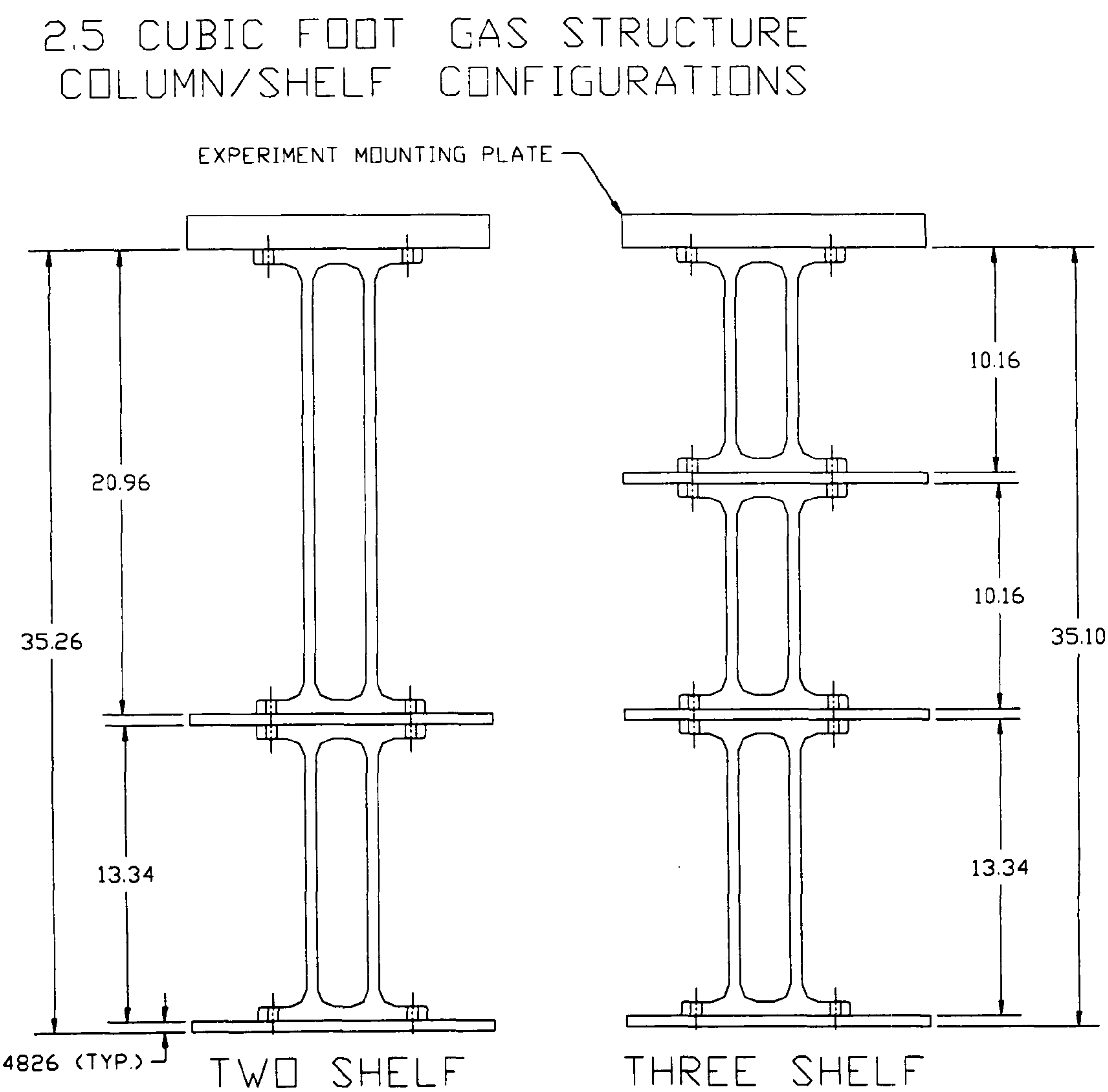

Figure 5: 2.5 cubic foot standard structure configurations (dimensions in centimeters)

OTHER STANDARD GAS COMPONENTS

Standard GAS Computer

Progress is also being made on the development of the other standard GAS components. The Sierra College space technology program was created by Michael Dobeck, who is a computer science professor at the school. Since the program is an outgrowth of the computer science department, the controllers for Sierra's GAS payloads have been viewed as the most easily developed subsystem of the experiments. G-399 used a controller designed and built by Sierra students based on an 8051 processor. G-178 used a commercially available 80386 single board computer. Designs have also been worked out for standard GAS computers based on low power 80x86 and 68xxx processors. The current plan, however, is to develop a standard GAS computer based on a very small, cheap, ultra-low-power RISC microcontroller. It was decided that this would be a more valuable contribution to the GAS community than duplicating other easily available single board computers. The RISC microcontroller has plenty of computing power for most GAS payloads, and has the advantage of very low consumption of both power and physical space. GAS experimenters who require more computing power have a number of readily available options in the commercial market.

Standard GAS Battery Box

The standard GAS battery box, like the computer, is still in the developmental stage. The design will use commercial alkaline F cells, which are highly suitable for GAS payloads due to their long shelf life, relative low cost, easy availability, and minimal safety hazards. Several designs for the box have been considered, seeking a model that can be built without welding while providing maximum flexibility in use. The current idea is to develop a relatively small box, which will give the gas experimenter many options for placement on the structure while allowing the total power available to be a function of the number of boxes flown. Another advantage of small battery boxes is that devices attached to the structure that weigh less than five pounds do not require additional structural analysis.

CONCLUSION

The GAS program provides a tremendous opportunity for low cost access to space based experimentation. Sadly, this program has not been taken advantage of to the fullest extent possible. Sierra College is developing standard GAS hardware to make the GAS opportunities more easily obtainable for potential experimenters. The availability of pre-approved GAS hardware should greatly simplify the development of a GAS payload, and hopefully will expand the use of the program.