STRUCTURE SUBSYSTEM

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ABSTRACT

Building a full size and traditional satellite is a very expensive and time costly procedure. A single satellite can cost several million dollars, and another several million to launch. Micro satellites are a way to design, build, test, and launch a fully functional satellite at a fraction of the cost. By reducing the cost to build and launch the satellite, less is at risk during launch or orbit. The University of Hawaii Manoa LEONIDAS team has a mission to change the development of a microsat. University of Hawaii will be able to house the entire satellite project from start to launch, and maintain control of the satellite communications while in orbit. This will be the first and only university in the world with these capabilities, and will revolutionize this industry by reducing costs, time and testing new technology.

INTRODUCTION

The LEONIDAS project is designed to prove the capabilities of the University of Hawaii to design, build, test, launch, and operate a microsatellite. Proving these capabilities will lead to many new opportunities within the aerospace industry. The success of the LEONIDAS project could lead to partnerships with NASA and could push the University of Hawaii to start its own aerospace program. The main objective for the current mission design is to conduct technology demonstrations in the laboratory of space.

The Structure subsystem is the backbone of the satellite. It will provide a lightweight, extremely strong chassis to house the physical satellite components. The structure will have to maintain its form during all phases of the mission, primarily the launch. During the launch, the frame will have to withstand over 12G's of force and vibration to hold the system components in place for proper operation.

The framework will consist of a truss like design, similar to the ones used in bridge building, aluminum plates machined out for mass savings, and aluminum and titanium fasteners for proper thermal transfer. The main pieces will most likely be made from 6061T6 aluminum. This material was chosen for its little mass and high performance. When designing a microsat, the mass is crucial to keep minimal. The framework will also have the capability of mounting the solar panels, imager, telecom, acs, power, and thermal subsystems where it is most ideal for them.

Panels will be made from solid sheets of 7mm thick, 6061T6 aluminum, then fastened together for maximum strength. To reduce thermal transfer of energy between panels of the structure, special G-10 spacers will act as an isolation spacer, allowing for the structure to better assist the thermal subsystem. With details such as these to be analyzed, a detailed set of system requirements for the structure system will have to take place. This is to keep the certainties certain, and the uncertainties solved.

REQUIREMENTS

For a more thorough understanding of the specific needs, conflicts and imposed requirements, a set of system requirements helps to guide the way. The requirements are crucial as they will shape and design the way in which other systems can and will function. The requirements will allow the structure system to take shape, and have maximum functionality. The structure, as simple as it sounds, has many parts to interact with. Since there are so many parts and different requirements to meet, the system requirements can be split into two different main groups: structure requirements, and mechanical requirements.

	Structure Requirements - Michael Menendez	Given By	Given To	Dates Modified
External Dimension Constraints				
5.01-	5.01.01 The structure will be contained within the launch vehicle of (TBD) (cm)	Mission	Structure	3/1/2007
	5.01.02 The structure will determine the surface area of (TBD) area.	Structure	Power	2/18/2007
	5.01.03 The structure will not have any moving parts.	Structure	Structure	2/18/2007
Forces / Stress (Dynamic)				
5.02-	5.02.01 The structure will withstand launch forces of 12G's.	Launch vehicle	Structure	2/18/2007
	5.02.02 The structure will be resilient to vibration of the (TBD) resonant frequency.	Launch vehicle	Structure	2/18/2007
	5.02.03 The structure will not flex or deflect under torsional, compressive, tensile stress. Stiffness	Launch vehicle	Structure	2/18/2007
Thermal Constraints				
5.03-	5.03.01 The structure will control heat using conduction and radiation.	Thermal	Structure	2/18/2007
	5.03.02 The structure will provide strapping to dissipate heat.	Thermal	Structure	2/18/2007
	5.03.02.01 The structure will mount heat dissipation radiator plates (TBD)	Thermal	Structure	2/18/2007
	5.03.03 The structure will control scatter with a (TBD) surface finish.			
	5.03.04 The structure will be (TBD) color to dissipate (TBD) heat.	Structure	Structure	2/18/2007
	5.03.05 The structure will allow for (TBD) amount of thermal expansion.	Structure	Structure	2/18/2007
Mass Constraints				
5.04-	5.04.01 The structure cannot exceed the 12 kg mass budget.	Mission	Structure	2/18/2007
Antenna & camera Placement				
5.05-	5.05.01 The placement of the camera and antenna will allow for maximum visibility towards Earth.	Payloads	Structure	2/18/2007
Configuration				
5.06-	5.06.01 The satellite's center of mass must be placed within(TBD) of the center of the structure.	ACS	Structure	2/18/2007
	5.06.02 The satellite's system components shall not overlap or come within (TBD) of each other.	Structure	Structure	2/18/2007
	5.06.03 The structure's rack space constraints are (TBD cm).	Mission	Structure	2/18/2007

	5.06.04 The structure will be able to mount at least one reaction wheel near the (TBD) center of mass. 5.06.05 The structure will locate the avionics equipment facing Earth. 5.06.06 The structure will divide up the bus into different bays in accordance to the center of mass.	ACS	Structure	2/18/2007 3/1/2007 3/1/2007
Insulation 5.07-	5.07.01 The structure will be insulated to control (TBD) thermal energy.	Thermal	Structure	2/18/2007
Fasteners 5.08-	5.08.01The structure shall be assembled using mechanical fastening. 5.08.01The mechanical fastening will allow for thermal transfer. 5.08.01.1The mechanical fasteners shall be tapped into the frame. 5.08.02 The structure will have a (TBD) surface texture at joints in contact.	Structure Thermal	Structure Structure	2/18/2007 2/18/2007
Interface Board 5.09-	5.09.01 The structure will have a centeral interface boards. 5.09.02 The structure's interface board will have (TBD) space between for cabling and plugs. 5.09.03 The circuit boards will be mounted on a standardized structural member. 5.09.04 All circuit boards will be removable for easy access. 5.09.05 The structural 'rack' will be locked into place. 5.09.06 The connections between system components shall be effective through (TBD) temperature range. 5.09.06.1 The connections shall fall within (+/- TBD %) signal loss. 5.09.06.2 The connections shall lock with a (TBD) mechanical device.	Structure Mission Structure Thermal	Structure Structure Structure Structure	3/1/2007 3/1/2007 2/18/2007 2/18/2007 2/18/2007 2/18/2007
Radiation 5.10-	5.10.01 The structure will have shielding for system protection against (TBD) radiation.	Structure	Structure	2/18/2007
Wiring 5.11-	5.10.01 The structure shall determine most efficient paths for cabling. 5.10.02 The structure will fasten cables for minimal movement. 5.The structure will provide a grounding system for system components. The structure shall be conductive.	All Structure All	Structure Structure Structure	2/18/2007 2/18/2007 2/18/2007
Gussets 5.12-	The structure will use gusseting and brackets.	Structure	Structure	2/18/2007
Panel mounting (solar) / camera 5.13-	The structure will provide rigid framework for solar panels. The structure will allow for framework to mount glass on the outsides of the frame. The outer panels of the structure will be machined.	Power Structure	Structure Structure	2/18/2007 2/18/2007

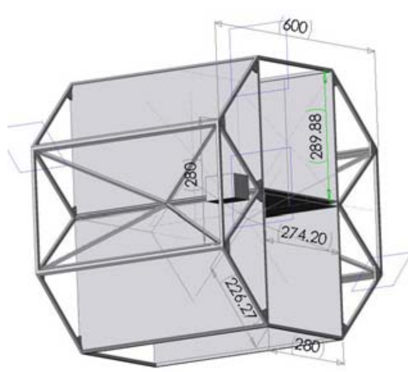
Materials Selection				
5.14-	The structure will be made from a material that can handle (TBD) temp. range.	structure	structure	3/1/2007
	The structure will be made from a material with good thermal conduction properties	structure	structure	3/1/2007
	The structure will be made from a material with (TBD) yield strength.	structure	structure	
Payloads				
5.15-	The structure will have structural brackets to hold the payloads.			3/1/2007
	The structure will use isolators to reduce vibration.			3/1/2007
	The structure will use isolators to have thermal control.			3/1/2007

The mechanical requirements are for parts that move, and require mechanical properties for proper system requirements. The structural requirements are physical system requirements for parts of the structure subsystem that have to be stiff and stationary while fulfilling other subsystem requirements which it has originated from.

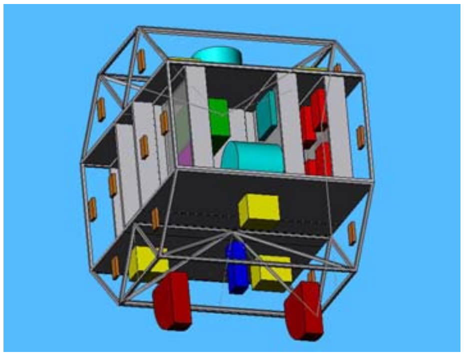
ANALYSIS

The specific structure system requirements allow for a more specific goal in mind, and simplified solutions to get there. This is why the analysis is so important. The analysis tells us if the structure system is meeting its listed requirements, and if not how it can be addressed in a specific way. It is important not to overlook the specifics of the system requirements when doing the analysis.

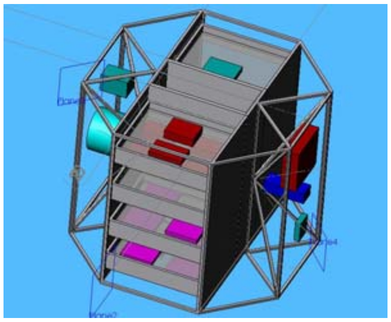
Using SolidWorks 2005, a model was created to exact scale to represent the frame/structural bus mentioned and designed with the listed requirements. This CAD drawing allowed me to stress test basic parts of the satellite to know where the weak points were for further analysis. The model also showed component placement. Within the program SolidWorks 2005, I created a scale part of every subsystem and payload component for optimal placement and center of mass weight distribution.



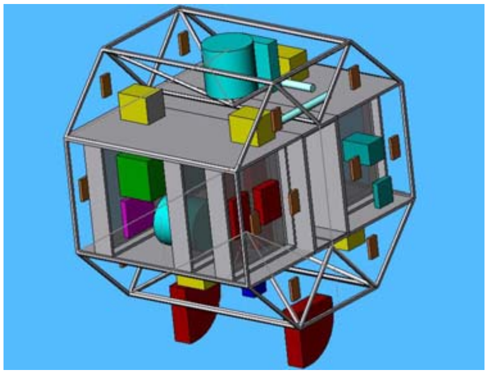
In the picture above, a bare bones non-populated frame designed around the structure system requirements and analysis is shown. This is to show the basic truss framework to support the 12G load. The dimensions are labeled in mm to show exact outer dimensions.



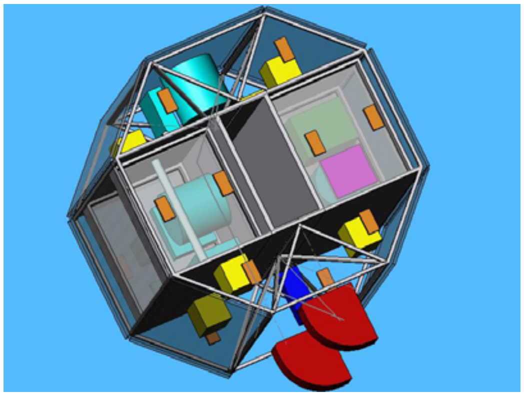
The CAD drawing above shows the populated version of the structure system with its component placement. The solar panels are removed to show the inside with its ‘racking’ system. This ‘racking’ system is there to allow for a reconfigurable bus system that will allow us to quickly make changes and additions using off the shelf parts. The components are also placed in a way that is logical for the thermal system, convenient cabling and a good center of mass. With the configuration shown, the center of mass is very near the center. This is necessary for vehicle control and stability while pitching and yawing in space to slew over the islands and take a picture.



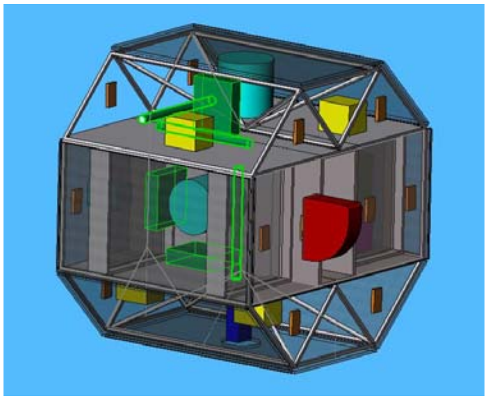
This is another close up of the reconfigurable bus with its ‘racking’ system. The blue box represents the imager; therefore that side will always be facing earth.



There are a number of thermal shunt resistors that allow heat to be transferred to the radiator plates located on the top and bottom of the satellite. The top and bottom can be defined as the sides in the shape of the octagon. The octagon was chosen as the primary shape due to its great efficiency of space, strength properties and little mass. In this drawing there are approximately 16 shunt resistors which are the small, dark red boxes floating at the surface.



As a requirement placed on the structure subsystem, the s-band antennae are placed on the outside of the satellite, facing earth at all times. since the satellite is going to stay is the same orientation while orbiting earth, the s-band antennae will also face earth along with the imager. In the picture above, the red, fin shaped objects are the two s-band antennae.



In this picture, the highlighted green tubes are the magnetic torquers. These are another form of propulsion to maneuver the satellite along with the light blue colored reaction wheels. The magnetic torquers have to be strapped to the frame in such a way that the 3 axes of the satellite can be maneuvered accurately and easily. To do so, the magnetic torquers have to be mounted around the center of mass, similar to the reaction wheels. The magnetic torquers are similar to a coil or wire in an elongated cylindrical shape. When current is passed through the coil, it creates an electromagnetic field that can react with the magnetic field of earth.

CONCLUSION

Most of the testing and analysis was done using a CAD program called SolidWorks 2005. This software gives a calculated evaluation on how the frame will react to stresses and loads. It also gives a 3-D physical representation of the placement and center of mass of the satellite. This means the results and analysis are calculated, computer generated results of which changes will be made when fabricating in reality. Testing and assembling in reality will allow for optimal analysis and component placement. Work still needs to be done to continue the detailed analysis of the LEONIDAS satellite structure system in order to have the most accurate results. More stress analysis and load testing needs to be done to finalize the structural integrity of this satellite. Mass reduction needs to increase to make this frame optimal. And research still needs to be done on further material and thermal development. All of these components need to be done to have a final analysis of the structure system, and for a premium balance of functional requirements.

REFERENCES

Larson, Wiley J., and James R. Wertz. Space Mission Analysis and Design. 3rd ed. El Segundo, CA: Microcosm Press, 1999