Lunar Habitat Concept Employing the Space Shuttle External Tank

Charles B. King,* Ansel J. Butterfield,† and Warren D. Hypes‡
The Bionetics Corporation, Hampton, Virginia
and
John E. Nealy§ and Lisa C. Simonsen¶
NASA Langley Research Center, Hampton, Virginia

Abstract

THE space shuttle external tank, which consists of a liquid oxygen tank, an intertank structure, and a liquid hydrogen tank, is an expendable structure used for approximately 8.5 min during each launch. A concept for outfitting the liquid oxygen tank-intertank unit for a 12-person lunar habitat is described. The concept utilizes existing structures and openings for both man and equipment access without compromising the structural integrity of the tank. Living quarters, instrumentation, environmental control and life support, thermal control, and propulsion systems are installed at Space Station Freedom. The unmanned habitat is then transported to low lunar orbit and autonomously soft landed on the lunar surface. Design studies indicate that this concept is feasible by the year 2000 with concurrent development of a space transfer vehicle and manned cargo lander for crew changeover and resupply.

Contents

A concept has been developed for converting the liquid oxygen tank-intertank portion of the Space Shuttle's expendable external tank assembly (see Fig. 1) into a lunar habitat.[1] The liquid oxygen tank is a butt-fusion-welded, gas-tight pressure vessel of aluminum alloys. The tank is hydrotested for use at 172.3 kPa (25 psia) for safe flight operations, well above the internal pressure of 101.3 kPa (14.7 psia) required for the lunar habitat. Its size (8.4 m in diam and 16.6 m in length) is ideally suited for a lunar habitat. Conceptual design studies were performed in sufficient detail to provide estimates of mass and volume requirements of systems and support structures essential to outfitting the tank as a lunar habitat. These include designs for the micrometeoroid/orbital debris shield, radiation protection, and the environmental control and life support (ECLS), thermal control, and propulsion systems for outfitting the external tank-intertank assembly. Power, communications, and guidance, navigation, and control systems were not conceptually designed but were included in the mass allocations (see Table 1). All internal habitat equipments were sized to pass through the tank's manholes.

Received May 23, 1989; synoptic received Dec. 4, 1989. Full paper available from National Technical Information Service, Springfield, VA 22151, by title, at the standard price (available on request).

*Project Engineer.
†Project Engineer.
‡Consultant.
§Aerospace Engineer, Spacecraft Analysis Branch, Space Systems Division. Member AIAA.
¶Aerospace Engineer, Spacecraft Analysis Branch, Space Systems Division.

Ground Operations

On Earth, the structural and subsystem components can be temporarily installed in the habitat and tested before delivery to the Space Station Freedom. Erectable floor panels are designed to simplify installation of support structures and subsystem components. After the habitat has been fully assembled and tested, components are disassembled and packaged for delivery to Space Station Freedom.

Orbit Operations

Once the external tank arrives in low Earth orbit (LEO), the liquid hydrogen tank is removed, and the liquid oxygen tank intertank is transported to Space Station Freedom by an orbital maneuvering vehicle (OMV) for outfitting. The hydrogen tank can be saved for other uses by placing it in a higher orbit, or it can be destroyed during re-entry.

To facilitate assembly of the lunar habitat at Space Station Freedom, a concept was developed to outfit the space station with a resource node, an air lock, an additional module to house ECLS equipment, and a habitat area for the outfitment crew. The resource node permits berthing and access to the tank. The ECLS module supplies a habitable atmosphere for the refitment, which minimizes extravehicular activity (EVA). However, EVA is required for installation of the micrometeoroid shield and propulsion system.

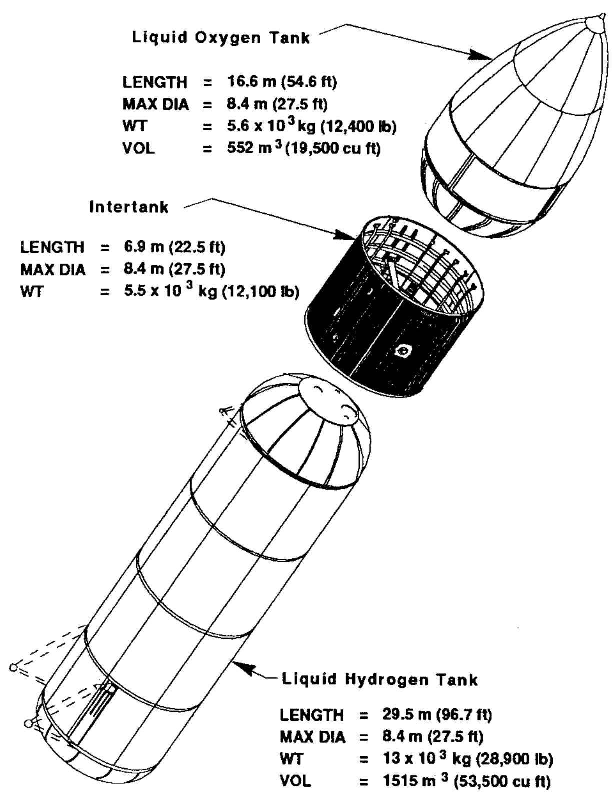

Fig. 1 External tank subassemblies.

Table 1 Containers/items installed in low Earth orbit

System	Tank interior: Quantity containers/ items	Tank interior: Total mass kg	(lbs)	Tank exterior: Quantity containers/ items	Tank exterior: Total mass kg	(lbs)
Structures						
Flooring and struts	33	2500	(5500)	—	—	—
Air lock				1	800	(1770)
Micrometeoroid protection						
Shield	—	—	—	16	3550	(7830)
ECLS						
Habitability	20	820	(1,800)	—	—	—
Water management	14	1030	(2260)	—	—	—
Air revitalization	19	730	(1600)	12	3450	(7600)
Integration equipment	2	160	(350)	—	—	—
Food, storage, and preparation	25	2500	(5500)	—	—	—
Waste management	4	350	(770)	—	—	—
Subtotal	84	5590	(12,280)	12	3450	(7600)
Thermal control						
Acquisition	—	—	—	—	—	—
Internal thermal control	9	1130	(2500)	—	—	—
Air temperature and humidity control	13	750	(1650)	—	—	—
Transport	—	—	—	11	320	(700)
Rejection	—	—	—	—	—	—
Heat pump	—	—	—	1	80	(180)
Radiator assembly	—	—	—	25	480	(1060)
Subtotal	22	1880	(4150)	37	880	(1940)
Power, communications, and guidance, navigation, and control	40	600	(1330)	30	600	(1330)
Propulsion						
Tanks within intertank	—	—	—	10	2000	(4400)
Tanks outside intertank	—	—	—	16	3270	(7200)
O_2-H_2 engines	—	—	—	4	2400	(5300)
Subtotal	—	—	—	30	7670	(16,900)
Totals	179	10,570	(23,260)	126	16,950	(37,370)

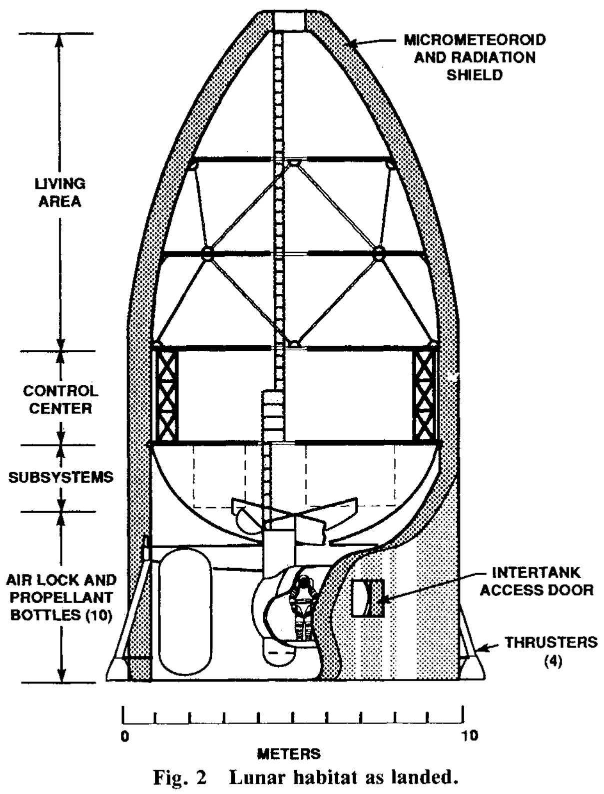

Fig. 2 Lunar habitat as landed.

Postlanded Assembly

After soft landing, adjustable footpads provide vertical alignment of the lunar habitat relative to the lunar terrain topography. The thermal radiator panels are erected and attached to a heat pump system located in the intertank region. Regolith is added to the cavity between the outer wall of the tank and the micrometeoroid shield for protection from space radiation due to solar energetic particles and galactic cosmic radiation. With the arrival of a manned cargo lander with life-support items and additional subsystems components as required, the 12-man lunar habitat (see Fig. 2) is fully operational. The habitat is designed for continuous operations with subsystems and expendables tailored to a 70-day resupply cycle.

Summary

Using current technology and existing structures, a concept for outfitting the Space Shuttle external tank at Space Station Freedom for use as a 12-man lunar habitat is presented. The addition of a resource node, an air lock, and an ECLS module to the Space Station Freedom minimizes EVA in the assembly of the habitat. Conceptual design studies provided details on the systems and support structures essential for outfitting the tank as a lunar habitat. Postlanded operations require erection of the thermal rejection system, installation of a power system, and use of lunar regolith for radiation shielding prior to manned occupancy.

References

[1]King, C. B., Butterfield, A. J., Hypes, W. D., Nealy, J. E., and Simonsen, L. C., "A Concept for Using the External Tank from a National Transportation System (NSTS) for a Lunar Habitat," 9th Annual Space Studies Institute/Princeton Conference on Space Manufacturing, Princeton, NJ, AIAA, Washington, DC, May 1989.