NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PRELIMINARY SPECIFICATIONS

FOR

MANNED SATELLITE CAPSULE

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1. INTRODUCTION

1.1 This preliminary specification outlines the technical design requirements for a manned satellite capsule. This capsule will be used in the initial research on manned space flight. The research will be concerned primarily with man's ability to adapt to and perform in a space environment as well as in those environments associated with projection into space and with return to the surface of the earth.

1.2 The scope of this specification encompasses the capsule configuration, stability and control characteristics, heating and loads environments, structural design, onboard equipment and instrumentation. In certain areas, specific design approaches are outlined herein. The contractor shall follow the outlined approaches except in cases where mutual agreement is reached between the NASA and the contractor that an alternate approach is to be taken. Suggestions by the contractor of improved alternate approaches are invited.

1.3 The contractor shall undertake and be responsible for the design, fabrication or procurement, integration, and installation of all components of the capsule system as described herein. Details of the responsibilities for the matching of the capsule and the booster vehicle will be clarified at a later date.

1.4 The design approach shall emphasize the safety of the mission. Although not specified herein in every instance, due consideration shall be given to simplicity, redundancy, and the use of backup systems in order to improve mission reliability.
2. MISSIONS

2.1 General.- All missions to be described shall be capable of accomplishment with and without a human occupant and with appropriate animals if desired.

2.2 Primary mission.- The primary mission shall be the launching of a manned capsule into a semipermanent orbit and subsequent safe recovery to the surface of the earth at a designated time and/or position through use of retrothrust and aerodynamic drag. The design mission profile is as indicated in figure 1 and time histories of pertinent trajectory variables are shown in figure 2.

2.2.1 The design of the capsule shall be based on the use of a single Atlas D missile as the launching booster. The capsule shall replace the missile nose cone in a manner which requires a minimum of modifications to the booster system.

2.2.2 The launching site shall be Cape Canaveral, Florida. Launching shall be possible at any azimuth within thirty (30) degrees of due east.

2.2.3 A target value of effective launch weight shall be twenty-four hundred (2,400) pounds. Effective launch weight is defined by the following equation:

\[ W_e = W_o + 0.2W_j \]

where

- \( W_o \) weight of capsule when projected into orbit
- \( W_j \) weight of capsule components jettisoned at Atlas staging

2.2.4 The launch booster system shall be capable of projecting the capsule into orbit with the following tolerances:

2.2.4.1 The projection altitude shall be not greater than one hundred and twenty (120) nautical miles.

2.2.4.2 The perigee altitude shall not be less than one hundred and ten (110) nautical miles.

2.2.4.3 The eccentricity shall be not greater than five thousandths (0.005).
2.2.5 For the initial orbital missions, the number of orbital cycles per mission shall be two (2); however, an arbitrary number of orbital cycles per mission up to eighteen (18) shall be possible.

2.2.6 The following specifications pertain to the recovery of the capsule from orbit:

2.2.6.1 The nominal position of the point at which entry is initiated shall be such that impact occurs in a prescribed area in proximity to the launching station; however, in the event of an emergency, it shall be possible to initiate the entry at any point in the orbit.

2.2.6.2 The entry shall be accomplished by application of retrothrust to produce a perigee altitude within the atmosphere. The magnitude and direction of the retrothrust shall be regulated so that angles of entry into the atmosphere at an altitude of sixty (60) miles shall be between one half (1/2) and three (3) degrees.

2.2.6.3 Consideration shall be given to high altitude deployment of a drogue parachute. This drogue parachute would be deployed near a Mach number of one (1) and is intended to provide improved dynamic stability to the capsule.

2.2.6.4 A landing parachute shall be deployed at an altitude sufficiently great to allow time to deploy a second parachute in event of failure of the first and to reduce sinking speed at impact to less than thirty (30) feet per second. Impact shall be considered to take place at an altitude of five thousand (5,000) feet. Commensurate with the above requirements, deployment altitudes shall be low enough to keep drift from winds aloft from seriously affecting the area of impact.

2.2.6.5 The capsule shall be designed for water landing and shall be buoyant and stable in the water; however, consideration shall be given in the design to emergency landing on land surfaces. Protection from serious injury to the human occupant shall be afforded under conditions of land impact.

2.2.6.6 The capsule and the systems within the capsule necessary for location, recovery, and survival shall be capable of sustained operation for a period of twelve (12) hours after impact with the surface of the earth. This requirement is in addition to the twenty-eight (28) hours requirement associated with the space flight phase of the operation.
2.3 Checkout missions.- In order to expeditiously lead up to successful achievement of the primary mission, the requirements of the following checkout missions shall be considered in the capsule design.

2.3.1 Ballistic trajectories of limited velocity and range for entry and recovery simulation.- A typical mission profile of this type is illustrated in figure 5. The entry and recovery phases of this mission shall be accomplished in the same manner as specified for the primary mission. The peak decelerations achieved during entry shall equal those applicable to the primary mission. As this type of checkout mission may represent the first flight tests of a manned space capsule, a buildup in velocity and range may be required. Rocket motors which are immediately available shall be used for this checkout mission.

2.4 Aborted missions.- During various periods of the launch operation, it may become necessary to abort the mission and escape from the vicinity of the rocket booster system. An active escape system shall be an integral part of the capsule until five (5) seconds after booster staging. At times greater than booster staging plus five (5) seconds, escape shall be accomplished by shutting down the Atlas sustainer engine and operating the nose cone separation motors which are a part of the Atlas system. If desirable, the capsule retro-rockets can be used to produce a more rapid separation after staging.

2.4.1 The following requirements apply to the escape system.

2.4.1.1 The occupant shall remain within the capsule, and escape shall be accomplished by the firing of an escape rocket using solid propellants. In event of an abort, provisions shall be made for a thrust cut-off on the booster rocket.

2.4.1.2 The minimum separation distance after one (1) second from escape rocket firing shall be two hundred and fifty (250) feet at ground launch.

2.4.1.3 In an escape from the ground launching pad, the maximum altitude achieved shall be greater than twenty five hundred (2,500) feet.

2.4.1.4 Up to booster rocket staging, the capsule shall accelerate to a minimum velocity lateral to the plane of the trajectory of thirty (30) feet per second in one (1) second during an escape maneuver.
2.4.1.5 During the firing of the escape rocket and until the capsule decelerates to low dynamic pressure, the capsule shall be aerodynamically stable and shall trim in the same attitude as normally exists in flight when mounted on the booster rocket. During the escape when the dynamic pressure approaches zero, the capsule configuration shall be altered (if necessary) in a manner to provide an aerodynamically stable trim condition in the normal reentry attitude.

2.4.1.6 When the escape maneuver takes place outside the atmosphere, the capsule shall be aligned in the reentry attitude by means of the attitude control system to be specified in section 4.2.

2.4.1.7 Special consideration shall be given to selecting a launch trajectory that will minimize deceleration and heating during entry from an aborted mission.

2.4.1.8 Consideration shall be given to providing a system which will detect imminent unsafe conditions during launch and which will initiate the abort. In the design of this system, the independence of the booster guidance system shall be preserved.
3. CONFIGURATION

3.1 Configuration requirements. - The configuration selected for the capsule shall fulfill the following requirements:

3.1.1 The external configuration shall have an extremely blunt forebody in the entry attitude.

3.1.2 The contours of the forebody shall be such as to provide the maximum practical wave drag and uniform surface heating consistent with other requirements.

3.1.3 The afterbody shape shall be dictated by requirement for subsonic stability, adequate volume, and low heating as well as requirements for parachute storage and attachment of the escape rocket system.

3.1.4 The overall capsule configuration at the time of entry shall be aerodynamically stable in one direction only (blunt face leading) and shall exhibit no tendency to tumble during entry even in recovery from extreme initial angles of attack.

3.1.5 Oscillatory motions of the capsule during any phase of the mission shall not be of a character to incapacitate or injure a human occupant. If this requirement cannot be met by control of the configuration shape automatic damping means may be employed.

3.1.6 The shape and internal volume of the capsule shall be amenable to certain experiments on manned space flight such as:

3.1.6.1 Limited mobility tests (calisthenics, programmed movements, etc.).

3.1.6.2 Observation tests (external and internal).

3.1.6.3 Manual control tests (open loop and closed loop).

3.1.7 The effect of entry forebody shape on water and land impact loads shall be considered in the design.

3.1.8 The configuration shall be stable in the water with blunt face down and shall be capable of righting itself from any position.
3.2 Configuration details.- A configuration meeting the requirements of these specifications is illustrated in figures 4, 5, and 6. An inboard profile of the configuration as it would appear when ready for the launch operation is shown in figure 4. Configurations for the different phases of flight are shown in figures 5 and 6.

3.2.1 The blunt forebody of the capsule shall incorporate a beryllium heat sink. A heat shield of the ablation type may be considered as an alternate form of heat protection providing experimental data directly applicable to the capsule reentry is obtained which establishes to the satisfaction of the NASA that this form of heat shield is applicable. The capsule forebody shall be attached to the launch rocket system by a suitable adapter.

3.2.2 The pylon-like framework on the launch configuration, (figures 5(a) and 5(b)) shall support solid-fuel rocket motors that shall be used to accomplish an escape maneuver in the event of a malfunction of the launch rocket system. The escape motors shall be mounted on the pylon-like structure with enough ballast to give the launch configuration static stability in its mounted orientation under all flight conditions to the time of staging. On a normal launch, the escape motors and pylon shall be jettisoned by small auxiliary motors at five (5) seconds after staging of the launch rocket system.

3.2.3 In orbit, the capsule will have the configuration shown in figure 5(e). The retrograde maneuver shall be accomplished by firing the spherical rocket motors mounted outside of the heat shield. These motors shall then be jettisoned and the entry phase will be made by the configuration illustrated in figure 5(f).

3.2.4 The capsule is to enter the atmosphere with the blunt face leading. The aerodynamic heating at this face would be absorbed by the heat shield. The area between this heat shield and the pressure vessel (in addition to containing carry-through structure) would contain equipment which is expendable at the time of deployment of the landing parachute, and the heat shield along with this equipment shall be jettisoned at this time. (See figure 5(g).) This operation will produce sizable reductions in the parachute loading and will prevent conduction of heat from the hot shield into the pressure vessel during the descent. The bottom contour of the pressure vessel shall be designed from consideration of water and land impact loads. In addition, an inflatable impact bag shall be used to absorb the shock of landing (figure 5(h)).

3.2.5 In the event of a malfunction in the launch rocket system, on the ground or in flight, the escape motors shall propel the capsule out of the danger area in the configuration shown in figure 6(b). This configuration (figure 6(b)) shall then coast in the pylon-first
attitude until the dynamic pressure approaches zero. At this point, the escape rocket system shall be jettisoned and the capsule, with its new center of gravity, will be rotated by aerodynamic moments (figs. 6(c) and 6(d)) until the heat shield moves to the windward side. If the escape maneuver takes place outside the atmosphere, the rotation of the capsule to the reentry attitude shall be accomplished by means of an attitude control system of a type to be specified in 4.2. At this point, the capsule configuration is the same as illustrated in figure 5(f) for a normal flight. Parachute deployment and heat shield separation shall then be as programmed for a normal flight (fig. 5(g)).
4. STABILIZATION AND CONTROL

4.1 General. Stabilization and control of the capsule shall be provided in accordance with the following outline of the various phases of the primary mission.

4.1.1 Launch. The launch trajectory control and guidance shall be considered an integral part of the launching rocket system. This system (or systems) shall make possible the missions described in Section 2 of this specification.

4.1.2 Orbit. After booster burn out and separation, the capsule shall be automatically stabilized in attitude as specified in Section 4.2. An independent manual control system shall be provided as specified in Section 4.3. A passive optical instrument from which attitude information can be obtained shall also be provided as specified in Section 4.3.2.

4.1.3 Entry. During the period from retro firing to build up of atmospheric drag, the automatic control system shall provide attitude stabilization according to Section 4.1.2. After drag build up to 0.05 g units, all channels of the automatic control system shall convert to a damper mode. The manual control system shall function throughout the entry phase.

4.2 Automatic Control System

4.2.1 Requirements

4.2.1.1 The stabilized orientation of the vehicle during orbiting and re-entry prior to build up of atmospheric drag shall be such that the longitudinal axis (axis of symmetry) is in the orbital plane and normal to the local earth vertical. The blunt face of the capsule shall be leading. The capsule shall be roll stabilized so that the occupants head is up with respect to the local earth vertical.

4.2.1.2 After drag buildup to 0.05 g all channels of the stabilization system shall convert to a damper mode. The contractor shall study the desirability of imposing a low steady roll rate to reduce the impact error resulting from lift components of aerodynamic force.

4.2.1.3 The alignment described in Section 4.2.1.1 shall be attained within three (3) minutes after booster separation is achieved and maintained continuously throughout the orbiting phase and re-entry prior to drag buildup except under the conditions described in Sections 4.2.1.5 and 4.3.

4.2.1.4 The accuracy of the stabilization system shall be within plus or minus five (5) degrees about each of the three (3) axis except under the conditions described in Section 4.2.1.5.
4.2.1.5 Immediately before and during firing of the retrograde rocket the capsule alignment shall be maintained to within plus or minus one (1) degree of the orientation specified in 4.2.1.1. The contractor shall study the desirability of controlling the pitch attitude of the capsule during firing of the retrograde rocket to the value which has minimum sensitivity of landing error to attitude error.

4.2.1.6 The specifications given in Sections 4.2.1.3, 1.4, 1.5, and 1.6 may be relaxed if properly justified by the contractor. Consideration shall be given to the limits on alignment allowable for emergency firing of the retrograde rocket.

4.2.1.7 A study shall be made to determine the propellant utilization during the mission both for automatic and manual control. The expenditure of propellant in limit cycle oscillations shall be minimized by the design of the control system. The use of the deadband and an impulse chain closely matching the velocity perturbation are examples of such design techniques.

4.2.2 Reaction Controls

4.2.2.1 For attitude control of the capsule, consideration shall be given to a dual-mode system consisting of a high torque mode and a low torque mode of operation.

4.2.2.2 The high torque mode shall employ reaction jets for three-axis control and shall operate during the following periods of high torque demand: (a) Damping of residual motion of the capsule after booster burnout and separation, (b) Stabilization during firings of the retrograde rockets, (c) Damping during entry, (d) Periods of high torque requirement in the event that the low torque system becomes saturated.

4.2.2.3 The low torque mode shall employ reaction jets or reaction wheels for three-axis control during the orbiting phase and entry phase prior to drag buildup to stabilize the capsule against both external and internal disturbances.

4.2.2.4 The reaction jets shall be so situated that no net velocity change will be given to the capsule as a result of applying control torque.

4.2.2.5 The maximum disturbance torque for the high torque mode of operation may be assumed to be that resulting from firing of the retro rocket specified in Section 4.4. It may be assumed that the pilot will be in the fully restrained condition during retrograde firing.
4.2.2.6 High reliability shall be provided in the reaction control designs. Consideration shall be given to the use of redundancy in the automatic system and in addition, the advantage the manual control system on a safeguard against failures shall be determined.

4.2.3 Attitude Sensing

4.2.3.1 Consideration shall be given to roll and pitch attitude sensing accomplished with a horizon scan system, and yaw sensing obtained using rate gyros to determine the direction of orbital precessional rate of the attitude stabilized capsule.

4.2.3.2 As an alternate to the horizon scan system, the contractor shall study the feasibility of utilizing a stable platform with appropriate programming for this purpose. If such a system is proposed, it may be assumed that the pilot, using an optical device described in Section 4.3, can erect the platform to the alignment specified in Section 4.2.1.1, but it shall be a requirement that the safety of the mission shall not be jeopardized in the event the pilot is unable to perform this function.

4.3 Manual Control System

4.3.1 General. - The manual control system shall afford the pilot means of controlling the attitude of the capsule and enable him to achieve a safe re-entry in the event of an emergency. The manual control system shall meet the following requirements.

4.3.2 Reaction Controls

4.3.2.1 Three-axis control of the capsule shall be achieved from a small controller(s) located so it is readily accessible from the pilot's normal restrained position.

4.3.2.2 A mechanical linkage shall connect the controller(s) to mechanical valves which control the flow of reaction jets. The reaction jets and all components of the manual control shall be independent of the automatic control system.

4.3.2.3 The manual control jets shall be capable of overcoming the disturbance torque resulting from firing the retrograde rockets as specified in Section 4.4.

4.3.2.4 Adequate safeguard shall be provided to prevent inadvertent operation of the manual controls. Positive action shall be required of the pilot to activate the manual control and de-activate the automatic control when he wishes to change attitude of the capsule.
4.3.3 Attitude presentation

4.3.3.1 A display of capsule attitude shall be presented to the pilot to provide a reference from which he will initiate manual control action.

4.3.3.2 An optical system which gives an unobstructed view of the earth when the capsule is stabilized in orbit (as described in section 4.2.1.1) shall be conveniently located in the pilot's field of vision when in his normal restrained position.

4.3.3.3 The optical system specified in 4.3.1 shall have features which will allow the pilot to derive capsule attitude information within sufficient accuracy to enable him to level the capsule within 20° of the orbit attitude specified in 4.2.1.1.

4.4 Retrograde rocket system

4.4.1 Description. - The entry shall be initiated by the firing of a retrorocket system incorporating a cluster of (3) three solid-propellant rockets all of which shall be fired simultaneously.

4.4.1.2 The retrorockets shall be mounted external to the heat shield and shall be jettisoned after firing.

4.4.2 Requirements

4.4.2.1 The magnitude of the retro-impulse shall produce a velocity decrement of five hundred (500) feet per second.

4.4.2.2 A study shall be made to determine environmental protection for the retrorockets and adequate protection shall be incorporated in the design.

4.4.3 Method of firing

4.4.3.1 The retrograde rockets shall be fired upon signal from a timer device carried on board. The timer shall be set at launch and reset periodically by command link from ground control.

4.4.3.2 Under emergency conditions, the pilot shall be able to fire the retrograde rockets. Safeguards shall be provided to prevent inadvertent firing. The pilot shall be able to fire the individual rockets simultaneously or individually through use of redundant circuits.
5. STRUCTURAL DESIGN

5.1 Design loading and heating requirements

5.1.1 General scope.- the requirements of this specification apply to the following:

5.1.1.1 The strength and rigidity of the structure of the capsule and related components which include surfaces and supports provided for reacting aerodynamic, hydrodynamic, and inertial forces.

5.1.1.2 The strength of any control systems and their supporting structure that are provided for use during the launch, orbit, entry, or aborted mission phase including such items as retrorockets, escape rockets, attitude control rockets, and parachutes.

5.1.1.3 The strength of fittings attached to the capsule for the purpose of transmitting forces to the structure.

5.1.2 General Loads requirements

5.1.2.1 Ultimate factor of safety.- In lieu of an ultimate factor of safety, design may be based on a specified probability of destructive failure based on the design mission and specified deviations from the design mission.

5.1.2.2 Ultimate strength.- Failure shall not occur under design ultimate loads. Excessive leakage of the pressure capsule under ultimate load is considered as a failure.

5.1.2.3 Temperature.- The effects of temperature on loading conditions and allowable stresses shall be considered where thermal effects are significant.

5.1.3 Loading types.- The following types of loads are to be considered for all loading conditions:

5.1.3.1 Aerodynamic Loads
5.1.3.1.1 Maneuver (static - dynamic)
5.1.3.1.2 Gust
5.1.3.1.3 Wind shear
5.1.3.1.4 Buffeting
5.1.3.1.5 Flutter
5.1.3.2 Inertial loads
5.1.3.3 Impact loads (water and land)

5.1.3.4 Loads or stresses induced by vibration including noise effects

5.1.3.5 Loads or stresses induced by heating.

5.1.4 Loading conditions. - The following trajectory phases must be examined for loading conditions.

5.1.4.1 Ground handling. - The effect of all ground handling conditions must be considered such as the strength of fittings attached to the capsule for purpose of transmitting handling loads to the capsule.

5.1.4.2 In-flight conditions

5.1.4.2.1 General. - Air loads and inertial loads for all phases of the mission shall be associated with the design trajectories with deviations from the design trajectories to be specified by the proven statistical reliability of the propulsion and control systems.

In addition, certain specified conditions of malfunction of the propulsion and control systems shall be considered specified. The structural weight penalties associated with these malfunctions shall be assessed.

Consideration should also be given to the penalties in mission profile caused by structural weight increases due to malfunction of the propulsion or control system. The mission profile parameters for which a mission will be aborted rather than considered for design shall be designated by the limitations given in 2.2 of this specification for the primary mission.

5.1.4.2.2 Launch phase. - Loading conditions shall be considered as indicated in 5.1 of this specification for all phases of launch trajectories including capsule separation.

5.1.4.2.3 Aborted mission. - The possibility of an aborted mission during all phases of the launching operation and trajectory shall be considered; however, aborted trajectories which would result in axial accelerations greater than twenty-five (25) g need not be considered. (Safety features will, if necessary, include means for anticipating unsafe launch trajectories so that an abort maneuver can be accomplished to keep the g level below twenty-five (25).)

5.1.4.2.4 Orbital phase. - The following effect should be considered: Possibility of meteorite damage - The probability of penetration of the pressure capsule by meteorites such that the pressure loss would prove fatal shall be less than 0.001 for a twenty-eight (28) hour period.
5.1.4.2.5 **Entry.** - The loading conditions for entry are specified by the design trajectory with deviations as indicated in 5.1 of this specification. Consideration should also be given to the reactions of the retrorocket.

5.1.4.2.6 **Parachute deployment.** - The loads on the capsule, parachute, and related equipment shall be considered for entry and aborted mission conditions as given in 2.2, 2.4, and 6.5 of this specification.

5.1.4.2.7 **Landing.** - Consideration shall be given to impact loads for water and land impact conditions.

(a) **Water** - Consideration shall be given to water impact loads in rough water as well as calm water. The capsule design must be such that the buoyancy and water stability is not effected by impact.

(b) **Land** - Consideration shall be given to emergency impact on land surfaces. The capsule design must be such that the human occupant will survive without injuries severe enough to prevent his own escape from the capsule.

5.1.5 ** Loads calculations.** - The loads on the structure and distribution of air and water loads used in design shall be those determined by the use of acceptable analytical methods and with the use of experimental data which are demonstrated to be applicable. The applicable temperature, Mach number, and Reynolds number effects must be included for the existing flow regime.

5.2 **Assumed methods of construction for preliminary design.** - For the purpose of a feasibility study, a type of construction has been assumed which is compatible with the environment of anticipated vehicle trajectories. The principle components are a pressure capsule, external heat and micro-meteorite shielding, and intermediate layers of heat and noise insulation. With this arrangement, integrity of the pressure capsule structure and control of the internal environment can be maintained during widely varying external environmental conditions. A summary of major design requirements for each of these components and brief descriptions of possible structural solutions are given in the following sub-sections.

5.2.1 **Pressure capsule.** - A construction is required capable of sustaining internal pressures up to fifteen (15) psi with negligible air leakage after being subjected to the vibratory and sound pressure loadings associated with launch. It must also withstand collapsing pressures up to two (2) psi to withstand a blast wave from booster failure, and be vented to preclude the possibility
of greater collapsing pressures during a normal mission. The capsule must be designed to withstand rigid body accelerations of twenty-five (25) g axially and four (4) g laterally corresponding to the maximum which might be encountered during launch and entry. The trapped atmospheric pressure may be utilized to enhance structural stability and strength during the launch phase, but structural integrity during all entry phases shall not depend upon internal pressure for stabilization. The resulting design shall not be vulnerable to explosive decompression if punctured. The capsule must be leak resistant after a water impact loading of approximately fifteen (15) g's.

The capsule may be divided into three main sections for descriptive purposes; a bottom which supports the internal equipment and which will be subject to a water or earth impact, a mid-section designed to accommodate an entrance hatch, viewing ports, and a top dome designed to accommodate parachute attachments, and mounts for the escape rocket system. Each of these sections may experience somewhat different temperature time histories, with a possible temperature difference between sections of three hundred (300) degrees Fahrenheit. The maximum temperature of each part shall be held to six hundred (600) degrees Fahrenheit through use of heat shielding. Stresses in the capsule induced by differences in thermal expansion between the capsule and its external heat shielding shall be reduced to tolerable values through suitable flexibility in shield mounting.

These design requirements may be met by a shell of titanium honeycomb sandwich. A vessel of this material provides maximum strength, stiffness, and heat resistance with the least weight. A more conventional construction capable of meeting the requirements is a welded semi-monocoque shell of either titanium or stainless steel. The material shall be chosen for maximum ductility and weldability.

5.2.2 Heat and micro-meteorite shielding.- An analysis of the convective heating during atmospheric entry revealed the need for heat protection for both the blunt face and afterbody of the vehicle. In addition, the expected frequency of strikes by micro-meteorites of various sizes indicated that a shield thickness equivalent to 0.010 inch of steel is desirable for protection of the underlying pressure capsule against impacts.

Stagnation heating associated with the probable range of entry angles 1/2 to 3 degrees, indicates a duration of heating as long as 500 seconds and maximum heating rates in the range of 50 to 100 Btu/ft². A total heat input of about 8000Btu/ft² is associated with the entry angle of 1/2 degree with lesser inputs for greater angles. A beryllium heat sink appears feasible for front face heat protection. Recent tests have indicated that this type of heating input may be compatible with the behavior of some of the available ablation materials. Hence, a back up approach for protection is an ablating shield.
The front shield must be supported on the capsule bottom and/or sidewalls in a manner which permits ready disengagement at parachute deployment to expose the landing bag system. The method of support must not cause excessive stresses in the shield during capsule pressurization. For the heat sink type of shield, thermal expansion capability relative to the capsule must be provided.

Estimates of afterbody heating have led to predictions of radiation equilibrium temperatures on the side shields of one thousand and four hundred (1,400) to one thousand and six hundred (1,600) degrees Fahrenheit. The total heat input is in the order of one thousand (1,000) Btu/ft². The simplest and lightest weight form of heat protection for these areas appears to be obtained with radiation shields. These shields must be flutter free and yet be free to expand thermally with respect to the capsule structure. Although they are vented, a conservative design criterion is that they be able to carry the local pressure loading. This criterion insures adequate local stiffness and increased resistance to noise fatigue. They must withstand sound pressure fluctuations caused by boundary-layer noise and booster engine noise.

Tests have been made on various shield configurations and it appears that a shield constructed on a 0.010-inch-thick longitudinally corrugated nickel base alloy may be satisfactory. Such a shield provides a low probability of being punctured by micro-meteorites in a twenty-eight (28) hour orbital period, and with a proper corrugation depth and support spacing can meet the other design requirements.

5.2.3 Heat and Acoustical Insulation.- The shielding arrangement previously described implies the use of insulation between the shields and the capsule structure. This insulation must be able to withstand a transient temperature pulse of fifteen hundred (1,500) degrees Fahrenheit, and not deteriorate due to vibration. Transient heating calculations show that 3/8 lb/ft² of commercially available insulations should provide the required heat protection to the capsule structure during the entry maneuver.

Heat soaked up by the structure must also be prevented from heating the capsule contents. The insulation required on the inner wall must also be effective in damping sound pressure waves. It is estimated that 1/8 lb/ft² of dual-purpose insulation should reduce the total heat transmitted to the capsule contents to twenty-five (25) Btu/ft² of wall area during entry. The combination of two metal walls and two insulation layers should be capable of providing a 30 dB reduction in noise at frequencies above six hundred (600) cps.
6. ONBOARD EQUIPMENT

6.1 Capsule environment controls

6.1.1 General

6.1.1.1 Equipment shall be provided for control of the pressure, temperature, and humidity within the capsule and within a suitable pressure suit to be worn by the occupant.

6.1.1.2 Equipment shall be provided for the supply of breathing gas for the control of the oxygen partial pressure and carbon dioxide concentration in the breathing gas.

6.1.1.3 Equipment shall be provided for the control of the oxygen partial pressure and the carbon dioxide concentration of the capsule atmosphere.

6.1.1.4 The foregoing equipment shall be as simple and passive in operation as practical.

6.1.1.5 The absorptivity and emissivity of the capsule to radiation in the infra-red shall be such that the shell is basically cold and that only small heat addition is required to maintain the internal temperature limits of the capsule; however, a study of the effects of the entry temperature pulse shall be made to establish if any cooling requirements exist.

6.1.1.6 The possibility of buildup of toxic contaminations and objectionable odors in the capsule shall be evaluated and if required, provisions shall be incorporated for their removal.

6.1.1.7 Adequate drinking water and food should be provided for twenty-four (24) hour orbital period and a forty-eight (48) hour post-orbital period. The food should be of the low residue type.

6.1.1.8 Provision shall be made for the disposal and/or storage of human excretions.

6.1.1.9 Protection against failure of the capsule environmental control systems shall be achieved by incorporation of appropriate redundancies.
6.1.2 Quantitative requirements

6.1.2.1 The capsule temperature shall be maintained between fifty (50) and eighty (80) degrees Fahrenheit.

6.1.2.2 The relative humidity in the capsule shall be maintained between the limits of twenty (20) and fifty (50) percent.

6.1.2.3 The capsule pressure shall never be less than local atmospheric pressure.

6.1.2.4 The partial pressure of the oxygen supplied to the occupant of the capsule shall be maintained between one hundred and fifty (150) and three hundred (300) mm Hg in either the normal or in any emergency condition.

6.1.2.5 The carbon dioxide content of the breathing gas shall be limited to less than one (1) percent.

6.1.2.6 The environmental control systems shall be capable of maintaining the foregoing conditions for: (a) the part of the prelaunch period when the environment cannot be maintained by external supply, (b) for a space flight period of twenty-eight (28) hours, (c) for the landing and recovery period of twelve (12) hours. The last condition can be waived if it can be demonstrated that satisfactory ventilation to the external atmosphere can be achieved in rough seas (through use of a snorkel-type apparatus, for example).

6.1.2.7 The character of the vibrations and the acoustic noise within the capsule shall be considered in the design and alleviation of undesirable conditions shall be provided.

6.1.2.8 Where it can be shown that any quantitative requirement herein severely restricts the design, consideration shall be given to a limited adjustment of the requirements.

6.2 Pilot support and restraint

6.2.1 A couch shall be provided which will safely and comfortably support the human occupant.

6.2.2 As a basis for the design, acceleration environments associated with the launch, the aborted launch, the entry parachute deployment, and the landing impact (land and water) shall be considered. In particular, aborted launch conditions in which peak accelerations of the order of twenty (20) g units shall be withstood by the occupant without incurring serious or permanent injury.
6.2.3 The support system shall be oriented within the capsule so that the peak accelerations can be withstood without repositioning during flight.

6.2.4 The support system shall distribute the loads over as large an area on the subject as practical and as uniformly as practical (eliminate pressure points).

6.2.5 Shock absorption shall be provided in the support system for the reduction of high but short term accelerations existing under such conditions as parachute deployment and landing impact.

6.2.6 Particular attention shall be paid to the elimination of the possibility of large negative accelerations on the occupant. Such conditions are most likely to occur during asymmetric impacts with water and land surfaces.

6.2.7 The occupant shall be firmly restrained in the support system by a suitable harness that shall provide satisfactory support for the conditions of maximum accelerations in a direction to lift the occupant off the couch. Such a condition will occur after burnout of the escape rocket when the escape takes place at maximum dynamic pressures.

6.3 Landing system

6.3.1 General

6.3.1.1 A landing system shall be employed which shall utilize two (2) independent parachute systems mounted side by side and a system of air bags for landing impact protection.

6.3.1.2 The two independent parachute systems shall be deployed sequentially, but the reserve system shall be deployed only if the primary system fails to deploy satisfactorily.

6.3.1.3 In addition to the main landing parachute, a drogue parachute for the purpose of capsule stabilization shall be deployed at an altitude of approximately seventy thousand (70,000) feet and a Mach number of one (1).

6.3.1.4 The primary landing parachute shall be deployed at an altitude of approximately ten thousand (10,000) feet. The primary landing parachute shall be deployed by releasing the drogue parachute from the capsule in such a manner as to serve as a pilot chute. The reserve landing parachute shall be deployed by a normal pilot chute.
6.3.1.5 At deployment of the primary landing parachute, the heat shield and expendable equipment shall be jettisoned and the landing impact bag shall be inflated.

6.3.2 Drogue and pilot parachutes

6.3.2.1 The drogue parachute canopy shall be a FIST ribbon type and shall be capable of opening at Mach numbers up to one and one-half (1.5). This canopy shall have a diameter large enough to provide adequate dynamic stability to the capsule.

6.3.2.2 This canopy shall be built to conform to applicable military specifications.

6.3.2.3 The parachute shall incorporate a metallic coating in a manner to provide a suitable radar reflector.

6.3.2.4 The drogue parachute shall be forcibly deployed by means of a mortar tube. The deployment bag and packed drogue chute shall be housed in this mortar tube and shall be capable of withstanding the burning powder charge resulting from firing of the mortar. The bridle between the deployment bag of the main chute and the drogue chute shall be forty-five (45) feet in length. The mortar shall have sufficient force to propel the drogue chute and bag a distance equivalent to the bridle length.

6.3.2.5 The pilot chute for the reserve landing parachute shall be of standard pilot chute construction. This parachute shall be deployed in the same manner as specified in 6.3.2.4. To aid deployment, lead shot may be sewn in at the apex. There shall be a forty-five (45) foot bridle between the deployment bag and the pilot chute.

6.3.3 Main landing parachutes.—The two main parachutes shall be of equal size and shall be an extended skirt design (similar to Pioneer Parachute Co. design drawing 1.425). Each of these parachutes shall be a proven type having previously been flight tested under conditions representative of the present application. The parachute shall be constructed to withstand the shock loads of opening at twenty thousand (20,000) feet.

6.3.3.1 The gore colors shall be natural and international orange alternately arranged.

6.3.3.2 The main canopy and risers shall be packaged in a deployment bag. The main parachute deployment bag shall conform to the interior of the parachute canister.
6.3.3.3 Actuation of deployment of the drogue chute shall be by reliable and proven barometric switches. Each switch on each chute shall be independent of the other although the secondary chute firing sequence should be arranged such that the primary chute is jettisoned prior to actuating the secondary chute. However, if the primary chute fails to jettison, this should not prevent the secondary chute actuation.

6.3.3.4 Provision should be made for manual override of the automatic system should it fail.

6.3.3.5 Provision shall be made for satisfactory operation of the chutes in case of abort.

6.3.3.6 Provision shall be made for release of the parachutes after impact.

6.3.4 Landing impact bag

6.3.4.1 The landing impact bags shall be constructed of an inflatable material and shall be located behind the heat shield in the deflated condition. On separation of the heat shield, these bags shall be inflated.

6.3.4.2 The bags shall be designed so they will deflate on impact under a constant predetermined load.

6.3.4.3 The bags shall be constructed and located in such a manner that they shall be effective under conditions of drift, parachute oscillation, and uneven landing terrain.

6.3.5 Helicopter pickup provisions.- Provision shall be made for a helicopter pickup of the capsule after landing. An attachment point shall be located at approximately the parachute attachment point. Auxiliary attachments points shall also be provided just above the capsule water line.

6.4 Cockpit layout

6.4.1 The contractor shall submit proposed layouts of the capsule interior to the contracting agency for approval. In addition to the environment equipment specified in section 6.1, these layouts shall show the location and approximate appearance of all pilot-actuated controls, instruments, and warning devices.
6.4.2 Consideration shall be given to the restrictions imposed on the pilot by the restraining harness specified in Section 6.2.7 and by acceleration forces in the selection of location and method of actuating all pilot-operated controls and in the grouping and placement of instruments and warning devices so as to provide an optimum display of information.

6.4.3 The contractor shall submit a list of all instruments, pilot actuating devices and warning devices to be displayed to the pilot to the contracting agency for approval. This list shall include those instruments specified or described in Section 7.

6.4.4 Consideration shall be given to the location and operation of the optical instrument for display of capsule attitude and navigational information specified in Section 4.3.3. Consideration shall also be given to a means of displaying capsule attitude information to the pilot during the launch and entry period where the optical presentation may be inadequate.

6.5 Communications.

6.5.1 This specification is intended to include only the vehicle systems. However, these systems must be completely compatible with the ground station complex. It is intended that wherever practicable the systems of telemetry, tracking, and voice communications now existing will be used.

6.5.2 List of communications systems.- The following systems of communications will be required aboard the vehicle:

Two-way voice communication
Command receiver from ground to vehicle
Telemetry from vehicle to ground
Radio tracking beacon (108 megacycles)
Rescue beacons (HF and UHF) and other recovery aids.
S- and X-band beacons for GE Guidance System, with retro-rocket firing command system
C-band radar tracking beacon
Flashing lights, for tracking
6.5.2.1 The two-way voice communications system will utilize frequencies in both the HF and UHF bands. In the event of failure, a HF-UHF transceiver normally intended for use during the recovery phase may be employed at any time.

6.5.2.2 Two command receivers will be operated continuously on VHF to accept coded commands from ground stations. Verification of the reception of the commands will be transmitted via telemetry. The command receivers will be capable of accepting and decoding retrograde rocket firing commands. Also, it will be used to turn on the telemetry system.

6.5.2.3 Initial guidance and orbit insertion will be accomplished through utilization of the GE Guidance System. Additional tracking data will be obtained from FPS-16 radars, from the 108 Megacycle Mini-track complex and other radio tracking devices, and from visual observations.

6.5.2.4 The 108 megacycle tracking beacon will have an output of not less than 0.10 watts, and will have frequency stability commensurate with Doppler measuring techniques.

6.5.2.5 The C-band radar tracking beacon is to be compatible with the FPS-16 radar equipment, and will have an output peak power of at least 100 watts. The beacon receiver shall have the capability of triggering the beacon at line-of-sight ranges up to 1000 statute miles.

6.5.2.6 Consideration should be given to the installation of high-intensity flashing lights to aid ground observers in sighting the vehicle during dark phases of the orbit.

6.5.3 Antennas.- Antennas will be provided for all systems - voice communications, telemetry, tracking, guidance, command, and rescue. Antennas for each system will provide maximum coverage for each phase of the mission. Design will be simplified somewhat by the vehicle stabilization, in that coverage is required only for one hemisphere, during the orbiting phase. Recovery system antennas will protrude from the upper part of the capsule in such a manner to prevent loss of signal from water or salt spray. Multiplexers will be utilized where necessary to limit the number of antennas. Early developmental flights will determine vehicle skin temperatures, enabling more precise antenna design. This will aid in decisions as to types of antennas.

6.5.4 Recovery.- The tracking of the vehicle shall be facilitated, during the landing phase, by the ejection of radar chaff at the opening of the drogue chute.
The vehicle shall contain a suitable small rescue beacon to facilitate air search. It shall transmit suitable signals on 8.564 and 243.0 megacycles and have a range of at least two hundred (200). In the case of the low frequency signal, a thousand (1000) mile range would be desirable. It shall have self-contained batteries suitable for at least twenty-four (24) hours operation.

A high-intensity flashing light system operating from self-contained batteries and automatically starting upon landing shall be provided with provision for twenty-four (24) hours operation. The lights shall be suitably mounted for maximum sighting distance.

A lightweight transceiver shall be used for voice communication backup during the recovery phase. It shall have self-contained batteries, have a range of approximately 200 miles, be suitable for twenty-four (24) hours operation and have a suitable antenna on the vehicle.

So-Far bombs which will automatically fire at reasonable time interval after landing shall be used so that signals received at suitable stations will aid in locating the vehicle.

Dye marker shall be deployed upon landing to aid in the visual location of the vehicle during the search phase.

6.6 Navigational Aids

6.6.1 The pilot shall be provided with a means of navigation. To provide a back up to the ground range tracking facilities, in the event of failure of the capsule tracking beacons or other contingency that would exceed the capability of the ground range system. This operation would entail the determination of altitude, velocity position and local earth vertical, and ground track over the earth.

6.6.2 The optical periscope, or equivalent specified in Section 4.3.3 and a chronometer, shall be provided to fulfill the above requirements. Also, manual aids in the form of simplified tables or displays shall be provided to facilitate navigational problems based on observations of earth, sun, moon or stars. The periscope will be used to indicate the misalignment of the longitudinal axis of the capsule with respect to the flight path over the earth. In the case of failure of the stabilization system, it will allow the pilot to manually align the capsule with the flight path prior to firing the retro rockets.

6.7 Power Supply

6.7.1 The main supply shall be of the silver-zinc type. It shall be suitable for providing the capsules various power requirements for the twenty-eight (28) hour orbital flights plus the twelve (12) hour recovery phase.

6.7.2 Consideration should be given to the use of an emergency silver-zinc battery to operate vital equipment during the re-entry phase in case of failure of the main power supply.
7. INSTRUMENTATION

7.1 General.- In the design of the various instrumentation components, reliability, weight and power requirements are to be considered of greatest importance.

7.1.1 The data to be measured are separated into the following categories:

a) Aero-Medical Measurements.
b) Internal Environment.
c) Vehicle Measurements.
d) Operational Measurements.
e) Scientific

7.2 List of Instrumentation.- The following detailed list of required measurements includes the data required on the first orbital manned flight and does not reflect the requirements for the unmanned flight tests. This list is to be considered only tentative and will be altered in accordance with the current needs of the project.

### 7.2.1 Aero Medical

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Pilots Ind.</th>
<th>T.M.</th>
<th>On-Board Recording</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electro Cardiogram</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Respiratory rate and depth</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Suit, Pressure</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Body Temperature</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Motion Picture of Pilot</td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Voice Recording</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Alarm (May Day)</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Mental Acuity and Phys. Coordination</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
</tbody>
</table>

### 7.2.2 Capsule Environment

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Pilots Ind.</th>
<th>T.M.</th>
<th>On-Board Recording</th>
</tr>
</thead>
<tbody>
<tr>
<td>O₂ Partial Pressure (omit if single gas system)</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>CO₂ Partial Pressure</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>----------------------</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>O₂ Flow Rate</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>CO₂ Filter Status</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>O₂ Reserve</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Cabin Pressure</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Air Temperature</td>
<td>x</td>
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<td>x</td>
</tr>
<tr>
<td>Humidity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motion Pictures Inst. Panel</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Noise Level</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vibration</td>
<td>x</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 7.2.3 Vehicle Measurements

<table>
<thead>
<tr>
<th></th>
<th>Pilots Ind.</th>
<th>T.M.</th>
<th>On-Board Recording</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acc. - 3 lin</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Time</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Q</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Static Pressure</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Attitude - 3 from Stab. Sensors</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Structural Temperatures</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Pilot Control</td>
<td></td>
<td></td>
<td>CPT</td>
</tr>
<tr>
<td>Motions 3</td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Stabilizer Control</td>
<td></td>
<td></td>
<td>CPT</td>
</tr>
<tr>
<td>Motions 3</td>
<td></td>
<td></td>
<td>x</td>
</tr>
</tbody>
</table>

### 7.2.4 Operational Measurements

<table>
<thead>
<tr>
<th>Power Supply Voltage</th>
<th>x</th>
<th>x</th>
<th>x</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sequence of Events</td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>(Chute, Retro-separation, etc.)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Failure Signals for System x x x
Reaction Gas Supply Pressure x x x

7.2.5 Scientific Observations and
Photographic Measurements

Cosmic Radiation x
Meteorite Impacts x
Earth and Sky Cameras x

7.3 Recording.- Four methods of data recording shall be employed as follows:

On-board data recording,
Telemetering to ground recorders,
On-board tape recording of voice,
Photographic recording of pilot and instrument panel.

7.3.1 General.- It is evident, in the detailed instrument listing, that as
many as three different systems are frequently used to record the output of a single data sensor or pickup. As it is not desirable from the standpoint of weight and power to use separate pickups for each system, a satisfactory isolation technique must be employed to avoid cross talk and interference between the several systems being fed from a common pickup. Where this is not feasible, duplicate pickups may be employed.

Provision shall be made for pre-launch check-out of all the instrument and communication systems. The pilot shall be provided with a suitable interphone connection with ground personnel to assist in this check-out procedure.
7.3.2 **On-Board Data Recording.**—The on-board recorder shall handle the measurements as indicated in the detailed data list. This recorder shall operate on a continuous basis during launch, reentry and abort or emergency maneuvers. During orbit flight and after landing, the data recorded may be programmed to operate periodically to conserve the use of recording medium.

With the exception of EKG and respiratory rate and depth, which have fairly high frequency content, the data may be sampled at rates as low as once per second.

7.3.3 **Telemetering to Ground Recorders.**—Data will be telemetered to ground stations to provide necessary real time information concerning pilot, capsule, and life support system. In addition, telemetry will afford back-up in the event the on-board recorded data are lost for any reason.

These data will be transmitted via radio links operated in the 225-260 megacycle telemetry band. Reliability will be improved through the use of two independent telemetry systems.

In addition to the two UHF links, the 108 megacycle beacon will be modulated with several channels of physiological and capsule environment data, for continuous transmission to ground stations.

One UHF system will operate continuously, with output power of at least 0.25 watts. A second UHF system with 4 watts output power will operate only on a coded command signal from the ground. Upon interrogation, the system will operate for a period of 6 minutes, at which time it will turn itself off and be in ready status for the next interrogation.
All telemetered data will be tape recorded at the ground stations. In addition, certain physiological and other data will be displayed in real time for quick observation by engineering and medical personnel.

7.3.4 **On-Board Tape Recording of Voice.**—The on-board recording of voice will be required continuously during launch, re-entry, and abort maneuvers. During orbit and after landing, the voice recorder shall be turned on by the pilot to record comments and observations. In addition, all voice messages sent to ground stations by the pilot shall be recorded by this equipment.

7.3.5 **Photographic Recording**

7.3.5.1 **Pilot and Instrument Panel.**—Two cameras are to be provided for use within the capsule. One for recording the pilot's appearance and motions and the other for recording the indication of the pilot's instruments. The frame rates may be as low as 3 fr/sec during launch and re-entry and 1 frame every 10 seconds during orbit. The lighting for cameras and general illumination shall be a duplicate system.

7.3.5.2 **Photographic Recording of Earth and Sky.**—Cameras shall be used to record pictures of the earth with a 360 degree horizon coverage. As the line of sight at 120 mile altitude in about 2000 miles, the frame rate may be as low as 1 frame every 3 minutes to provide a 50% overlap of picture coverage.
8. TESTING

8.1 The capsule, all subsystems, and components shall be designed to withstand the environmental stresses encountered in the missions previously outlined. Suitable simulated environmental ground tests shall be performed by the contractor to establish proof of operational reliability and performance.

8.2 A program of research and development testing of the capsule will be undertaken by the NASA. This program will include full-scale flight tests of simplified capsules. The simplified capsules are not a part of the present specifications.

8.3 The capsules supplied by the contractor will be used in a qualification test program to be conducted by the NASA. This qualification program will have as its final objective the accomplishment of the mission described in 2.1.
Figure 1: Mission Profile for Original FL-mode"