LANGLEY WORKING PAPER

CONCEPT OF A BACKPACK CARRIER FOR USE

BY LUNAR EXPLORERS

By Amos A. Spady, Jr., and Frank G. Read

Langley Research Center
Langley Station, Hampton, Va.

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

October 11, 1966
LWP - 300
October 11, 1966

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Prepared by

Amos A. Spady and Frank G. Read
Amos A. Spady Jr., and Frank G. Read

Approved by William H. Phillips
William H. Phillips
Chief
Space Mechanics Division

LANGLEY RESEARCH CENTER
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SUMMARY

The exploration of the lunar surface will require the astronaut to carry various instruments, tools, etc., from place to place. This paper presents a backpack carrier concept which allows the pressure-suited astronaut to don, carry, and doff a backpack load unassisted. The backpack carrier concept can be adapted to a number of uses, including an emergency unit for carrying a disabled astronaut.

INTRODUCTION

Prior to the invention of the wheel man was faced with the problem of transportation of heavy articles from place to place with the least physical effort. A variety of methods and techniques were devised to implement this effort. Of these, the most practical and efficient system was the use of man's own back for optimum load-carrying ability and balance. Modern day research has verified that the most efficient place for a man to carry a load is on his back (reference 1). Therefore, for lunar astronaut explorers, the back-carrying systems should prove to be the most efficient when dealing with human factors as related to load-carrying capability. Current unpublished test results (reference 2) obtained using Langley Research Center's reduced gravity
simulators (reference 3) show that in simulated lunar gravity man can efficiently carry, without any significant balance problems, a 500-pound load secured to a standard army backpack frame. The use of a backpack frame in its simplest form is not applicable for lunar surface exploration; however, with proper modification, the backpack frame load-carrying technique can be used by an astronaut explorer to expand his load-carrying ability. The concept and usage of such a backpack system are discussed in this paper.

**BASIC CONCEPTS**

The backpack carrying unit as conceived would consist of a stand container with three or more folding or telescopic legs, as shown in figure 1, configured to fit around the astronaut's portable life support system (PLSS), or design combinations of PLSS and mobility units. Figure 2 depicts an instrument module or container attached to the basic backpack frame. The unit as a whole or in modular components could be stored on the spacecraft to facilitate easy removal by the astronaut. A typical operational procedure from checkout through deployment is depicted in figure 3. Step (a) depicts the astronaut checking the unit; (b) preparing to don by aligning himself in position using the leg actuator bars for position; (c) shows the astronaut backing the PLSS into place and securing harness; (d) he leans forward to assume the load; and (e) the arms are now pulled upward mechanically rotating the legs to a secured vertical position. With the completion of the above procedure walking locomotion may be accomplished with heavy loads. To remove the backpack unit upon arrival at his destination, he doffs the unit by reversing the donning procedure. After doffing the unit the astronaut could begin (f) preparations for setting up a
remote data-gathering site, using the unit as a work platform, and (g) putting the remote site into operation.

UTILIZATION

The basic backpack frame concept is readily adaptable to the following general uses:

1. An instrument and tool carrier
2. A platform for research instrumentation
3. A platform for a one-man rocket system
4. An emergency carrying device for a disabled astronaut
5. A lunar sample carrier
6. A television camera base or tripod
7. An antenna base
8. A tool support base

An explanation of these uses is presented in the Discussion Section. There are obviously other uses for this concept which will become more apparent during development.

EXPLORATORY TEST RESULTS

As part of a continuous research program being conducted at the Langley Research Center utilizing Langley's reduced gravity simulator, tests have been conducted with test subjects in lightweight flight suits, carrying a backpack weighing up to 500 pounds (reference 2). A picture of a subject in the simulator wearing the backpack is shown in figure 4. Basically, the results indicate that a test subject could control and carry a 500-pound backpack while
standing, walking, sprinting, loping, and jumping. The subject was also able to regain a standing posture from a prone position with little difficulty.

Follow-on tests, also using Langley's reduced gravity simulator, were conducted where test subjects in lightweight flight suits were required to carry a crude fixed-leg framework (fig. 5), weighing approximately 90 pounds, secured to a standard army backpack. Test results show that this configuration allowed the test subject to easily don or doff the unit unassisted in a standing position, and indicated that the extended leg frame did not restrict maneuverability of the test subject while walking and running on a smooth, firm surface. However, the test subjects found that while decelerating from running velocities there was a tendency for the extended front leg to scrape the walkway. This problem was eliminated by the test subject's ability to adjust his stance during this maneuver. Therefore, on the basis of the test results, it appears that the backpack concept, as proposed, is a feasible method by which the astronauts can transport loads across the lunar surface.

A short film sequence has been prepared showing the test subject (wearing a lightweight flight suit) in simulated lunar gravity while carrying a 500-pound load. Also shown is the donning, carrying, and doffing procedure of the pack frame as described in the above test. The film is available on loan and may be obtained from the Chief, Photographic Division, NASA, Langley Research Center, Langley Station, Hampton, Va. 23365.

DISCUSSION OF CONFIGURATION

The backpack carrier has many basic advantages in that it allows the explorer to transport heavy or bulky payloads, yet leaves his hands free for balance and/or adjusting his PLSS, carrying out small experiments, taking
pictures, and so forth. The unit would be constructed using aerospace design
techniques to produce a lightweight functional lunar tool.

The standing position of the backpack, when not being carried, will allow
the backpack to be used as a waist-high work or service platform and storage
rack. The waist-high feature would eliminate considerable stooping and bending,
which are difficult when wearing a full-pressure suit.

The pack frame could, by virtue of its legs, be either grounded to or
insulated from the lunar surface, depending on the materials used.
Consequently, it could be left by the explorer at a desired point to serve as
a support unit for scientific instruments, television camera and/or an elec-
tronic relay link either as a single unit or as part of a lunar operations
network.

The design concept of this unit lends itself for use as an emergency
carrying device for a disabled astronaut. One method would be for the second
astronaut to off-load all test equipment from the backpack, then secure the
disabled astronaut to the carrier in an upright face forward position, as
shown in figure 6, don the carrier and proceed back to base operations. Provi-
sions could be made to interconnect both PLSS systems of the astronauts for
the situation where the disabled astronaut is low on storables. A second
approach is to convert the carrier into a wheelbarrow, utilizing a lightweight
inflatable wheel or wheels attached to the back legs of the carrier, using the
shoulder supports as handles (fig. 7). The disabled astronaut is then secured
to the wheelbarrow and either pushed or pulled back to base.

The integration of the proposed backpack carrier with a one-man rocket
propulsion system would allow an astronaut explorer to fly to an inaccessible
area, doff the unit, explore the area, don the unit and return. The advantage
of this system is that it allows the astronaut to carry instrumentation and lunar samples from place to place while permitting unhampered use of arms and hands to control the propulsion unit. If the astronaut explorer should inadvertently fall and end up in a supine position, he could easily raise himself to a sitting position by partially erecting the backpack legs (fig. 8), and from that position he could regain an upright position with relative ease. The backpack could also be contoured to assist in rolling over if necessary. It is also contemplated that to assist in rolling over, only one of the legs could be actuated creating a turning action.

CONCLUDING REMARKS

Based on the exploratory test results, it appears that the backpack carrier integrated with the portable life support system is a feasible concept. The backpack carrier will provide the lunar explorer a versatile load carrier with the many advantages as illustrated within the context of this paper.

To fully evaluate the concept, additional basic research is needed to determine the maximum center of gravity and weight limitations for various conditions of lunar surfaces and the metabolic costs of load carrying. Other tests should also be conducted to determine the optimum donning and doffing procedure, strapping arrangements, and so forth. A majority of the tests could be conducted using the Langley reduced gravity simulator; however, tests should also be conducted using other simulation techniques to verify the results.
REFERENCES


Figure 1.- Illustration depicting the basic backpack carrier.
Figure 2.- Assembly of astronaut, PLSS, basic frame, and instrument module or container.
Figure 3.- Illustration depicting general use of the backpack carrier.
Figure 4a.- Front view of test subject in reduced gravity simulator carrying a 100-pound backpack.
Figure 4b.- Rear view of test subject in reduced gravity simulator carrying a 100-pound backpack.
Figure 5.- Subject carrying a 90-pound fixed-leg framework in earth gravity.
Figure 6.- Use of backpack carrier as a rescue device.
Figure 7.- Use of backpack carrier for rescue device in wheelbarrow form.
Figure 8.- Use of backpack carrier as an aid in recovery from a fall.