THE GLOMR SATELLITE
PAYLOAD G-308

Abstract

This paper describes the Global Low Orbiting Message Relay (GLOMR) Satellite and its participation in the pioneering development of a Get-Away-Special (GAS) satellite launch capability. The GLOMR is a data relay communication satellite designed and built by Defense Systems, Inc. (DSI), a private company located in the Washington, D.C. area. Experiment objectives are to demonstrate the store-forward relay of data/messages and the communication to ground user equipment. The 150 pound brass satellite, powered by lead-acid batteries and solar cells, includes processing, control and RF electronics for data message handling and storage. GLOMR is uniquely mounted through a Marman clamp ejection/retention pedestal to a five cubic foot GAS canister bottom plate. The GAS canister includes a Full Diameter Motorized Door Assembly (FDMDA) lid which is opened remotely by astronauts for satellite launch.

Introduction

The GLOMR Satellite design was driven by experiment objective requirements to package the electronics that would incorporate a dual frequency transmission and receiving capability, data/message handling and storage, and DC power conversion and control (timing). Physical constraints were imposed by the NASA GAS canister volume, shown in Figure 1. In addition, safety requirements were imposed to preclude jeopardizing the Shuttle flight mission. A detailed listing of design issues and their solutions would be prohibitive in this forum, but significant activities addressed in this paper include:

1. Optimum weight to volume
2. Maximum solar cell exposure with random attitude
3. Structural integrity
4. Operational safety and hazard control

Satellite Description

Figure 2 is a photograph of the GLOMR Satellite mounted on the NASA ejection/retention pedestal. The polyhedron shaped shell is machined from naval brass. The solar panels form three orthogonal belts, including the bottom surface which interfaces with the pedestal. Satellite retention on the spring loaded pedestal is provided by a Marman clamp that is released on command by two pyrotechnic cutters. The compression spring thrusts the satellite out of the GAS canister at approximately 3.5 ft/sec after the cutters sever the Marman clamp bolts. The four dipole antennas are made of copper clad printed circuit board material and provide essentially an omni-directional beam pattern.

The internal electronics, shown in the two views of Figure 3, are mounted on a single aluminum central plate which also acts as a heat sink. Functional elements shown include dual transmitters and receivers, antenna phasing and control electronics, a digital processor and data storage memory system, dc-to-dc converters, and Gates D-size lead-acid batteries. The batteries are housed in two separately sealed containers. Housekeeping sensors include pressure and several temperature sensors.

Effective radiation power is approximately 10 watts.

Design Issues

The NASA supplied ejection/retention pedestal, previously used on Delta launch vehicles, limited the GLOMR Satellite weight to a maximum of 150 pounds. Brass was selected as the basic shell material because of its high density property, which provided a greater ability to approach the maximum weight constraint. In low orbits, higher weights for a given size improve the orbital life. In addition, brass has excellent thermal properties, an important consideration for electronic component performance. The exposed portions of the satellite's shell is painted with black absorbing paint to improve the solar heat input.

After ejection from the GAS canister, the satellite assumes a random attitude. To provide a predictable and optimum charge to the batteries while tumbling in orbit, the solar panels are installed in an array of three continuous orthogonal belts. This arrangement optimizes solar cell exposure to sun light reguardless of the satellite's attitude. In addition, the omni-directional antenna arrangement also provides full coverage at random attitudes.

The satellite structure was designed (and tested) to withstand up to 12.9 g's RMS. The unique material selection and orthogonal shell configuration necessitated an extensive analysis and vibration testing at the NASA T & E facility. The critical area requiring the most attention, both in structural design and in validation testing centered on the mechanical interface of the satellite to the pedestal. The Marman clamp retaines the satellite on a 9-inch diameter base. To provide the same 9-inch diameter continuous ring on the satellite would require the elimination of solar panels, or at least a structural ring that would shadow the cells. Both conditions were unacceptable. The solution was a unique segmented ring, four parts (feet) affixed to the satellite and the other four parts retained by the pedestal. The four feet on the satellite must, however, provide all the strength necessary to retain the satellite on the pedestal with the clamp while withstanding the shuttle launch and landing loads specified by NASA. Brass could not, but 4130 steel, hardened to 180 ksi could and did.

An hermetically-sealed microswitch was mounted integral with each of the four steel feet. The normally closed switches, redundantly wired in series and in parallel, "awaken" the GLOMR Satellites after release from the ejection/retention pedestal. In order to address NASA's safety concerns (discussed further in the next section), hermetically-sealed switches were required to preclude sparking in a potentially volatile atmosphere (e.g., propellant fumes, hydrogen gas, etc.). In addition, with the satellite attached to the pedestal and the switches in an"open" mode, inadvertant radiation is prohibited. Once launch occurs, the satellite's internal control circuitry must "see" two day-night cycles, plus 90 minutes, before transmission is allowed. This approach provides the time for natural separation in orbit between the GLOMR and the Shuttle.

GLOMR Qualification Process

To ensure maximum protection to the Orbiter, crew and other satellites, all GAS payloads must meet rigorous safety requirements. Detailed safety plans must be accepted by NASA authorities, usually after several joint sessions concerning test results. With respect to the GLOMR satellite, the following hazards were analyzed in detail:

- Satellite structural failure
- Antenna collision with GAS can during ejection
- Emission of RF Radiation
- Battery caused explosion or electrolyte leakage

The above hazards are typical of the many analyses and subsystem testing required to prove a gas satellite flightworthy. Defense Systems, Inc. (DSI), provided the following analyses during the GLOMR Satellite's qualification process:

- o Antenna patterns
- o Structural test for pressurization (final satellite was unpressurized)
- o Launcher release tests
- o Vibration tests
- o Thermal tests of each printed circuit board
- o Antenna blade fracture tests
- o Foot-mounted microswitch testing and alignment
- o Battery housing checks
- o Post ejection radiation control

These were the subject of many meetings and correspondance between DSI and NASA engineers to qualify the GLOMR for launch. While a launch anomaly prevented the April 1985 deployment of the satellite, the rigors of the 7 day mission have confirmed the findings of the extensive analyses.

The development of a unique, segmented Marman plate interface, typifies the exacting, time-consuming qualification process which must preceed every flight. Table 1 summarizes many of the areas requiring close coordination between the GAS Project Office and the experimenters.

Conclusion

The GLOMR satellite was built in less than 1 year. This would have been impossible without valuable assistance provided by the GSFC GAS Project Office. Not only did the Office provide assistance in component selection and qualification testing, but the GLOMR exists today as a forerunner of low cost access to space. Formidable technical and procedural obstacles have been overcome to allow this experiment to play a significant part in the NASA mission of Space Commercialization.

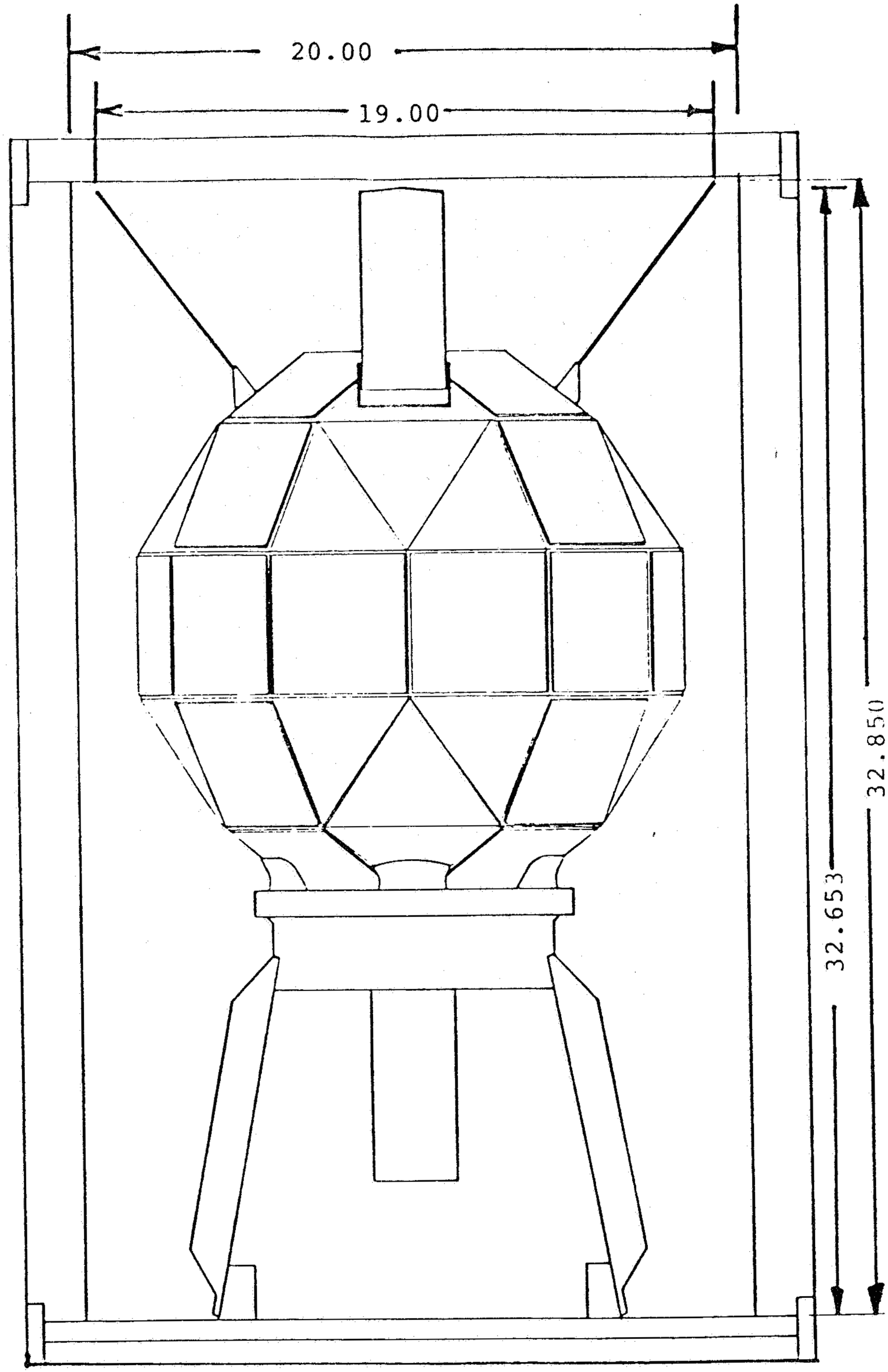

Figure 1. GLOMR in GAS Canister

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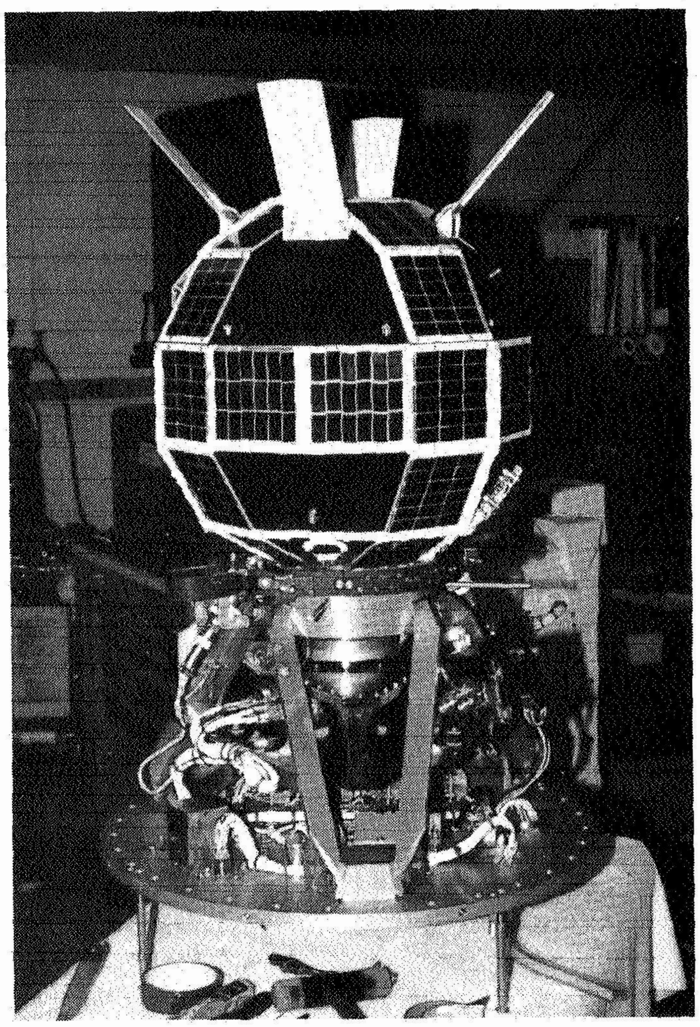

Figure 2. GLOMR Satellite and Launcher

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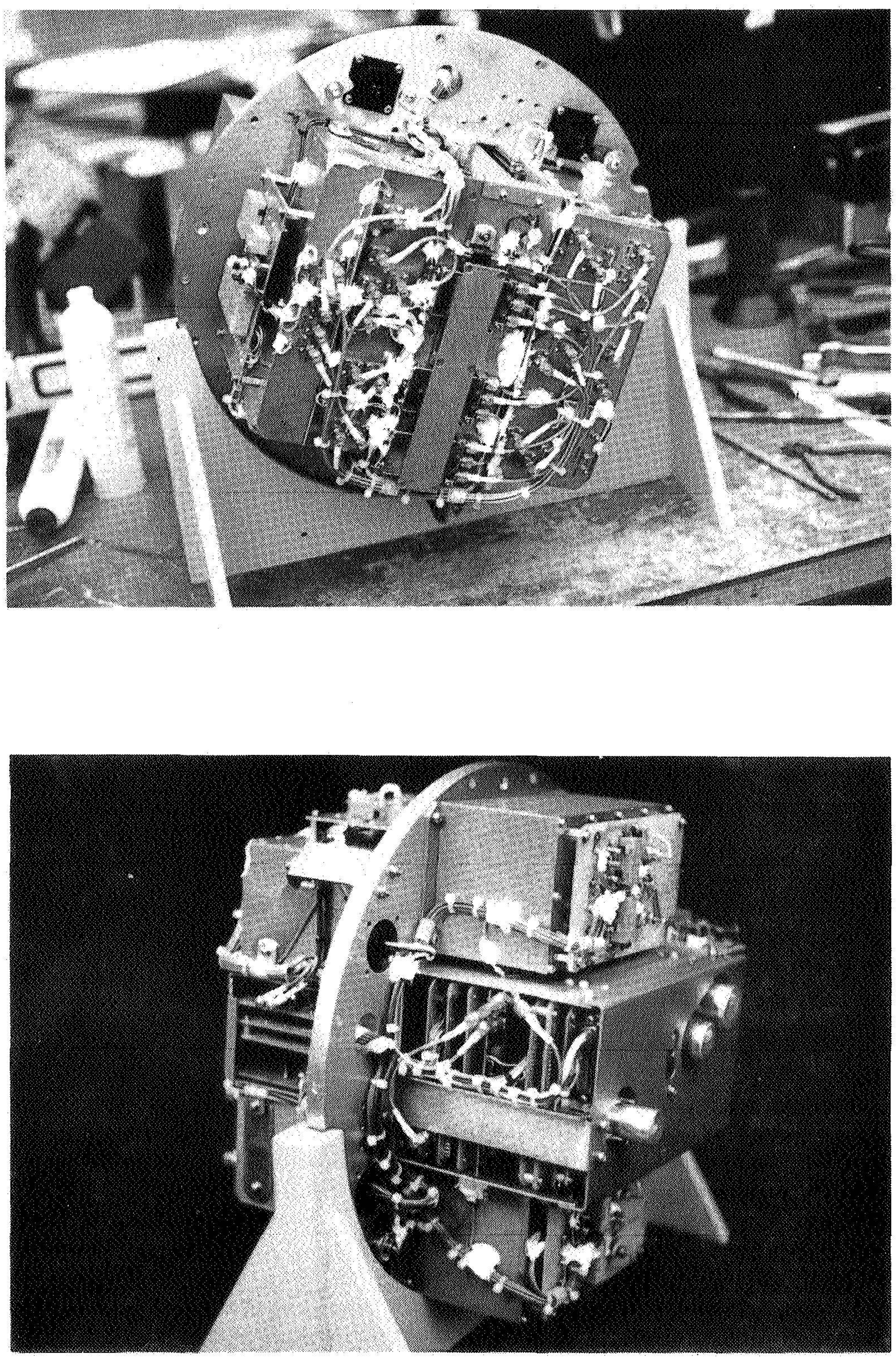

Figure 3. GLOMR Chassis, side view

Table 1
GAS Payload Qualification Requirements (A partial listing)

QUALIFICATION REQUIREMENT	NASA AND EXPERIMENTER ACTIVITIES
o Material stress factors	o Pressurization test to insure structural integrity of cast shell
o Satellite feet/ejection system compatibility	o Vibration and deploment tests o Implementation and test of hermetically-sealed microswitches
o Battery caused explosion (control hydrogen gas development and/or electrolyte leakage)	o Use NASA-approved batteries o Install pressurized battery housing o Use hemetically-sealed microswitches o Fuzing in negative lead
o Antenna design	o Flexible material avoids GAS can damage o Design features to preclude lateral motion o Non-interference with Shuttle communications
o Solar cell breakage	o Handling fixtures o Detailed integration handling procedures
o Other (corrosion, electrical shock, temperature extremes, out gassing materials)	o Experiment-unique. Coordinate with GAS Technical Liason