16:39:22 OCA PAD INITIATION - PROJECT HEADER INFORMATION 09/24/90

Active

Project #: E-25-~~518~~ 519 Cost share #: Rev #: 0
Center # : 10/11-6-P5081-0A0 Center shr #: OCA file #:
Work type : INST
Contract#: LETTER DTD 900808 Mod #: Document : GRANT
Prime #: Contract entity: GTRC

Subprojects ? : N
Main project #:

Project unit: MECH ENGR Unit code: 02.010.126
Project director(s):
BRAZELL J W MECH ENGR (404)894-3218

Sponsor/division names: UNIV SPACE RESEARCH ASSOC /
Sponsor/division codes: 500 / 037

Award period: 900915 to 910731 (performance) 910731 (reports)

Sponsor amount	New this change	Total to date
Contract value	16,000.00	16,000.00
Funded	16,000.00	16,000.00
Cost sharing amount		0.00

Does subcontracting plan apply ?: N

Title: NASA/USRA UNIVERSITY ADVANCED DESIGN PROGRAM

PROJECT ADMINISTRATION DATA

OCA contact: Kathleen R. Ehlinger 894-4820

Sponsor technical contact

MS. CELESTE WILSON
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NASA/USRA ADVANCE DESIGN PROGRAM
17225 EL CAMINO REAL, SUITE 450
HOUSTON, TX 77058

Sponsor issuing office

BARBARA RUMBAUGH
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UNIVERSITIES SPACE RESEARCH ASSOC.
SENIOR PROJECT ADMINISTRATOR
ADVANCED DESIGN PROGRAM
17225 EL CAMINO REAL, SUITE 450
HOUSTON, TX 77058

Security class (U,C,S,TS) : U ONR resident rep. is ACO (Y/N): N
Defense priority rating : N/A N/A supplemental sheet
Equipment title vests with: Sponsor X GIT

Administrative comments -
INITIATION OF PROJECT. FINAL INVOICES SHOULD BE SUBMITTED BY 7/31/91. FUNDS ARE NOT APPROVED FOR FACULTY RELEASE TIME.

GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION

NOTICE OF PROJECT CLOSEOUT

Closeout Notice Date 08/13/91

Project No. E-25-519 Center No. 10/11-6-P5038-4A0

Project Director BRAZELL J W School/Lab MECH ENGR

Sponsor UNIV SPACE RESEARCH ASSOC/

Contract/Grant No. LETTER DTD 900808 Contract Entity GTRC

Prime Contract No.

Title NASA/USRA UNIVERSITY ADVANCED DESIGN PROGRAM

Effective Completion Date 910731 (Performance) 910731 (Reports)

Closeout Actions Required:	Y/N	Date Submitted
Final Invoice or Copy of Final Invoice	Y	
Final Report of Inventions and/or Subcontracts	Y	
Government Property Inventory & Related Certificate	N	
Classified Material Certificate	N	
Release and Assignment	N	
Other	N	

Comments

Subproject Under Main Project No.

Continues Project No.

Distribution Required:

Project Director	Y
Administrative Network Representative	Y
GTRI Accounting/Grants and Contracts	Y
Procurement/Supply Services	Y
Research Property Managment	Y
Research Security Services	N
Reports Coordinator (OCA)	Y
GTRC	Y
Project File	Y
Other	N
	N

NOTE: Final Patent Questionnaire sent to PDPI.

Georgia Tech

THE GEORGE W. WOODRUFF SCHOOL OF
MECHANICAL ENGINEERING

Georgia Institute of Technology
Atlanta, Georgia 30332-0405

Barbara Rambaugh
Senior Project Administrator
NASA/USRA Advanced Design Program
17225 El Camino Real, Suite 450
Houston, TX 77058

July 29,1991

Dear Barbara,

Re: Final Report; NASA/University Advanced Design Program, E-25-519

Introduction:
During Fall, Winter, and Spring quarters, Georgia Tech's School of Mechanical Engineering students designed machines, structures, and devices related to Lunar Base construction. These included four joint projects with Textile Engineering students. Summaries of the joint projects are included in the Textile Engineering final report.

Project Excerpts:
Following are excerpts from representative projects designed by the students.

A LUNAR SURFACE VEHICLE MODEL

To facilitate the future exploration of and possible colonization of the moon, a remotely operated vehicle is needed so that materials and supplies could be easily transported. This vehicle must be able to pick up a specified payload, transport it over the rough lunar surface, and then unload the payload at a desired location. We have designed a model of such a vehicle to permit the evaluation of its performance in an Earth environment. The layout of the model consists of a six-wheel drive, four-wheel steering, remote radio controlled vehicle.

The chassis design consists of an aluminum two-tier arrangement to provide adequate space for the components and systems of the vehicle. The lower tier contains the powertrain components while the upper tier contains the steering mechanism, the speed controller, and the payload lifting mechanism.

The vehicle's independent suspension uses a nylon fiber reinforced composite upper and lower control arm for each wheel and a plexiglass transverse leaf spring for each axle. The upper control arm contains a turn buckle to allow for camber adjustment of each wheel. The leaf spring is a simple design which has an adjustable spring rate.

The powertrain consists of a 20,000 rpm, 0.16 hp, DC motor powered by a 7.2 volt, six cell battery pack. The motor is controlled by a resistor-type speed controller with variable braking and reverse and provides power to a 65:1 gear reduction unit which, in turn, powers three belt drives for the three differentials. The differentials are of a limited slip "ball" type used in model RC cars. This type of differential will allow for better traction in loose soil. The differentials provide torque to the driveshafts which are connected with universal joints at both ends.

The wheels for the vehicle are made of polystyrene foam for weight optimization and have an ellipsoidal shape. A custom, paddle type tread design is epoxyed to the wheel before the outer surface of the wheel is dipped in a rubber compound to give a uniform coating. The ellipsoidal shape provides a large contact patch which in sand for maximum traction and also allows point contact on hard surfaces which requires less steering force.

The steering system uses the Davis design which allows for the correct turning angles of the inside and outside wheels such that each wheel has the same center of rotation giving no "scrub". A maximum inside wheel turning angle of 30 degrees requires an outside wheel turning angle of 16 degrees. These angles provide for a small turning radius of 23.3 inches. The design uses a linear servo controlled moving slider bar connecting two slotted members, one for each wheel. The movement of the slider bar causes the slotted members to rotate through different angles of rotation giving the necessary wheel angles. The vehicle design uses four bar linkage to connect the rear steering angle with the front steering angle with the aid of two spur gears to change the angle of rotation from rear to front.

The payload is an aluminum spool with a mass of 0.5 kg. The bottom lip of the spool contains more mass than the upper lip to prevent it from being tipped over easily. The lift mechanism consists of a chassis-mounted track, a sled that slides along the track, a pair of forks hinged to the front of the sled, a servo mounted to the chassis underneath the track, and a lifting arm mounted to the servo. The arm is connected to the forks through a cable; the end of this cable slides on the arm to prevent binding. The lift operates by approaching the payload with the sled in its lowest vertical position with forks extended. After the payload is positioned within the forks, the lift arm, riding in a vertical slot through the center of the sled, pulls the forks into a vertical position so that the payload then rests within a round depression in the face of the sled. At this point, the lift arm makes contact with the end of the slot. A roller is mounted at the point of contact to minimize friction. The lift arm now pushes the sled up along the track, to a horizontal position behind the front wheels. The payload is held by gravity within the depression in the top of the sled. To unload the payload, the lift arm pushes the sled back down the track, then lowers the forks down to vertical position such that the payload is resting on the ground. The vehicle then backs away from the payload.

LUNAR LOADER/TRANSPORTER

With the increasing possibility of inhabiting the moon, researchers are exploring feasible modes of lunar transportation. This paper researches one such transportation vehicle. The lifting mechanism offers several degrees of freedom. The additional degrees of freedom assist the operator in the loading and unloading of cargo in most regions of the moon terrain.The vehicle's tires and body were both designed to efficiently operate on the moon's rocky surface. The lunar transporter, specified within, may offer researchers some answers and incentives for future space exploration.

TRENCHING AND CABLE-LAYING DEVICE FOR THE LUNAR SURFACE

This paper details the design of a trenching and cable-laying machine designed for use on the moon. Lunar bases will require exterior cables for power and communication. Burying these cables 1 meter below the lunar surface shields the cables from radiation, meteorites, and surface traffic. The cable-laying device described in the paper excavates a narrow trench 1 meter in depth and lays a cable (2.5 cm maximum diameter) over a distance of 1 km. The trench is formed by a vibratory dual-plow system. The first plow digs a trench .5 meters in depth and 10 cm wide, and the second plow deepens the trench to a depth of 1 m and 5 cm wide. The two-pass configuration of the plow greatly reduces the draw-bar force of the plowing action. Additionally, each plow blade is vibrated to further decrease the force needed to shear the soil. The drive system for the cable-laying plow consists of an auger mechanism. The auger drive system overcomes the traction problems associated with plowing in the low gravity environment of the moon. Since the traction is not gained through the weight of the vehicle itself, pulling the plow by the auger allows the cable-laying machine to remain small and light-weight.

A LUNAR VEHICLE SYSTEM FOR HABITAT TRANSPORT AND PLACEMENT

This paper addresses the need for a piece of machinery to unload, transport, and place a lunar habitat on the moon's surface. Since NASA intends to carry out mining operations, as well as prepare the moon for future colonization, habitats are needed to accommodate the astronauts on the extended lunar missions. Therefore, NASA must find a way to relocate these habitats once they are delivered to the moon by a lunar lander. The design solution recommended by this paper is the use of two track vehicles containing scissors-lifts with cradles located on top. Each vehicle will be aligned under one end of the habitat. The scissors-lift will extend and the cradle will be adjusted to line up with the coupling neck of the habitat. Each scissors-cradle mechanism will extend to a height in excess of 10 m to lift the habitat off the lander. The vehicles will be turned parallel to one another and moved until the habitat is clear of the lander. The scissors-cradle mechanism will then collapse, and the vehicles will be aligned and driven to the desired habitat location. At this point the scissors-cradle mechanism will fully compress to a vehicle height of 2.5 m, placing the habitat on the lunar surface. The vehicles will then drive out from under the habitat. This design solution takes into account power requirements, torque requirements, and the dimensions of the lander and shuttle bay.

LUNAR STORAGE FACILITY

Before the construction of a manned lunar base can begin, a storage facility must be initially set up. The purpose of this facility will be to store electronic equipment and small containers of other miscellaneous equipment, while protecting it from radiation. The goal of this project was to assess the need and then to find the optimal design by considering many performance objectives and constraints.

The proposed lunar storage facility is self erecting, utilizes material (regolith) from the lunar surface, and will be capable of storing objects of variable geometry, up to three meters in height. During shipment in the space shuttle cargo bay, the shed will be reduced to a basic cylinder shape whose outer dimensions will be 4 m diameter by 15 m in length. Set-up of this shed will consist mainly of releasing a locking mechanism, after which the release of potential energy will cause the shed to erect itself. Radiation protection will be provided by filling an outer bladder with 2 meters of regolith utilizing a regolith slinging mechanism.

Impacts to the Program:

During this academic year, the NASA/University Advanced Design Program has been of special benefit to the Georgia Institute of Technology, the School of Mechanical Engineering, its faculty and students in a number of important ways. The baseline of previous years' support and encouragement continues to enrich the program in a very positive manner. This report deals only with those benefits that accrued this academic year which were in addition to this established baseline.

An Apple Computer Company Macintosh IIci computer was added to the Engineering Design Laboratory. Graphics tablets were added to this computer and the Macintosh II computer. The finite elements analysis software in stalled this year has been used by each of the design teams and has facilitated the design optimization of a number of machine components.

The instructor attended conference related to planetary surface construction and mining activities to obtain state-of-the-art information in this field.

The continuation of the program served as encouragement to pursue the patent related to the three-legged walker known as "SKITTER." The program was influential in the faculty's decision to restructure the design course as a two-quarter sequence.

The American Society of Mechanical Engineers (ASME) guidelines for journal papers were used by each design team as they prepared an ASME paper representing their project. Two of these papers were entered in the regional ASME student paper competition and won first and second places.

The program has influenced the employment choices made by several recent graduates. One student was selected for a position with a prestigious design consulting firm, two are employed by major aerospace firms, and one has an application pending at NASA.

Conclusions:
The 90/91 program was successful in enhancing the teaching of engineering design to all three classes of Mechanical Engineering Design (ME 4182) students.

Sincerely,

James W. Brazell
Instructor