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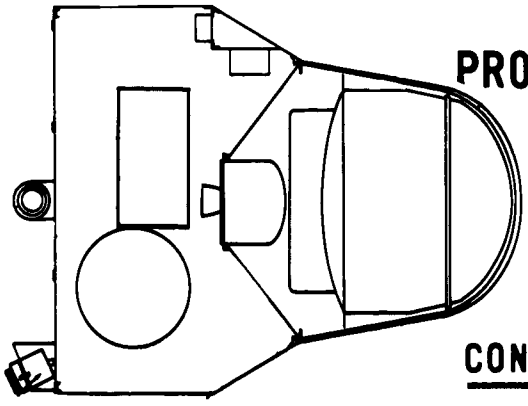

PROJECT: BIOSATELLITE B

(To be launched no earlier than Sept. 7, 1967)

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2ND BIOSATELLITE TO STUDY BIOLOGY OF SPACE FLIGHT

The United States will launch its second biological research spacecraft, the Biosatellite B, from Cape Kennedy, Fla., no earlier than Sept. 7.

The National Aeronautics and Space Administration satellite is designed to provide answers to questions about a large number of basic biological processes.

Thirteen experiments selected to determine the effects of the space environment on various life processes will be orbited in the spacecraft for three days -- 47 orbits of the Earth.

Because the launch window for Biosatellite is determined primarily by requirements of its biological experiments, a two-day interval is required for recycling in the event a launch is delayed.

Thus, the planned launch time of 3 p.m. EDT, Sept. 7, would be rescheduled at the same hour on Sept. 9 -- again, 3 p.m., Sept. 11, should events require such delay.

-more-

The first of the six planned Biosatellites, Biosatellite I, was launched last Dec. 14. It carried a payload identical to that of Biosatellite B and performed effectively in orbit. However, the scheduled firing of the retro-rocket after three days in orbit to return the spacecraft experiments capsule to Earth did not occur. As a result, the experiments could not be recovered, and no data were obtained on experiment results.

To assure recovery of Biosatellite B (Biosatellite II in orbit), an intensive system study has resulted in addition of a duplicate firing circuit, and improved checkout circuits and procedures for all de-orbit systems.

The biological specimens to be flown on Biosatellite B have been intensively studied in ground laboratories, including many phenomena of the space environment which can be simulated on the ground. The most important factor that cannot be simulated on Earth is weightlessness. The Biosatellites provide weightlessness of 1/100,000th of Earth's gravity or less.

Effects of weightlessness will be studied on organisms including pepper plants, wheat seedlings, frog eggs and amoeba. These experiments will study three different levels:

- growth and form of entire plants and animals;
- structure and growth of cells and tissues;
- basic biochemistry of the cell.

One experiment, for example, will observe the root growth of the wheat seedling. The direction of root growth is determined by gravity. How will this biologic process be affected in a near zero-g environment?

Another biologically-significant factor of the space environment is cosmic radiation and the radiation associated with solar flares. While much information is available on effects of radiation on many organisms, little is known about whether comparable effects will occur under weightlessness.

Thus, a second mission objective is to determine whether the effects of a known quantity or dose of radiation on organisms in weightlessness are the same, greater or less than they are known to be on the same organisms on Earth.

Organisms chosen to provide these data include bacteria, common bread mold, a flowering plant, a flour beetle, a parasitic wasp, and larvae and adults of the common vinegar gnat. In orbit, they will be irradiated with gamma rays from an on-board radiation source of 85-Strontium.*

-more-

* This term conforms to a 1965 decision of the International Union of Pure and Applied Chemistry.

The bacteria will contain a latent virus which can be activated upon exposure to extremely low doses of radiation, thus taking over the bacteria's protein-synthesizing system and subsequently killing the bacteria. In the bread mold, precise data can be obtained on the frequency of mutation in two different genes.

The flour beetle and flowering plant are both very sensitive to radiation and are unusually suitable for mutation rate studies at low exposures. The parasitic wasp has the advantage that all of the genetic effects can be detected in one generation in one experiment. Existing genetic information on the vinegar gnat is the most complete for any organism so it is an extremely valuable organism for radiobiological experiments.

The 13 biological experiments will be carried out in a 196 statute mile circular orbit by a seven-foot long, 940-pound spacecraft.

Biosatellite B will be launched by a two-stage Thrust-Augmented Improved Delta vehicle which will not require its customary solid-fuel third stage.

The Biosatellite consists of three main sections -- an Adapter Section which remains in orbit; the Reentry Vehicle which carries the retro-rocket and heat shield for reentry into the Earth's atmosphere; and the Experiment Capsule which contains the scientific experiments, life support equipment, the parachutes and a radio beacon to aid in recovery.

The 440-pound Reentry Vehicle -- a four-foot-long blunt cone -- will reenter the Earth's atmosphere over the Pacific Ocean, deploy a parachute and radio its position. Plans call for the capsule to be recovered in the air by the U.S. Air Force.

The 280-pound Experiments Capsule will be flown to temporary NASA laboratories at Hickam Air Force Base, Hawaii, for preliminary examination. The scientific investigators then will return their experiments to their home laboratories for more detailed study and analysis.

If aerial recovery is not successful, the Experiments Capsule will land in the ocean and send signals to search ships and aircraft.

During its three days in orbit, Biosatellite I maintained temperature, pressure, humidity, and weightlessness for its experiments.

Ninety-seven per cent of fertilization, photography, feeding, and other experiment operations were accomplished. Useful engineering and whole-system information was obtained.

The loading of experiments aboard Biosatellite I was completed only four and a half hours before launch, tightly integrated with other countdown events. Very late loading is required by the life cycles of the living organisms. This compares with experiment loading several months in advance for physical science satellites.

The pre-launch experience and three days of successful orbital operations with Biosatellite I will be useful in the Biosatellite B mission.

The Biosatellite Program is managed by NASA's Office of Space Science and Applications. Project management is by NASA's Ames Research Center, Mountain View, Cal. The Delta launch vehicle is managed by Goddard Space Flight Center, Greenbelt, Md., and is launched by Kennedy Space Center, Fla.

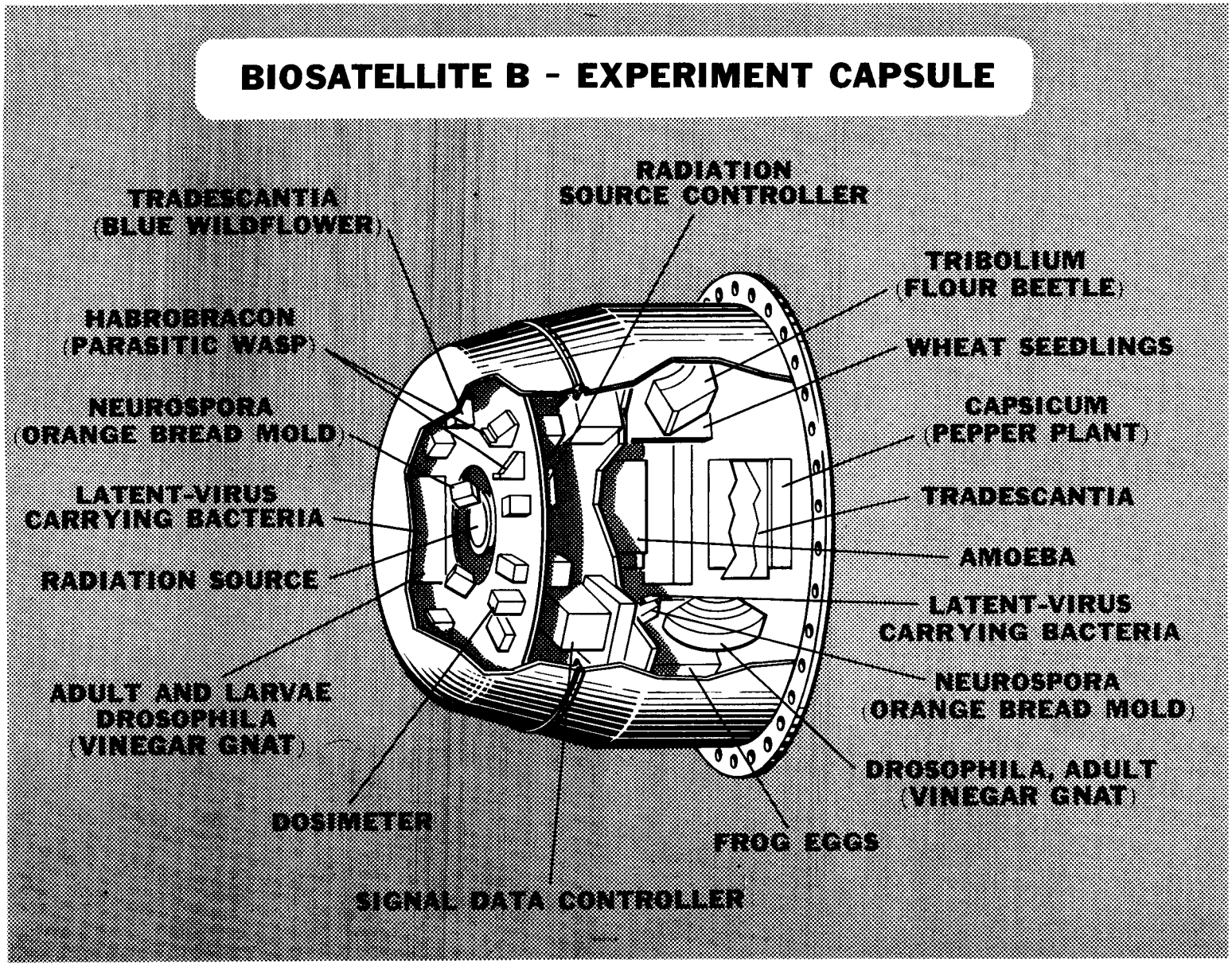
Communications and tracking will be by NASA's Satellite Tracking and Data Acquisition Network (STADAN), operated by Goddard.

The Biosatellites are built by the General Electric Co., Reentry Systems Dept., Philadelphia. The Delta is built by the Douglas Aircraft Co., Santa Monica, Cal.

The 13 scientific experiments for Biosatellite B are provided by eight universities, four industrial firms and three government laboratories.

Biosatellite studies were recommended to NASA by the National Academy of Sciences in 1963. Nearly 200 experiment proposals were reviewed in selecting the experiments for the program.

(END OF GENERAL RELEASE; BACKGROUND INFORMATION FOLLOWS)


BIOSATELLITE B - EXPERIMENT CAPSULE
TRADESCANTIA (BLUE WILDFLOWER)
RADIATION SOURCE CONTROLLER
TRIBOLIUM (FLOUR BEETLE)
HABROBRACON (PARASITIC WASP)
WHEAT SEEDLINGS
NEUROSPORA (ORANGE BREAD MOLD)
CAPSICUM (PEPPER PLANT)
LATENT-VIRUS CARRYING BACTERIA
TRADESCANTIA
RADIATION SOURCE
AMOEBA
LATENT-VIRUS CARRYING BACTERIA
ADULT AND LARVAE DROSOPHILA (VINEGAR GNAT)
NEUROSPORA (ORANGE BREAD MOLD)
DROSOPHILA, ADULT (VINEGAR GNAT)
DOSIMETER
FROG EGGS
SIGNAL DATA CONTROLLER

-more-

THE BIOSATELLITE B SPACECRAFT

The Biosatellite B spacecraft performs most of the functions of a manned spacecraft on a smaller scale.

It divides into the Adapter Section, which remains in orbit, and the Reentry Vehicle, which returns the Experiments Capsule to the surface of the Earth.

Adapter Section

The 400-pound Adapter is a four-foot long cylinder-cone from 40 to 57 inches in diameter, which houses all systems needed in orbit, and not needed for recovery. These are attitude control system, main radio transmitter, radio receiver, command decoder, several programmers, orbital battery, power controller, and tracking beacon.

Stability and Attitude Control

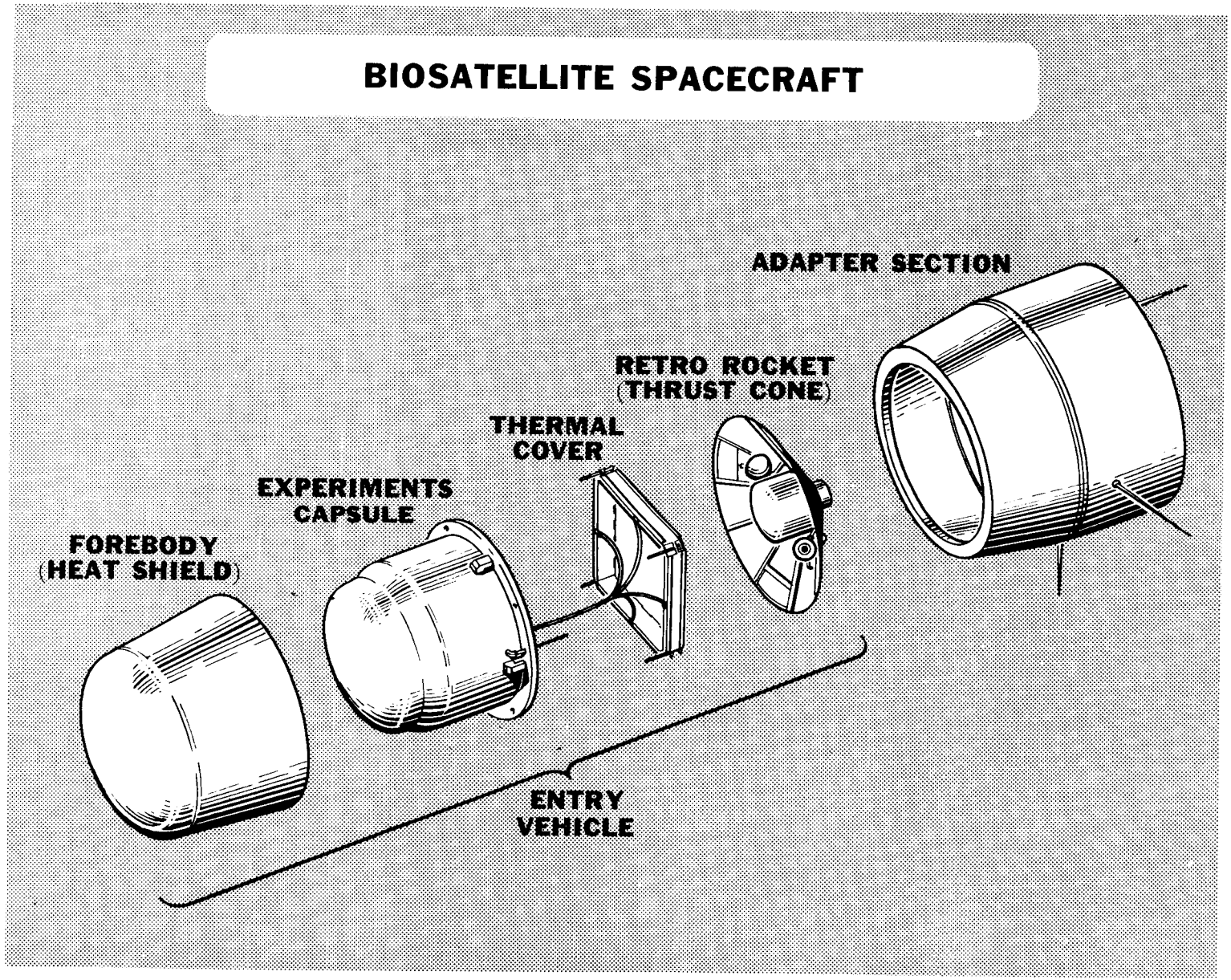
The attitude control system has two functions. It positions the Reentry Vehicle for reentry. It stabilizes the spacecraft in orbit so that rotational forces are less than 1/100,000 g for 95 per cent of the time (much more weightlessness than manned spacecraft).

For most of the mission, the system does not maintain the spacecraft in a fixed orbital attitude but merely prevents it from rotating faster than about once in 20 minutes. Slight spacecraft decelerations are caused by atmospheric drag of seven-millionths g at orbital altitude.

The on-orbit stabilization system consists of stored high-pressure nitrogen gas, six cold-gas thruster jets, and three motion-sensing gyros. The gyros sense tiny motions in three perpendicular axes. The jets fire selectively to eliminate motions, producing accelerations of less than 1/10,000 g.

For reentry, the spacecraft must be aligned precisely to its orbital path, facing backward, and pitched downward 36 degrees.

For this, two infrared horizon scanners align the spacecraft in pitch and roll to the deorbit attitude.



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For yaw, a magnetometer senses the direction of the Earth's magnetic field. Ground commands transmit data to bias the magnetometer to account for the direction of the Earth's field lines at the geographical point of retro-fire. The magnetometer is used as a reference to line up the spacecraft in yaw with its orbital path.

Direct telemetry reports of energy received by the infrared sensors and two coarse magnetometers help verify spacecraft position.

With the required deorbit attitude in all three axes, the Reentry Vehicle can then separate and the retro-rocket fire.

Reentry Vehicle and Experiments Capsule

The atmosphere entry vehicle is a 40-inch-base-diameter blunt cone. It contains the Experiments Capsule and separation and entry systems. A thrust cone carries a retro-rocket and spin nozzles. Its cup-shaped, fiberglass forebody encloses the Experiments Capsule, and is completely covered by its phenolic nylon heat shield. A thermal cover at the aft end houses the parachutes and their deployment mechanisms.

The Experiments Capsule is an aluminum blunt cone, slightly smaller than the Reentry Vehicle, with six cubic feet of payload space. It provides life support for the experiments and carries the recovery system.

Separation and Entry Systems

The separation system is controlled by a programmed series of switches which first transfer electric circuits in the Experiments Capsule from batteries in the Adapter Section to those in the Capsule. They then order physical disconnect of the electric lines to the Adapter. They fire explosive pinpullers. This allows spring actuators to drive the Adapter and Reentry Vehicles apart at about one foot per second.

At 2.5 seconds after separation, two cold-gas jets spin up the Reentry Vehicle to 57 rpm. The A-45 solid rocket in the thrust cone burns for 10 seconds, producing 10,200 pounds of thrust, and slowing the vehicle by 420 mph. A second pair of gas jets then de-spins the vehicle to no more than 12 rpm.

Explosive bolts separate the thrust cone, and the spin-up system. The slowed vehicle then descends and enters the atmosphere. Aerodynamic forces turn it heat-shield-forward, and the ablative shield dissipates entry heating.

Recovery System

The recovery system is part of the Experiments Capsule. It consists of a two-parachute system, radio transmitters, and dye marker if sea recovery is needed.

About 17 minutes after retro-fire at 80,000 feet altitude, explosive bolts eject the Reentry Vehicle's aft thermal cover, deploying a 19 square foot drogue chute. The chute slows the Experiments Capsule, causing the Reentry Vehicle's fore-body with heat shield to fall away. Ten seconds later, the reefed main chute deploys to 72 square feet. Cutters dis-reef the main chute, opening it to 505 square feet. At about 10,000 feet, the main chute has slowed descent of the capsule to 18.5 mph.

For sea landing, a recovery radio beacon operates up to 36 hours.

Command, Programming, Entry Timing

Commands for spacecraft operations come from the ground, or from one of five on-board programmer-timers in the Reentry Vehicle.

Ground commands cannot be received by the Reentry Vehicle once it separates from the Adapter, and all entry and recovery commands are from two programmer-timers.

Each programmer measures time intervals and contains logic circuits to originate commands in timed sequence.

The main programmer-timer provides regular time pulses. It commands experiments, heaters, and many other systems.

The separation timer has the key job of commanding separation and retro-fire at the precise time on orbit to reach the planned recovery point. It is started by ground command, timed to 1/10 second, which orders an exactly calculated time delay (40 minutes to 7.5 hours) before the beginning of separation commands.

The back-up separation timer can also, if needed, start separation events by timed ground command.

The deorbit timer in the Reentry Vehicle sends the commands for spin-up, retro-fire, and de-spin. The recovery timer starts by deceleration switch, and issues recovery commands.

Ground commands are received by one of two redundant sets of command receivers and decoders in the Adapter. These route commands to: tracking beacon; telemetry transmitters; programmers, separation programmer; attitude gyros, infrared horizon scanners, and magnetometer and experiment cameras, feeding and fixing systems, radiation source.

The ground command system uses a varying-tone digital technique with a capacity of 70 separate commands, of which 51 are used. Frequency of the command receivers is 148-159 mc.

Telemetry and Data Retrieval

The spacecraft carries two sets of two-watt telemetry transmitters, digital sampling and coding equipment. One set in the Adapter sends data to the ground during orbit. The other in the Experiments Capsule sends data after separation.

Additional data is stored by the seven-channel tape recorder in the Experiments Capsule. This recorder stores experiment, engineering and force data during launch and recovery -- and up to six hours after sea landing, if required.

Orbital telemetry is sent at 136.68 mc in the reliable, low-power pulse code modulation mode. Data "words" have seven data bits each, and are sent at a rate of one 256-word frame per second.

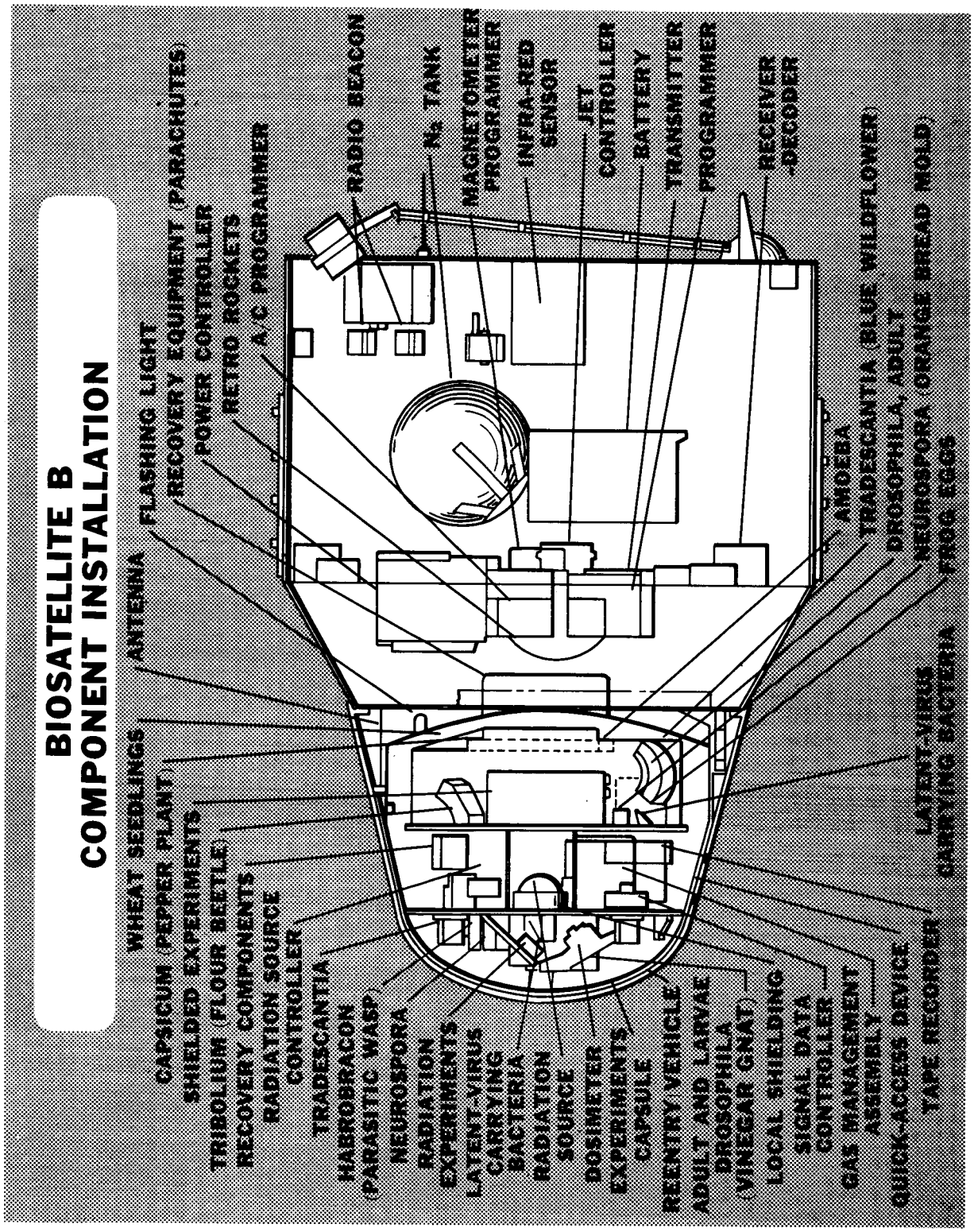
Data returned reports spacecraft attitude, nitrogen gas storage temperature and pressure, temperatures throughout the spacecraft; voltage levels and current distribution; Experiments Capsule air supply, and fixing, feeding, temperatures and camera operation of individual experiments.

Deorbit telemetry is sent at 240.2 mc in an FM-FM mode. It reports spin-up, retro-fire, and de-spin.

Tracking

The spacecraft reports its position by tracking beacon, with a continuous signal at 136.05 mc. One of two redundant beacons is selected by command to radiate 100 milliwatts via an omni-directional antenna. Tracking stations measure position of the spacecraft, and this information is used to calculate the spacecraft orbit.

The homing beacon in the Recovery Capsule has a peak power of 7.5 watts and frequency of 242 megacycles.


BIOSATELLITE B
COMPONENT INSTALLATION
WHEAT SEEDLINGS
CAPSICUM (PEPPER PLANT)
SHIELDED EXPERIMENTS
TRIBOLIUM (FLOUR BEETLE)
RECOVERY COMPONENTS
RADIATION SOURCE
CONTROLLER
TRADESCANTIA
HABROBRACON (PARASITIC WASP)
NEUROSPORA
RADIATION EXPERIMENTS
LATENT-VIRUS CARRYING BACTERIA
RADIATION SOURCE
DOSIMETER EXPERIMENTS CAPSULE
REENTRY VEHICLE
ADULT AND LARVAE DROSOPHILA (VINEGAR GNAT)
LOCAL SHIELDING
SIGNAL DATA CONTROLLER
GAS MANAGEMENT ASSEMBLY
QUICK-ACCESS DEVICE
TAPE RECORDER
ANTENNA
FLASHING LIGHT
RECOVERY EQUIPMENT (PARACHUTES)
POWER CONTROLLER
RETRO ROCKETS
A.C. PROGRAMMER
RADIO BEACON
N_2 TANK
MAGNETOMETER PROGRAMMER
INFRA-RED SENSOR
JET CONTROLLER
BATTERY
TRANSMITTER PROGRAMMER
RECEIVER -DECODER
AMOEBA
TRADESCANTIA (BLUE WILDFLOWER)
DROSOPHILA, ADULT
NEUROSPORA (ORANGE BREAD MOLD)
FROG EGGS
LATENT-VIRUS CARRYING BACTERIA

Radiation and Life Support

Within the Experiments Capsule, the experiments are located in fore and aft groups. The forward group includes the seven radiation experiments, located ahead of the 85 Strontium radiation source. The source is isloated in a tungsten-nickel-copper sphere, which is opened on command by spring mechanism in orbit (releasing a 180 degree cone of radiation), and closed by command prior to entry, or automatically as a result of entry forces.

The radiation experiments are placed concentrically around the source so that they get one of nine radiation dose levels (from 200 to 5,000 roentgens) on the three-day mission.

The forward section contains dosimeters to check total radiation. It is walled off from the rest of the capsule by a laminated aluminum-tungsten-aluminum backscatter shield.

The aft section contains the general biology experiments and control versions of the radiation experiments.

The life support system consists of a high pressure sphere containing air, a circulating fan, metering and pressure regulating system. Relative humidity is controlled at 40-70 per cent by silica gel absorbers.

Temperature Control

A passive system in the Adapter holds internal temperatures between 0 and 100 degrees F. It consists of a 28-layer aluminized mylar insulation blanket, attached to the vehicle skin.

Cutouts in the blanket allow dissipation of internal heat by radiation. Reflective exterior coatings provide further passive control of temperature.

Eight low-flux heaters, attached to the Experiments Capsule walls, and controlled by thermostats maintain about 70 degrees F interior temperature in orbit.

During entry, Capsule temperatures may reach briefly 100 degrees F, and insulation prevents them from rising higher.

Low-power heaters in the spacecraft batteries and in the infrared sensors of the horizon scanners prevent them from freezing. The 10-watt heaters in the sensors can bring them to operating temperature for deorbit of 50 degrees F in about one orbit.

Electric Power

The electric power subsystem consists of batteries, inverters, converters, regulators, and distribution circuits. These include a large silver-zinc 330-ampere-hour, 28-volt storage battery in the Adapter for power in orbit. There are small, special purpose batteries as follows: two small thermal batteries in the thrust cone for retro-fire operations, four smaller silver-zinc batteries in the Experiments Capsule to provide power during recovery -- including six hours of life support and 36 hours of radio beacon.

SCIENTIFIC EXPERIMENTS

To evaluate the genetic effects of the combination of radiation and weightlessness, the biologists will determine the frequencies of chromosome breakage and the frequencies of mutation at many different genetic loci.

Basic mechanisms to be studied by the non-irradiated experiments include cell division, synchrony and orientation of cell division, alteration in division and growth in cells of a developing embryo, effects on the basic structure of protoplasm, effects on enzymes (those concerned with cell division and those governing energy conversion), orientation to gravity of leaves, roots and shoots of various plants.

All biological material will be examined upon return for growth, changes in shape (morphology), changes in structure of tissue and cells (cytology and histology), and for biochemical changes. The experimenters will use light and electron microscopes, chromatography, and many other analytical techniques.

All 13 experiments will have identical control versions on the ground, subjected to conditions close to those of the flight experiments, except for weightlessness. The radiation experiments will also have non-irradiated replicas aboard the spacecraft. These experiments will supply further data on the effects of weightlessness alone.

Radiation Experiments

Virus Activation in Lysogenic (latent virus-carrying) Bacteria - NUS Corporation

The primary purpose of this experiment is to see how viruses, which are incorporated as pieces of genetic information, in the chromosomes of certain bacteria are produced under weightlessness with and without radiation. The process of virus formation in lysogenic bacteria is highly sensitive to environmental stress. Virus formation results from upsetting a fine biochemical balance which controls a specific series of steps in the transfer of genetic information to form protein. Previous Soviet studies on lysogenic bacteria indicated that they are a most sensitive material to the conditions of space flight.

When lysogenic bacteria are irradiated, the virus genetic information is activated, thereby producing mature viruses. These multiply rapidly within the bacterial cell. When a critical number is formed (about 100), the bacteria burst (or lyse).

Three experiment packages consisting of 16 chambers, each containing lysogenic bacteria, will be mounted so that they receive doses of 500, 1,000 and 2,500 roentgens, respectively. A non-irradiated package of 48 chambers will indicate the effect of weightlessness alone. During flight, these bacteria will multiply through about 20 generations and produce viruses.

After return to Earth, the cultures of bacteria and the viruses will be analyzed to see how many were produced under weightlessness with and without radiation. The bacteria themselves will be studied further to see if there are changes in structure, whether they are capable of producing viruses and how many viruses they are capable of producing. The ratio of living to dead bacterial cells will also be determined. Two different species of lysogenic bacteria will be tested; one was especially synthesized for this program.

A total of over 40,000 cultures will be made from this material. An even greater number of assays must be performed on ground control material to determine whether there is any effect of space flight.

Genetic Effects on Neurospora (Orange Bread Mold) - Atomic Energy Commission, Oak Ridge National Laboratory

This experiment was selected primarily because the frequencies of mutation in two different genes can be measured directly. In addition, a wide range of mutations can be detected, ranging from subtle molecular changes in the gene, to loss of the gene by chromosome breakage. The experimenters will determine whether the frequency of gene mutation and chromosome breakage produced by radiation will change with weightlessness and whether there is any difference in the array of mutations recovered.

The spores of the mold are collected on filter paper disks and the sandwich consisting of these filter papers and thin lithium fluoride disk dosimeters (to measure the radiation dose) are sealed in stacks of 10 in the experiment packages. Four of these packages are placed at different distances from the radiation source to vary the exposure per filter from 500 to 6,000 roentgens. A non-irradiated control package will be carried behind the radiation shield on the spacecraft. This arrangement will be duplicated on the ground to provide simultaneous ground-based control data.

The retrieval, the flight material and the ground control material will be returned to Oak Ridge National Laboratory for genetic analysis.

The experimenters will then compare the samples irradiated in flight with those irradiated in the simultaneous ground-based control. They will determine the levels of survival and the frequency of mutations in two different genes that control sequential steps in the same metabolic pathway. Samples of mutants will then be analyzed by a series of genetic tests to characterize the genetic alteration in each at the molecular level.

Mutation in Tradescantia (A Native Wild Flower) - Atomic Energy Commission, Brookhaven National Laboratory

The purpose of this experiment is primarily to determine whether ionizing radiation, combined with weightlessness, will produce a different frequency of mutation in plant cells than radiation alone.

The plant selected for the experiment is a special strain of the common spiderwort, a blue flowering, roadside plant native to many parts of southern and central United States. This plant is easy to handle experimentally, has a small number (12) of large chromosomes ideally suited for detailed studies of radiation injury, and a high mutation rate of a gene determining flower petal color. This gene has about the same radio-sensitivity as those in mammalian cells, and there is a large backlog of data concerning its response to ionizing radiation.

In the experiment, roots of young Tradescantia plants will be sealed in tubes filled with nutrient solution and the flower buds arranged in single tiers for uniform exposure to the gamma radiation. Radiation-induced effects will appear as color changes in the flowers a few days after retrieval. These changes are caused by mutating the flower color gene in some of the somatic cells in the petals and stamen hairs in such a way that the normal blue coloration fails to develop and is replaced by pink. Successive divisions of the cell with the mutant gene produces a row or cluster of pink cells. The number of pink mutant cells can be counted easily with the aid of a microscope and from these counts, a mutation rate can be calculated. Comparisons are then made with the ground-based specimens.

A control sample of Tradescantia will be exposed to the same effects of weightlessness but will be in a special compartment shielded from the radiation source. Any differences in mutation frequencies observed can then be attributed to weightlessness, decreased gravity or other environmental stresses associated with the flight.

The experiment package consists of 32 small plants growing in nutrient solution in small vials maintained in a plastic housing which holds the plants at a set distance from the gamma source. A total exposure of about 300 roentgens is expected in the forward compartment and at most only a few roentgens in the shielded area.

Genetic Effects on Habrobracon (A Parasitis Wasp) - Atomic Energy Commission, Oak Ridge National Laboratory; North Carolina State University, Raleigh; and Southwestern University, Memphis.

The genetic effects of the combination of radiation and weightlessness, as well as other aspects of flight dynamics, will be measured using male and female parasitic wasps. These insects are unique in that all of the genetic damage to the entire set of chromosomes can be measured in one experiment, mostly by direct counts of egg mortality. This is possible because normal male offspring come from unfertilized eggs.

In this type of experiment, dominant lethality which corresponds to different types of chromosome aberrations is reflected by death of embryos after treatment of either or both parents. Other kinds of cellular damage can be assessed by studying fecundity, fertility and life span.

Recessive gene damage and specific chromosomal breakage events in the second generation are measured in the surviving offspring by analyzing their egg mortality and adult viability.

When packed in place in the Biosatellite, four different doses of radiation are obtained. To determine dosage exactly, miniature dosimeters made of radio-sensitive glass are placed close to the wasps.

The Genetic Effects of Weightlessness and of Weightlessness in Combination with Radiation in Drosophila (vinegar gnats) in the Adult and Pupae Stages - Rice University

This experiment combines known genetic changes in succeeding generations of vinegar gnats under radiation alone with changes occurring under both weightlessness and radiation. In addition, genetic effects of weightlessness alone, under space flight conditions, will be looked for.

Radiation-induced visible mutations result from alterations to genes at specific locations vinegar gnat chromosomes and include changes in eye and body color, structure of wings and shape of bristles, as well as lethal mutations which result in death of the developing embryo. Under normal gravity, researchers can detect mutations in 10 genes in the first generation, and in the second generation the killing effect of the lethals can be detected, as well as chromosomal breaks. These breaks result in chromosome fragments which re-combine in various ways to form rearrangements known as translocations. Experimenters will also look for changes in the giant chromosomes of the salivary glands of the larvae under the microscope.

Some of the adult vinegar gnats will be x-irradiated immediately prior to launch. Frequency of lethal mutations and chromosome translocations occurring during flight will then be compared with the frequencies obtained on Earth for possible differences. One of the experiment packages containing eight cubicals will receive about 2,000 roentgens of radiation. The other package of eight cubicals will be shielded from the radiation. Each cubical contains an agar-based nutrient to feed the Drosophila.

Embryo Development in Drosophila (Vinegar Gant) Larvae - Bowling Green State University

The purpose of this experiment is to study the effects of radiation combined with weightlessness on the developing organism.

Vinegar gnat embryos are extremely sensitive to radiation, and known amounts produce measurable chromosomal changes in the cells of exposed individuals. A special strain of Drosophila melanogaster which easily allows for the detection of chromosome breakage following irradiation will be used. This type of damage results in areas of dead tissue in the rapidly dividing and developing cells of the larvae; if extensive enough, this may lead to premature death of the individual.

On retrieval, the over-all mortality will be determined. The survivors will be sectioned and/or have squash preparations made of their cells for direct microscopic studies of the effects on the chromosomes. This is primarily a study of developing organisms but some larvae will be carried out to the adult stage in order that their reproductive cells may be analyzed for lethal mutations.

The experimental package consists of eight square modules containing nutrient and larvae. The package containing about 500 larvae will be mounted at the point at which it will receive some 1,300 roentgen of radiation; a similar package containing about 500 larvae will be located in a portion of the satellite shielded from the radiation. Two additional packages, each containing 500 larvae, will serve as ground-based irradiated and non-irradiated controls, respectively.

Development in Tribolium (a Flour Beetle) - University of California, Berkeley

In this experiment, the effect of weightlessness, as well as the effect of the combination of weightlessness and radiation on the development of flour beetles, will be studied.

Many chemical and physical agents have the ability to enhance or detract from the radiation effects on living organisms.

Increased temperature, for example, increases the wing abnormalities resulting from exposure to radiation. This experiment would demonstrate any modification of the radiation effect in Tribolium due to weightlessness.

Gravity-dependence of Tribolium development from pupae to adult will also be studied.

Radiation-sensitive young pupae will be flown, a portion of which will be x-irradiated before flight with about 1,300 roentgens to sensitize them to the relatively small dose of about 100 to 200 roentgens obtained in flight.

Each of the two experiment packages consists of three compartments containing pupae, a thermostatically-controlled strip heater, and insulating materials. The heater maintains the beetles at a temperature of about 86 degrees F at which they normally grow.

General Biology Experiments

Effects of Weightlessness on Feeding and Growth of the Giant Multi-nucleate Amoeba Pelomyxa Carolinensis - Colorado State University and General Electric Company (MSD)

The experiment is designed to study the effects of weightlessness on nutrition and nuclear division of both starved and fed amoebae. Throughout the three-day mission, different groups of amoebae will be preserved. Some of these amoebae will be fed at various intervals before preservation. Upon retrieval, the feeding processes during weightlessness and structure involved in nutrition will be analyzed in these organisms. Nuclear division will be studied in the preserved amoebae and amoebae recovered alive.

Examination of the preserved amoebae with both light and electron microscopes will include morphological descriptions of the resting and dividing nuclei, mitochondria, lysosomes and food vacuole constituents. Cytochemical studies will localize the enzymes involved in the digestion of food. Comparison with amoebae from ground-based experiments will allow a partitioning of the effects of the space flight.

Under all conditions studied in ground-based experiments, the nuclei divide in a synchronous manner. The amoebae subjected to various periods of weightlessness will be analyzed to determine whether synchronous nuclear division continues in space.

The experiment package contains 24 cylindrical plastic chambers, each divided into three compartments. One compartment contains aboebae, another paramecia (one-celled animals on which the amoebae feed), and the third contains preservative. A spring-driven piston triggered by a timing mechanism first mixes amoebae and paramecia. After a feeding period, the piston advances another step and the preservative is released.

Sub-gravitational Effects on Frog Eggs - NASA Ames Research Center.

The purpose of this experiment is to seek effects at the cellular and sub-cellular level on developing frog embryos under weightlessness. These effects will be studied starting with the fertilized egg through a series of developmental stages to the tadpole.

The experimenter will be looking for abnormalities in cell structure, effects on cell division, and growth effects on embryonic structure. He will also look for abnormalities in mitotic spindle formation (part of the cell division apparatus), as well as effects on specific stages in the development of embryonic organisms.

Frog eggs were chosen because of their known response to gravity. They have a heavy end which rotates downward after fertilization of the egg. In a series of classic experiments, the maintenance of fertilized frog eggs in an inverted position has produced a variety of developmental abnormalities. The response of this material to weightlessness may provide some insight into the role of gravity in such cellular processes and the necessity of a gravitational field for embryonic orientation and development.

Eggs will be fertilized at room temperature, then cooled to 41 degrees F to retard the first cell division. In orbit, a heater will raise the temperature to about 70 degrees F to begin cell division. At various times preservation will stop embryonic growth. The embryos will be studied microscopically upon retrieval. Some of the embryos will be returned alive to allow them to develop into tadpoles and frogs.

The experiment package consists of an assembly of 16 cylindrical lucite chambers divided by a piston. On one side of the piston is a preservative; on the other, fertilized frog eggs. The spring-driven piston releases preservative into the egg chamber upon signal.

Effects on Form, Tissues and Biochemistry of Wheat Seedlings

For the first time the growth of plants from seeds will take place free from the Earth's gravitational field. Seventy-eight wheat seedlings will be orbited to study the effects of weightlessness on their growth. The seeds will germinate in the dark in four sealed chambers. Growth of seedlings in two chambers will be stopped at 48 to 60 hours after launch. The other 48 seedlings will be returned alive, then photographed and used for special studies. A few will be planted to observe effects of weightless environment on later growth.

The seedlings will be divided among researchers at three institutions as follows:

a. Dartmouth College, Hanover, N. H.

The experimenter has been studying the hormonal processes by which a typical plant maintains its erect form in spite of the force of gravity. He has found characteristic curvature of the leaves and branches when a plant is allowed to grow in his laboratory attached to a clinostat that keeps the stem horizontal while the plant is rotated slowly about its axis. By using a new system for germinating wheat seeds in moist air on a clinostat, he has found similar growth curvatures in roots. Such curvatures appear to be controlled by an unbalanced distribution of growth regulators in the absence of unidirectional gravity under which all life has evolved on Earth.

Although the horizontal rotation method of growing plants prevents the normal response to gravity, some effects of gravitational force cannot be eliminated on Earth. The growth of wheat seedlings in the Biosatellite will be the first test ever made of the effects of weightlessness on the form of a plant and the orientation of its organs.

b. Emory University, Atlanta, Ga.

The Emory experimenters will study their group of wheat seedlings for changes in size and internal structure during weightlessness. They will look for variations in the chemistry of tissues and in cell structures of both roots and shoots of seedlings fixed in orbit, of plants returned alive, and those germinated in flight and grown to maturity.

These experimenters have already grown seedlings at 10 g to 300 g and observed adaptive changes in shape and size and significant changes in protein and carbohydrate synthesis and localization due to increased gravity. They have also noted chemical changes in tissues of plants grown on a clinostat. These data form a background for comparison of seedlings grown under weightlessness.

c. Resources Planning and Control Corporation and North American Aviation, Inc.

The experimenters will study the wheat roots, shoots and remaining seeds for biologic changes caused by weightlessness. The physical properties and rates of reaction of key enzymes in the various pathways of metabolism and energetics will be examined and compared with effects found in the ground-based controls.

This should produce basic data on biochemical activity within plant cells under weightlessness.

Leaf Angle and Biochemical Effects on the Pepper Plant - North American Aviation, Inc.

It has long been known that higher plants depend on gravity-sensing mechanisms for orientation of plant organs. The roots grow downward into the Earth, the main stem in an upward manner and the leaves essentially in a plane horizontal to the Earth. The purpose of this experiment is to determine whether the leaf will remain in a normal position under weightlessness.

Four one-month old pepper plants will be flown in individual containers. They will be illuminated for five seconds every 10 minutes and photographed from the top and side in the period of illumination throughout duration of orbit. On return the film will be processed for an evaluation of the leaf angles. Comparison with ground-based control plants will be made to determine the magnitude of the effect of orbital weightlessness.

Since it is also known that the gravity-sensing mechanisms involve biochemical changes in the leaves, an additional five plants will be analyzed for carbohydrates and amino acids. A comparison with ground-based controls will indicate the magnitude of biochemical changes under orbital weightlessness.

BIOSATELLITE-B FLIGHT PLAN

Biosatellite-B, weighing 955 pounds, will be the heaviest spacecraft ever launched by the Delta rocket. It is 10 pounds heavier than its predecessor, Biosatellite-A, which was orbited by Delta in December 1966.

This launching will be the 51st for the reliable Delta which has orbited 47 satellites in 50 attempts.

For this mission which requires a low Earth orbit, Delta No. 51 will be in a two stage configuration, just like Delta No. 43 which launched Biosatellite-A.

Delta No. 51 will be launched from Launch Complex 17, Pad B, on an initial launch azimuth of 109 degrees.

The orbital elements for Biosatellite-B are apogee and perigee of 196 miles (circular orbit), an orbital period of 91 minutes and an inclination to the Equator of 33.5 degrees.

After the spacecraft separates from Delta some 9.5 minutes following liftoff, ground controllers will re-start the second stage for experimental purposes only.

The second ignition of the second stage, which has never before been attempted on Delta, is not part of the Biosatellite-B mission.

Project officials want to evaluate a second burn at this time because Delta will be required to perform two burns for an ESRO (European Space Research Organization) launching in 1970.

Before Delta re-ignites, the second stage will be pitched down 65 degrees and turned right 60 degrees. The short four-second burst will put the burned out second stage into an orbit ranging from 303 statute miles (apogee) to 192 statute miles (perigee).

DELTA CHARACTERISTICS

Height:	92 feet (includes shroud)
Maximum Diameter:	8 feet (without attached solids)
Lift-off Weight:	about 75 tons
Lift-off Thrust:	328,000 (includes strap-on solids)
First Stage (liquid only)	Modified Air Force Thor, produced by Douglas Aircraft Co., engines produced by Rocketdyne Division of North American Aviation
Diameter:	8 feet
Height:	51 feet
Propellants:	RP-1 kerosene is the fuel and liquid oxygen (LOX) is the oxidizer for the Thor stage
Thrust:	172,000
Burning Time:	About 2 minutes, 30 seconds
Weight:	Approximately 68 tons (including solids)
Strap-on Solids:	Three solid propellant rockets produced by the Thiokol Chemical Corp.
Diameter:	31 inches
Height:	19.8 feet
Weight:	27,510 (9,170 each)
Burning Time:	43 seconds

Second Stage:	Produced by the Douglas Aircraft Co., utilizing the Aerojet General Corp., AJ 10-118E Propulsion System.
Propellants:	Liquid--unsymmetrical dimethyl hydrazine (UDMH) for the fuel and red fuming nitric acid for the oxidizer.
Diameter:	4.7 feet (compared to 2.7 feet for the earlier Deltas)
Height:	16 feet
Weight:	7 tons (compared to 2-$\frac{1}{2}$ tons for the earlier Deltas)
Thrust:	About 7,800 pounds
Burning Time:	400 seconds (compared to 150 seconds for earlier Deltas)
Guidance:	Western Electric Co.

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NOMINAL BIOSATELLITE-B FLIGHT EVENTS

EVENT	TIME	ALTITUDE (STATUTE MILES)	SURFACE RANGE	VELOCITY (MILES PER HOUR)
Solid Motor Burnout	T+43 sec.	7 Miles	3 Miles	1,883
Solid Motor Separation	T+1 min. 10 sec.	16 Miles	12 Miles	2,728
MECO	T+2 min. 29 sec.	62 Miles	100 Miles	9,535
VECO	T+2 min. 35 sec.	67 Miles	112 Miles	9,535
2nd Stage Ignition	T+2 min. 35 sec.	67 Miles	112 Miles	9,535
Shroud Separation	T+2 min. 42 sec.	74 Miles	129 Miles	9,576
SECO	8 min. 47 sec.	196 Miles	1,225 Miles	17,266
Restart 2nd Stage (experiment only)	T+23 min. 46 sec.	192 Miles	5,120 Miles	17,217
Burnout 2nd Stage	23 min. 51 sec.	192 Miles	5,142 Miles	17,383

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TRACKING AND RECOVERY

Tracking, command, and data readout for Biosatellite B will be by NASA's Satellite Tracking and Data Acquisition Network (STADAN), headquartered at Goddard Space Flight Center.

Immediately after launch, spacecraft control will move from Cape Kennedy to the Biosatellite Operations Control Center at Goddard in Greenbelt, Md. It will remain there until after the final deorbit command is sent to the spacecraft. After this, responsibility for retrieval of the Experiments Capsule will shift to the Recovery Force.

Four STADAN stations will be used throughout the mission: Fort Myers, Fla.; Quito, Ecuador; Lima, Peru; and Santiago, Chile. Additional telemetry stations at Johannesburg, South Africa and Carnarvon, Australia will be used on the first and final orbits, and on others if needed.

The STADAN stations at Rosman, N. C. and Orroral, Australia will provide back-up support upon request.

On the last few orbits, if the main deorbit programmer fails, Johannesburg will start the back-up deorbit programmer.

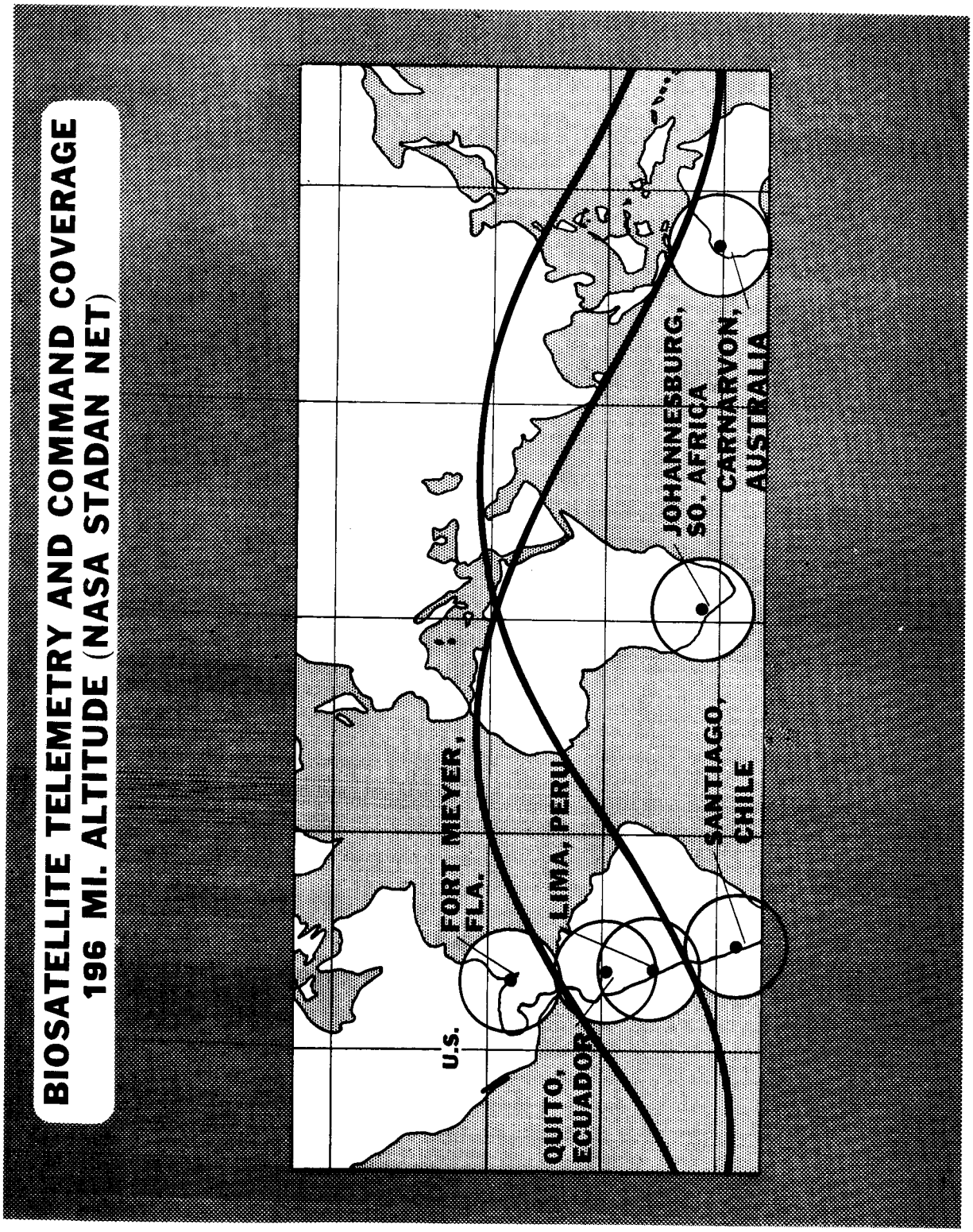
Computer facilities at Goddard will calculate the Biosatellite orbit during the first few revolutions. Orbit data will be used to pinpoint the planned recovery area in the mid-Pacific, as well as emergency recovery areas for each day.

On each orbit, one STADAN station will send commands and receive tracking and performance data.

The STADAN stations will see the spacecraft for from four to six minutes each pass for transmitting, receiving, and tracking.

On passes over Fort Myers and Carnarvon, data will be returned to Biosatellite Control via high speed (1,792 bits per second) data link in addition to being recorded at the station for later analysis.

This will allow real time monitoring of spacecraft response to commands on Fort Myers and Carnarvon passes, with most critical commands sent from Fort Myers. Other STADAN stations will transmit data as required by Biosatellite Control, for spacecraft operation and response to contingencies.


BIOSATELLITE TELEMETRY AND COMMAND COVERAGE
196 MI. ALTITUDE (NASA STADAN NET)
U.S.
FORT MEYER, FLA.
QUITO, ECUADOR
LIMA, PERU
SANTIAGO, CHILE
JOHANNESBURG, SO. AFRICA
CARNARVON, AUSTRALIA

For recovery, a voice link will join the Biosatellite control center at Goddard to the Air Force recovery control facility, and voice circuits will link Biosatellite Control and the deorbit monitoring aircraft near New Guinea.

Post retro-fire tracking of the Reentry Vehicle will be done by the U. S. Air Force station at Kaena Point, Hawaii. Data will be teletyped immediately to NASA's Goddard Space Flight Center for quick analysis.

Telemetry from the Experiments Capsule will be received by recovery stations, aircraft, and ships.

Following the mission, all recorded data from the flight will be sent to the Goddard Center for processing and distribution to experimenters.

Recovery Operations

Recovery of the Experiments Capsule will be made by U. S. Air Force with the support of other agencies.

Since the experiments are highly perishable, a prime objective will be to return them to laboratories within six hours.

Primary method of recovery is in the air as the Capsule descends by parachute from orbit.

To carry out recovery, the Goddard Center will compute recovery areas. The Biosatellite mission director at Goddard will then order time and place of recovery 4.5 to 7.5 hours in advance. Planned orbits put all recovery areas in the region of the Hawaiian Islands.

Aerial recovery will be made by an aircraft of the designated USAF recovery agency. If aerial recovery does not take place, search aircraft will locate the Capsule by its radio beacon, light, and dye marker.

In case of sea landing, retrieval will be by:

1) helicopter recovery with SCUBA divers; 2) surface-to-air pickup with Aerospace Rescue and Recovery Service personnel erecting a balloon station. A balloon would hold a line aloft attached to the capsule for aircraft snatch from the water; 3) if the capsule overshoots, USAF recovery agency will begin remote area retrieval operations.

Organizations taking part in recovery include the designated USAF recovery agency, USAF Aerospace Rescue and Recovery Service, NASA's Ames and Goddard Centers and General Electric Co., spacecraft contractor.

Support agencies are the Air Force Weather Forecasting Service; Hickam Air Force Base; the Federal Aviation Agency; Air Force Western Test Range; and the Navy Pacific Missile Range.

Facilities include fixed wing aircraft; a recovery ship with helicopters; balloon kits for direct sea pickup; voice and teletype links between all ships, aircraft, bases, and control centers. USAF Aerospace Rescue and Retrieval Service bases in Japan, Guam, Florida, Bermuda, and the Azores will be alert to the unlikely possibility of emergency calldown in their operating areas.

FLIGHT SEQUENCE

The three-day launch opportunity in September extends over the five-day period, Sept. 7-11. Launch window for each day would be 3 p.m. EDT, and continue for 30 minutes.

Window requirements for Biosatellite B are determined primarily by its biological experiments. A two-day interval is required for recycling in the event a launch is delayed, to permit replacement of the biological samples.

After internal disconnect, an event occurring 30 seconds before launch, control officials have only five minutes in which to begin spacecraft flight without compromising biological objectives. The three-day mission is precisely correlated with the life span and reproduction periods of the life specimens aboard.

Other factors affecting Biosatellite's launch opportunity period and window include the consideration that attitude for deorbit is most readily achieved during darkness, permitting reentry at daybreak and recovery in daylight.

These are the planned events in the Biosatellite B three-day mission:

The main Delta engine and three solid strap-on motors fire together. The solid motors burn for 43 seconds and their burned-out casings are jettisoned at 70 seconds after launch. The main engine burns out after two minutes and 27 seconds.

Three seconds later the Delta second stage ignites, and the first stage separates and falls away. The shroud covering the spacecraft is jettisoned at two minutes and 47 seconds after launch.

The second stage engines burn for six minutes and 23 seconds with burnout just under nine minutes after launch. Injection into the first of 47 orbits occurs at second-stage burnout. One minute later, separation of launch vehicle and spacecraft occurs.

Orbital Events

With separation, attitude control system is turned on to stabilize the spacecraft, and the boom for the reentry magnetometer is deployed.

Ten minutes after launch, the main programmer-timer commands the pepper plant camera to operate. It then photographs the leaf angle every ten minutes for the duration of the mission.

At 30 minutes after launch, the main programmer commands an increase in temperature of frog eggs to speed cell division.

At 32 minutes, Johannesburg acquires the spacecraft and reads out the first telemetry. At one hour, the main programmer orders opening of the gamma radiation source. Also the first group of amoebae is fixed and others are fed. The first pair of frog eggs is fixed.

At 96 minutes, the Fort Myers station first acquires. It commands readout of telemetry, and restabilization of the spacecraft. Backup commands are also sent to insure that onboard commands have been carried out.

(Commands for data readout and attitude stabilization will now be sent once each orbit.)

At two hours after launch, the second pair of frog eggs is fixed and at three hours, the third pair.

At 3.25 hours, Quito first acquires the satellite; at 4.9 hours, Lima acquires; and at 6.5 hours, Santiago acquires.

At 12 hours, the second group of amoebae is fixed, and others fed. At launch plus one day, the third group of amoebae is fixed and others fed.

At 32.13 hours, the fourth pair of frog eggs is fixed, and at 38.5 hours, the fifth pair.

At two days, the fourth group of amoebae is fixed, and others fed. The first group of wheat seedlings is fixed.

At 56.13 hours, time to planned entry point is loaded into the separation timer. The magnetometer is turned on, and its bias is adjusted to account for direction of the Earth's magnetic field at the planned entry point.

At 57.7 hours, the second group of wheat seedlings is fixed, and at 62.5 hours, the separation timer starts, and horizon sensors turn on.

At 64.13 hours, Fort Myers commands the attitude for retrofire and deorbit. At 68.9 hours, the fourth group of amoebae is fixed and others fed. The sixth pair of frog eggs is fixed.

(At about 69.5 hours, in case the main timer fails, Johannesburg will order start of the back-up separation timer to insure entry.)

Recovery Events

One and one-half orbits before separation, ground command arms the separation sequence.

At 400 seconds before separation, the separation programmer-timer begins to command separation events. It turns on the deorbit telemetry transmitter, resets the recovery programmer, and switches the capsule heater to the battery in the capsule.

At 15 seconds before separation, the programmer turns on the recovery beacon, and at four seconds, it orders electrical disconnect of Adapter Section and Experiments Capsule. At three seconds, it activates capsule batteries.

At 1.35 seconds, electrical disconnect of Adapter and retro-fire cone occurs, and the deorbit programmer-timer starts.

At separation, two days and 21.5 hours after launch, the programmer orders separation; pin pullers fire; Adapter Section and Reentry Vehicle move apart.

Two seconds later, the deorbit timer orders spin-up of the Reentry Vehicle for stable attitude; and 3.3 seconds after separation, retro-fire slows the capsule by 420 mph.

At 14 seconds, de-spin occurs, and at 16 seconds, the bruned-out retro-fire cone separates from the Reentry Vehicle.

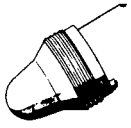
At 17.5 minutes after separation, at 80,000 feet, a deceleration switch starts the recovery programmer. Thirty seconds later, the programmer orders the Vehicle's aft thermal cover to eject; drogue chute deploys, causing fall-away of the Vehicle's forebody; the recovery light begins flashing.

Ten seconds later, the drogue chute pulls out the main chute from the Experiments Capsule. The main chute opens reefed, and five seconds later, cutters disreef it.

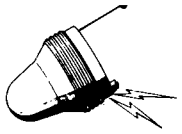
Aerial recovery then occurs. If aerial recovery is not accomplished, the capsule lands in the ocean at 44.7 minutes after separation.

A dye marker is released; radio beacon continues to operate. Ten minutes later, recovery telemetry stops. Life support batteries operate for six hours. Radio functions up to 36 hours after sea-landing.

BIOSATELLITE RECOVERY SEQUENCE

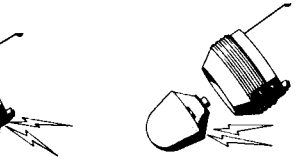


T_{PD} – 24.97m
T_S – 400s
1. ACTIVATE RECORDER
2. RECOVERY TLM ON
3. RESET RECOVERY PROGRAMMER RELAYS



T_{PD} – 18.55m
T_S – 15s
1. SHIFT POWER TO INTERNAL POWER SOURCE
2. COMPLETE CKT BETWEEN ORBITAL BATT. AND DEORBIT BATT.
3. ARM RECOVERY PROGRAM
4. RECOVERY BEACON ON

T_{PD} – 18.38m
T_S – 4.7s
FEEDLINE DISCONNECT

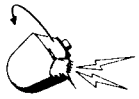


T_{PD} – 18.36 m
T_S – 3.9s
ELEC. DISCONNECT ADAPTER—R/V

T_{PD} – 18.35m
T_S – 3s
IGNITE DEORBIT BATT

T_{PD} – 18.32
T_S – 1.35s
1. ELEC. DISCONNECT. ADAPTER—T/C
2. DEORBIT PROGRAMMER STARTS TIMING

T_{PD} – 18.3m
T_S = 0
1. SEPARATION SIGNAL
2. PIN PULLERS FIRED
3. R/V & S/V SEPARATE



T_{PD} – 18.27m
T_S + 2.05s
1. R/V SPIN-UP

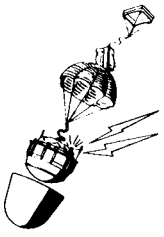
T_{PD} – 18.25m
T_S + 3.30s
1. RETRO ROCKET IGNITION

T_{PD} – 18.07m
T_S + 14.05s
1. R/V DESPIN

T_{PD} 18.04m
T_S + 15.55s
1. T/C SEPARATION

T_{PD} – 2.3m
T_S + 16m
1. ENERGIZE RECOVERY TIMER CKT'S
G-SWITCH CLOSES 200,000 FT. ALT.

T_{PD} – 48s
T_S + 17.5m
1. RECOVERY TIMER STARTS TIMING
G-SWITCH CLOSES 80,000 FT. ALT.



T_{PD} – 18s
T_S + 18m
1. AFT THERMAL COVER EJECTED 55,000 FT. ALT.
2. DECELERATION PACK EXTRACTED
3. DROGUE CHUTE DEPLOYED
4. FOREBODY SEPARATION
5. FLASHING LIGHT ON

T_{PD} – 3s
T_S + 18.25m
1. BAG LINE CUTTERS ACTIVATED
2. DROGUE CHUTE SEPARATES MAIN CHUTE FROM CAPSULE
3. DEPLOYMENT BAG STRIPS OPEN
4. DROGUE CHUTE EXPENDED
5. MAIN CHUTE OPENS REEFED

T_{PD} = 0
T_S + 18.3m
1. REEFING LINE CUTTERS ACTUATED
2. MAIN CHUTE DISREEFS

T_S = REENTRY VEHICLE SEPARATION
T_{PD} = PARACHUTE DEPLOYMENT

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BIOSATELLITE PROJECT TEAM

NASA Headquarters, Washington, D.C.

Dr. Homer E. Newell, Associate Administrator for Space Science and Applications
Dr. Orr E. Reynolds, Director, Bioscience Programs
Thomas P. Dallow, Biosatellite Program Manager
Dr. Joseph F. Saunders, Biosatellite Program Scientist
Robert W. Manville, Delta Program Manager

Ames Research Center, Moffett Field, Cal.

H. Julian Allen, Director
Robert M. Crane, Assistant Director for Development
Charles A. Wilson, Biosatellite Project Manager
Bonne C. Look, Biosatellite Spacecraft Systems Manager
Dr. G. Dale Smith, Biosatellite Project Scientist and Experiments Group Manager
John W. Dyer, Biosatellite Assistant Operations Manager
Thomas H. Harmount, Assistant Experiments Engineering Group Manager

John F. Kennedy Space Center, Kennedy Space Center, Fla.

Robert H. Gray, Assistant Director for Unmanned Launch Operations
Hugh A. Weston, Jr., Chief, Delta Operations

Goddard Space Flight Center, Greenbelt, Md.

William B. Schindler, Delta Project Manager
Eldon A. Volkmer, Biosatellite Tracking and Data Systems Manager

Biosatellite Project Officials

General Electric Company (Spacecraft Prime Contractor), Philadelphia, Pa.

Hilliard W. Paige, Vice President and General Manager, Missile and Space Division
Mark Morton, General Manager, Re-entry Systems Department
H. M. Wittner, Biosatellite Program Manager
John T. Glancey, Three-Day Biosatellite Spacecraft Manager
V. C. Deliberato, Biosatellite Systems Integration Manager
W. D. Anderson, Program Planning and Control Manager
W. E. Brunschwyler, 30-21-Day Biosatellite Spacecraft Manager
O. Klima, Chief Engineer

Biosatellite Experimenters

General Biology Experiments

Amoeba

Principal Investigator:	Dr. Richard W. Price Colorado State University Fort Collins, Colo.
Co-Investigator:	Dr. Donald E. Ekberg General Electric Company Philadelphia, Pa.

Frog Eggs

Principal Investigator:	Dr. Richard S. Young NASA Headquarters Washington, D.C.
Co-Investigator:	Dr. John W. Tremor NASA Ames Research Center Mountain View, Cal.

Wheat Seedlings (three experiments)

Principal Investigator:	Dr. Charles J. Lyon Dartmouth College Hanover, N. H.
Principal Investigator:	Dr. Stephen W. Gray Emory University Atlanta, Ga.
Co-Investigator:	Dr. Betty F. Edwards (same address)
Principal Investigator:	Dr. Herbert M. Conrad Resources Planning and Control Corp. El Segundo, Cal.
Co-Investigator:	Dr. Samuel P. Johnson North American Aviation Downey, Cal.

Pepper Plant

Principal Investigator:	Dr. Samuel P. Johnson North American Aviation Downey, Cal.

Co-Investigator: Dr. Theodore Tibbitts
University of Wisconsin
Madison, Wis.

Radiation Experiments

Tradescantia (Blue Wildflower)

Principal Investigator: Dr. Arnold H. Sparrow
Brookhaven National Lab.
Upton, N. Y.

Co-Investigator: L. A. Schairer
(same address)

Neurospora (Orange Bread Mold)

Principal Investigator: Dr. Frederic J. de Serres
Oak Ridge National Lab.
Oak Ridge, Tenn.

Co-Investigator: Dr. Brooke B. Webber
(same address)

Habrobracon (Parasitic Wasp)

Principal Investigator: Dr. R. C. von Borstel
Oak Ridge National Lab.
Oak Ridge, Tenn.

Co-Investigators: Dr. Daniel S. Grosch
State University of North Carolina at Raleigh
Raleigh, N.C.

Dr. Anna R. Whiting
Oak Ridge National Lab.
Oak Ridge, Tenn.

Dr. Roger H. Smith
(same address)

Dr. R. L. Amy
Southwestern University at Memphis, Tenn.

Tribolium (Flour Beetle)

Principal Investigator: Dr. John V. Slater
University of California
Berkeley, Cal.

Adult Drosophila (Vinegar Gnat)

Principal Investigator: Dr. Edgar Altenburg
Rice University
Houston, Tex.

Co-Investigator: Dr. Luolin Browning
(same address)

Drosophila Larvae (Vinegar Gnat)

Principal Investigator: Dr. Irwin I. Oster
Bowling Green State University
Bowling Green, Ohio

Lysogenic (Rupturing) Bacteria

Principal Investigator: Dr. Rudolf H. T. Mattoni
NUS Corporation
Hawthorne, Cal.

Co-Investigators: Dr. W. T. Romig
University of California
Los Angeles, Cal.

Dr. W. T. Ebersold
(same address)

Dr. Edward C. Keller, Jr.
NUS Corporation
Hawthorne, Cal.

Biosatellite B Industrial Team

Biosatellite B Contractors and Sub-Contractors

Prime Contractor:

General Electric Company
Reentry Systems Department
Philadelphia, Pa.

Major Sub-Contractors & Vendors

Irving Air Chute Company, Inc.
Irving Para-Space Center
Glendale, Cal.

CTS Corporation
Ridgefield, Conn.

Eagle Picher Industries, Inc.
Joplin, Mo.

Fairchild Camera and Instrument Corporation
Fairchild Controls Division
Bayshore, N.Y.

Midwestern Instruments, Inc.
Tulsa, Okla.

Schoenstedt Instrument Company
Silver Spring, Md.

Systron-Donner Corporation
Concord, Cal.

Electro Mechanical Research, Inc.
Sarasota, Fla.

Stellar Metrics, Inc.
Santa Barbara, Cal.

United Aircraft Corporation
Hamilton Standard Division
Windsor Locks, Conn.

Data Control Systems, Inc.
Danbury, Conn.

Avco Corporation
Electronics and Ordnance Division
Wilmington, Mass.

General Devices, Inc.
Princeton, N. J.

Columbia Research Laboratories, Inc.
Woodlyn, Pa.

Applied Electronics Corporation of N.J.
Metuchen, N.J.

Sterer Engineering and Manufacturing Company
Los Angeles, Cal.

Barnes Engineering Company
Stamford, Conn.

Thiokol Chemical Corporation
Elkton, Md.

Experiment Flight Hardware

North American Aviation, Inc.
Space and Information Systems Division
Downey, Cal.

General Electric Company
Reentry Systems Department
Philadelphia, Pa.

Recovery Operations Hardware

Irving Air Chute Company, Inc.
Lexington, Ky.

Inflatable Technology, Inc.
Vee-Line Division
Costa Mesa, Cal.

Launch Vehicle Contractor

Douglas Aircraft Company
Santa Monica, Cal.

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