N92-15880

1991

NASA/ASEE SUMMER FACULTY FELLOWSHIP PROGRAM

MARSHALL SPACE FLIGHT CENTER

LUNAR TRANSIT TELESCOPE LANDER DESIGN

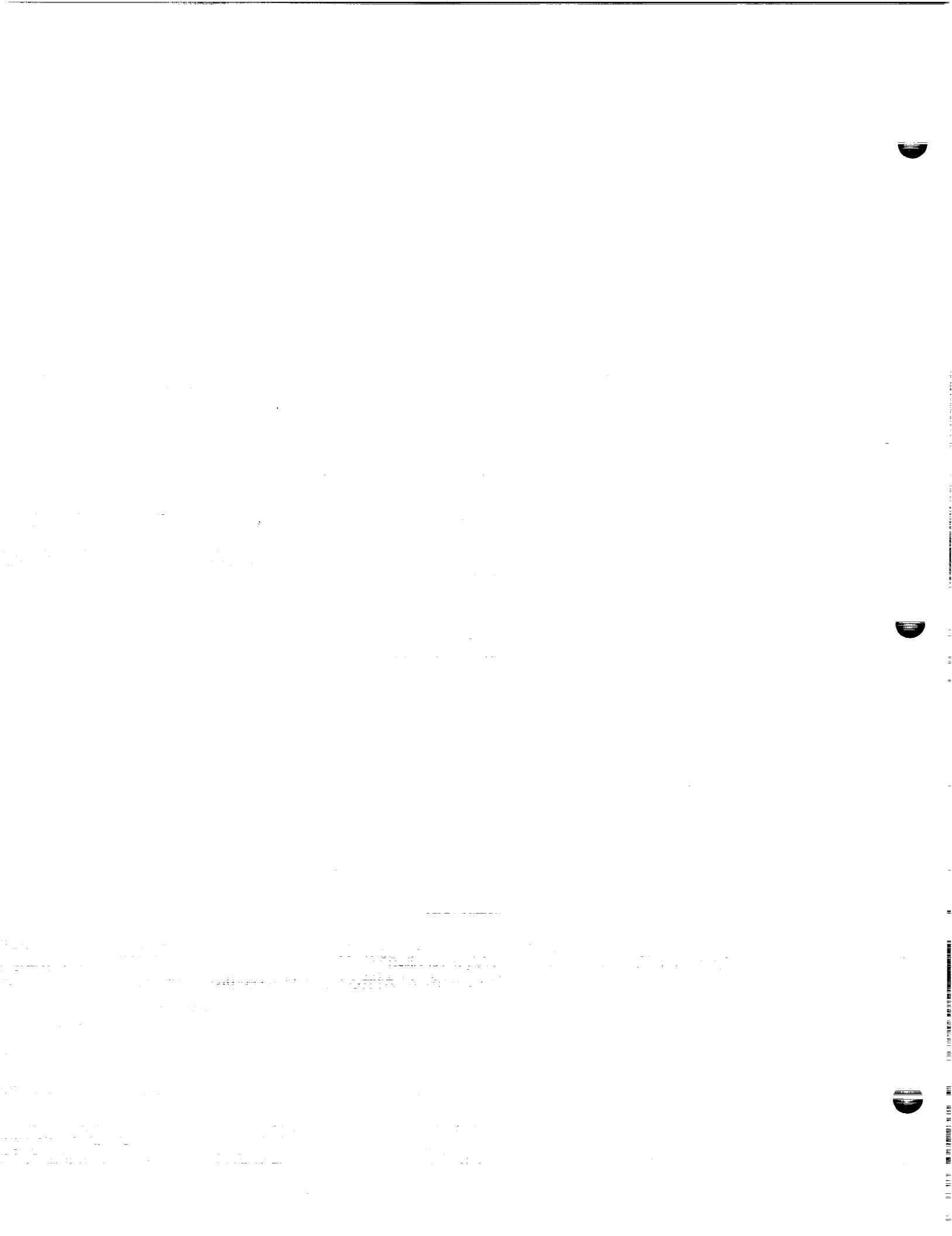|	
Prepared By:	**Husam A. Omar**, Ph.D.
Academic Rank:	Assistant Professor
Institution:	University of South Alabama Department of Civil Engineering Mobile, Alabama 36688
NASA/MSFC:	
Office:	Space Explorations PS02
Division:	Program Development
Colleague:	Max Nein
Contract No.:	NGT-01-008-021 University of Alabama in Huntsville

Lunar telescopes provide several advantages over earth based and space telescopes. The absence of atmosphere around the moon provides a much clearer view than earth based telescopes. Furthermore, the lunar surface can provide anchorage and support for the telescope thus eliminating a lot of vibrations associated with free flying space telescopes. The precise movements of the moon can serve as a platform for telescopes that can be used to scan the skies both efficiently and economically. The Program Development group at NASA's Marshall Space Flight Center has been involved in studying the feasibility of placing a 16 meter telescope on the lunar surface to scan the skies using visible/ Ultraviolet/ Infrared light frequencies. It became apparent that many of the technologies needed to achieve this objective are not currently available and will not be available in the near future. Therefore, the astronomical science community, realizing the many advantages of Lunar Telescopes, decided to go for a precursor telescope that is simple to build, transport and deploy on the lunar surface. This telescope will provide the science community with basic science in the near future and the engineering community with badly needed information about the influence of the Lunar environment on the telescope's mirrors, support systems and structure. The precursor telescope is now called the TRANSIT LUNAR TELESCOPE (LTT). The Program Development Group at Marshall Space Flight Center has been given the task of developing the basic concepts and providing a feasibility study on building such a telescope. The telescope should be simple with minimum weight and volume to fit into one of the available launch vehicles. The preliminary launch date is set for 2005.

A study was done to determine the launch vehicle to be used to deliver the telescope to the lunar surface. The TITAN IV/Centaur system was chosen. The engineering challenge was to design the largest possible telescope to fit into the TITAN IV/Centaur launch system. The telescope will be comprised of the primary, secondary and tertiary mirrors and their supporting system in addition to the lander that will land the telescope on the lunar surface and will also serve as the telescope's base. The lunar lander should be designed integrally with the telescope in order to minimize its weight thus allowing more weight for the telescope and its support components.

The objective of this study were to design a lander that meets all the constraints of the launching system. The basic constraints of the TITAN IV/Centaur system are as follows
- Max. dry weight of telescope and lander is 3075 Kg
- Max. shroud size of the Centaur is 4.52 meters
- Lateral frequencies must be above 2.5 Hz
- Avoid axial frequencies between 17 and 24 Hz
- Avoid lateral frequencies between 6 and 10 Hz

TELESCOPE/LANDER CONFIGURATION

Several telescope/lander configurations have been considered in this study. Figure 1 shows a typical lander configuration. A three mirror telescope will be used. The mirrors and supporting equipment will be surrounded with a solar shield as shown in the figure. The lander will have four legs for added stability. The diameter of the telescope and the lander in the stowed position will be 4.26 meters thus leaving a 0.13 meter clearance on all sides of the Centaur. Four H_2 and four O_2 propellent tanks will be used. Four side beams are used to connect the four tanks together. The O_2 tanks are supported on the side arms. The telescope components are supported on the O_2 tanks.
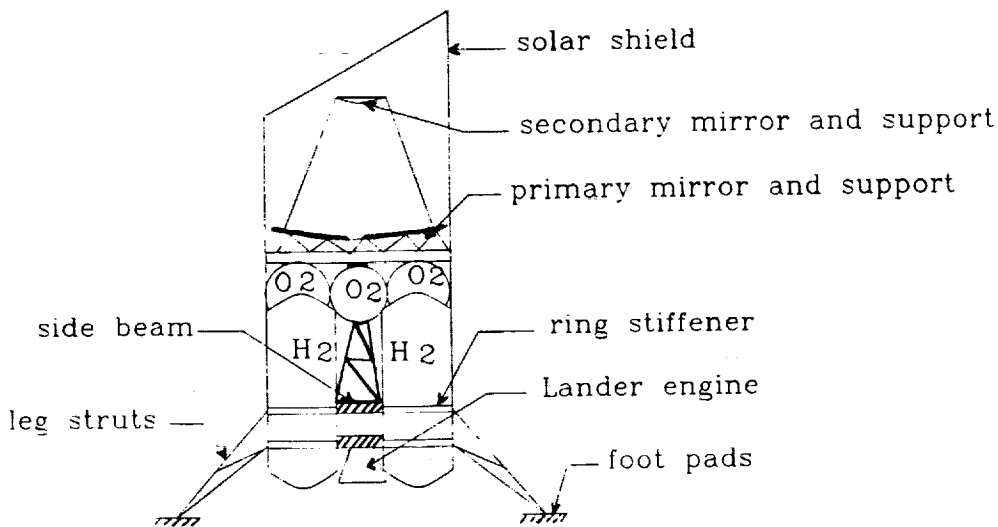
Figure 1: Telescope/Lander configuration

MODELING THE LANDER

The lander shown in Figure 1 has been modeled using a finite element program called SAP 90. The program used is capable of modeling both static and dynamic loading. It has plate/shell elements that can model the in-plane and out-of-plane stiffness of the propellent tanks where the legs connect. The lander legs were modeled using frame elements. Because of symmetry in the lander about two axis only one-fourth of the lander has been modeled.

The foot pads were designed assuming a lunar soil bearing pressure of 6.9 kPa (equivalent to 1 psi). Using the initial weight estimates for all subsystems the diameter of a single foot pad was found to be 0.61 meters. The initial size of the foot pads were used in the finite element model to generate stresses and deformations.

DD-2

Since the telescope is scheduled to be launched in the near future the material used in the lander design should one whose properties and behavior are well known and available. In this study the material of choice was Al Li Weldalite[TM] 049 produced by Martin Merietta. This Aluminum alloy is light weight (Density is 2.7 g/cc), weldable, has high ultimate tensile strength (UTS is 620 MPa), and has high modulus of elasticity (E is 76.5 GPa).

Two types of loads were applied to the model. The first is static loads which represent the weights of the telescope's mirrors, support systems and support structure. The second is dynamic impact loads resulting from landing the telescope on the Lunar surface. In the literature, the impact loads have been traditionally modeled using a spike of the accelerations in a short period of time. Therefore, in this study the same procedure was followed and a spike of 3g were applied in the vertical direction and 0.5g in the horizontal direction in a time period of 0.6 seconds.

A preliminary study was conducted to determine the feasibility of supporting the lander legs using the H_2 tanks. The objective was to determine the tank thickness required to support the lander legs without excessive stresses. The analysis showed that the thickness needed was not less than 0.02 meters which will yield extremely heavy tanks (weight of four tanks 1728 Kg). Therefore, the tanks were then stiffened in the horizontal direction using ring stiffeners located at the level where the leg struts join into the tank. The ring stiffeners will support all lateral loads coming from the legs upon impact. This allows significant reduction in the thickness of the tank's walls. Currently the analysis shows that when using two ring stiffeners that are 0.03 meters by 0.06 meters allows the tank walls to be reduced to 0.008 meters in thickness which makes the total weight of the four H_2 tanks 693 Kg. Figure 2 shows the maximum moment distribution in the tank.

The SAP 90 analysis program also calculates stresses in the leg struts, foot pad and side beams connecting the tanks together. Based on the analysis the following sizes seem to be appropriate. The leg struts are assumed to be thin shell tubes 0.08 meters in diameter and 0.005 meters in thickness. The struts are filled with honeycomb crushable Aluminum to provide appropriate attenuation for the vibrations resulting from landing on the lunar surface. The total estimated weight for the leg struts is 169 Kg. A foot pad thickness of 0.005 meters has been shown to be appropriate thus resulting in total mass of 75 Kg. The side beams used were 0.1 meters high, 0.03 meters deep and 0.553 meters long. The total mass for the connecting beams was found to be 72 Kg. Therefore,

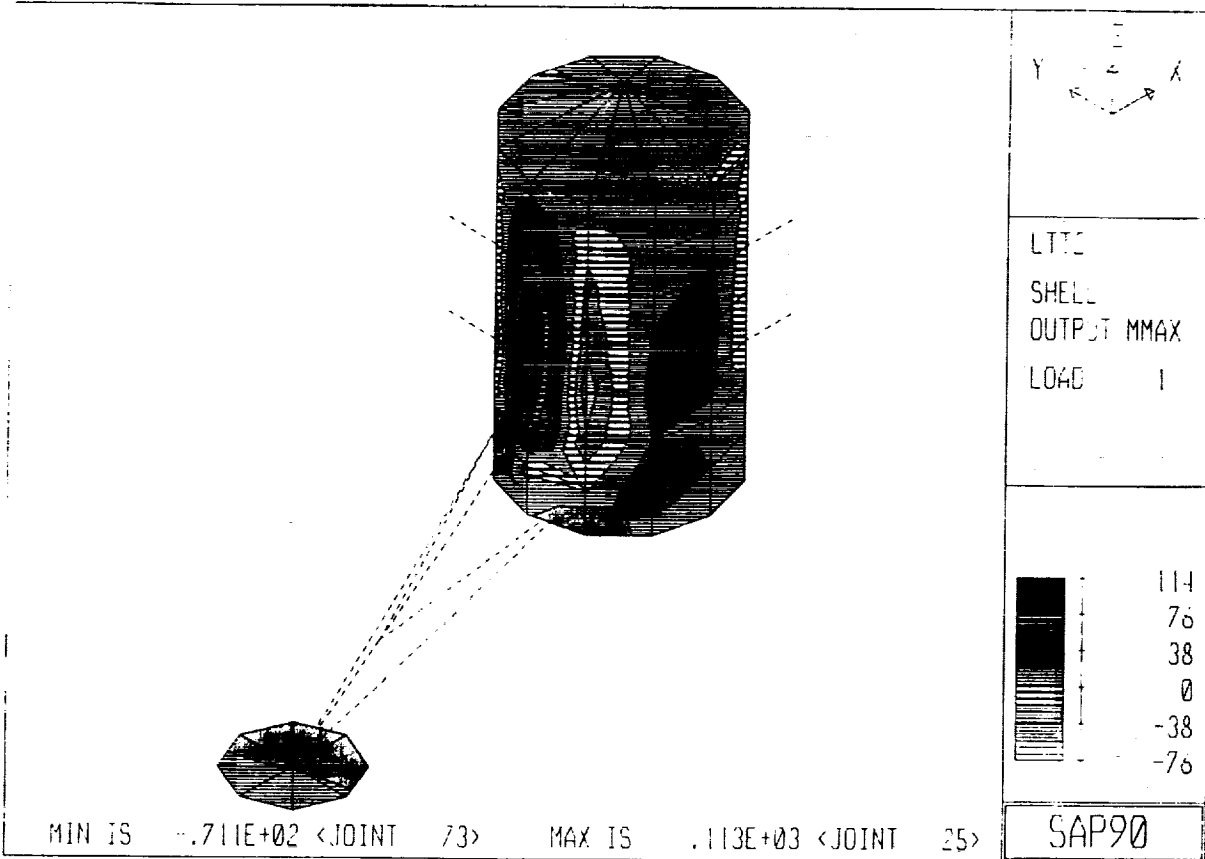the total current estimate of the lander components is 1009 Kg.

Figure 2: Maximum moment distribution in tank

SUMMERY AND RECOMMENDATIONS

The LUNAR TRANSIT TELESCOPE (LTT) will serve as a precursor for other bigger and better lunar telescopes in the future. It is a great challenge to design a Telescope/Lander system that can be launched using existing vehicles such as the TITAN IV/Centaur system. All the work done so far is preliminary and many changes will take place before the final version of this telescope will be built and deployed.

Although the objectives of this study of producing a preliminary design for the LTT has been achieved there is still several aspects that need to be investigated. The influence of lunar regolith properties on the dynamics of landing should be studied. In addition, the stability of landing on a slope or in a crater should be investigate. Furthermore, the location of the lander leg struts should be optimized to reduce stresses in the tanks and increase stability of landing.