NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546
TELS. WO 2-4155
WO 3-6925

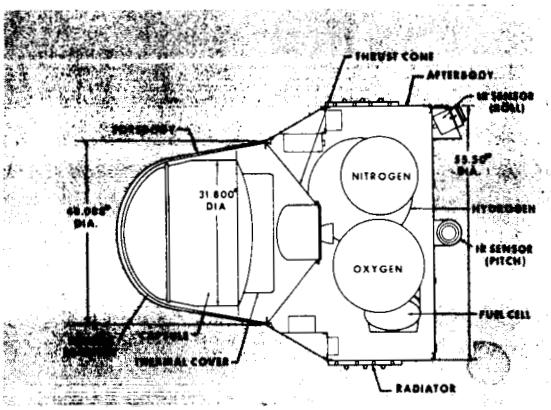
FOR RELEASE: FRIDAY P.M.
December 9, 1966

RELEASE NO: 66-312

PRESS KIT

PROJECT: BIOSATELLITE A

(To be launched no earlier than December 14, 1966)



CONTENTS

GENERAL RELEASE----------1-6
BIOSATELLITE A SPACECRAFT----------7-12
SCIENTIFIC EXPERIMENTS----------13
RADIATION EXPERIMENTS----------13-18
GENERAL BIOLOGY EXPERIMENTS----------18-21
DELTA LAUNCH VEHICLE----------22-23
TRACKING AND RECOVERY----------24-26
FLIGHT SEQUENCE----------26-28
BIOSATELLITE PROJECT TEAM----------29-34

-End-

12/5/66

NEWS

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

TELS. WO 2-4155
WO 3-6925

FOR RELEASE: FRIDAY P.M.
December 9, 1966

RELEASE NO: 66-312

BIOSATELLITE A
FIRST IN SERIES
OF SPACE STUDIES

The United States will begin a large-scale study of basic biology in space with the launching of the first of a series of Biosatellites.

Successful completion of the Biosatellite program will provide answers to questions of great scientific interest about a number of basic biological processes.

The first of these spacecraft -- Biosatellite A -- will be launched by the National Aeronautics and Space Administration from Cape Kennedy, Fla., no earlier than Dec. 14.

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.

The biological specimens chosen for Biosatellite flights 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. Biosatellite will provide weightlessness of 1/100,000th of Earth gravity.

-more-

Effects of weightlessness on various life processes will be studied on experimental organisms including pepper plants, wheat seedlings, frog eggs and amoeba. These experiments will study physiological effects at three different levels of organization:

- growth and form of entire plants and animals
- structure of 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 zero gravity affect this?

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

Thus, a second objective of the Biosatellite A mission is to determine whether the effects 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 the most comprehensive data on this question include bacteria, common bread mold, a flowering plant, a flour beetle, a parasitic wasp, and both the larvae and adult of the common fruit fly. In orbit, they will be irradiated with gamma rays from an on-board radiation source of Strontium 85.

The bacteria will contain a latent virus which can be activated and subsequently kill the bacteria upon exposure to extremely low doses of radiation. 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 fruit fly 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 170-mile high-circular orbit by a seven-foot-long, 940-pound spacecraft.

Biosatellite A 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 retrorocket and heat shield for reentry into the Earth's atmosphere; and the Experiment Capsule which contains the scientific experiments, life support equipment and recovery equipment.

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 Experiment 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.

In orbit, a suitable gas mixture at a sea level pressure, power, data recording, and radio telemetry to ground stations will support the experiments. The temperature will be maintained at 65 to 75 degrees F.

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

Biosatellite B functions as a backup to A in the event a failure occurs immediately prior to launch. Biosatellite B will be launched approximately three months after Biosatellite A (carrying the identical experiments) in the event that the first launch is not completely successful.

Biosatellite D (for which F is a backup) will be launched in 1968 and will carry a primate for 30 days to study in depth the effects of weightlessness on its central nervous system, cardiovascular system, and metabolic processes in the muscular and skeletal systems.

Biosatellites C and E are to be launched in 1969 to study during a 21-day flight, the effects on the 24-hour biological rhythms in animals that removal from the Earth's periodicity will impose and to study the effects of weightlessness on gross body composition. Plant and human cell growth and development will also be studied.

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, Calif. 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, Pa. The Delta is built by the Douglas Aircraft Co., Santa Monica, Calif.

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

Biosatellite studies were recommended to NASA by the National Academy of Sciences in 1963. Over 100 proposals were suggested originally for the program.

(END OF GENERAL RELEASE; BACKGROUND INFORMATION FOLLOWS)

THE BIOSATELLITE A SPACECRAFT

The Biosatellite A 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 six-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).

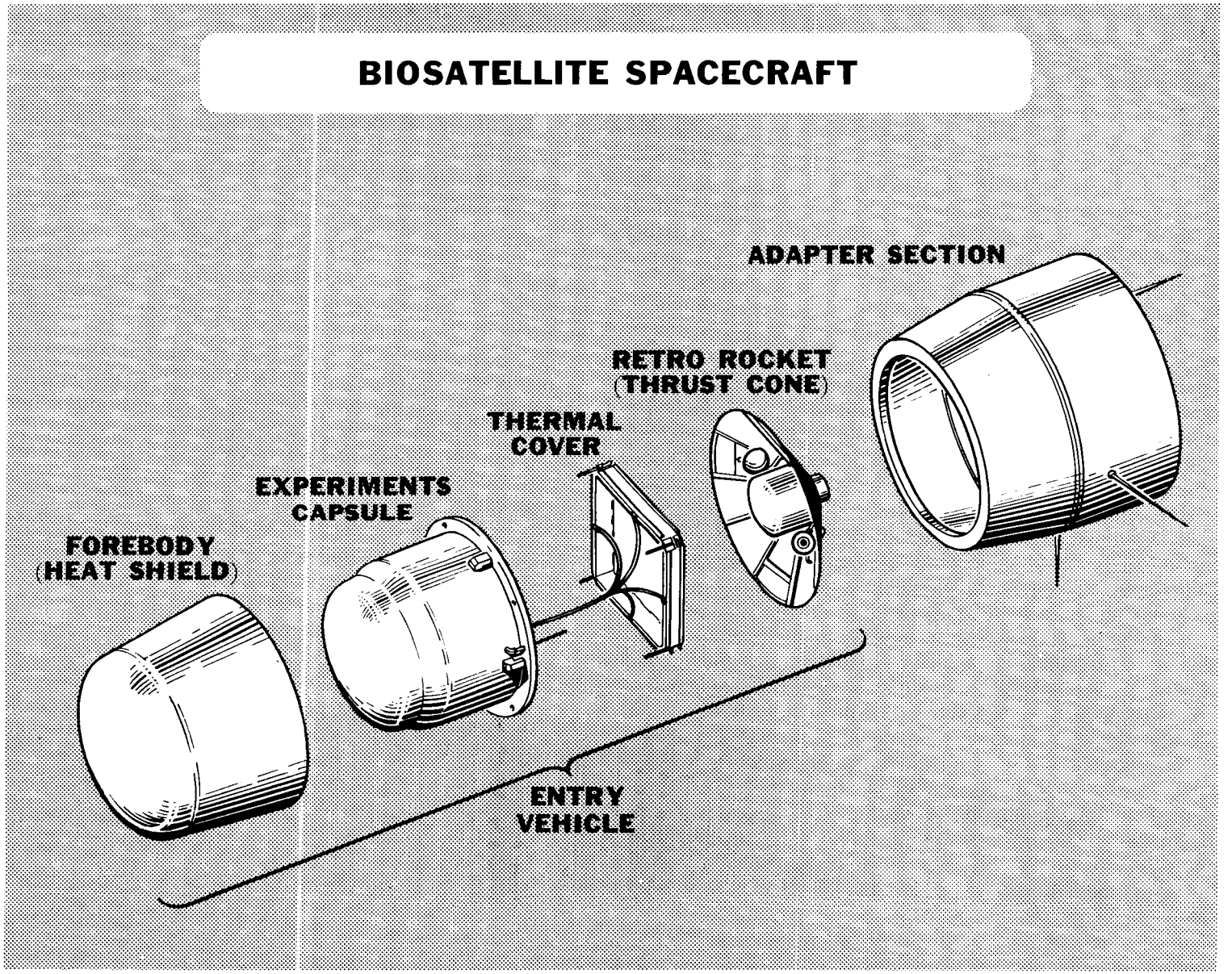
For most of the mission, it does not maintain the spacecraft in a fixed orbital attitude, but merely prevents it from rotating faster than about once in 20 minutes. Slight spacecraft decelerations are caused by atmospheric drag of seven millionths G at orbital altitude.

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.

BIOSATELLITE SPACECRAFT



-more-

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
AMES RESEARCH CENTER, MOFFETT FIELD, CALIFORNIA

For yaw, a magnetometer senses 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 retrofire. The magnetometer is used as a reference to line up the spacecraft in yaw with its orbital path.

With the required deorbit attitude in all three axes, the Reentry Vehicle can separate and the retrorocket fire.

Reentry Vehicle and Experiments Capsule

The atmosphere entry vehicle is a 40-inch-base-diameter blunt cone. It contains the Experiment Capsule and separation and entry systems. Its thrust cone carries a retro-rocket and spin nozzle. Its cup-shaped, fiberglass forebody encloses the Experiment Capsule, and is completely covered by its phenolic nylon heat shield. Its 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 ten seconds, producing 10,200 pounds of thrust, and slowing the vehicle by 420 mph. A second pair of gas jets then despins 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 to 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, flashing light, and dye marker if sea recovery is needed.

About 17 minutes after retrofire 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 forebody with heat shield to fall away. Ten seconds later, the reefed main chute deploys to 72 square feet. Cutters disreef 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, recovery radio beacon and light operate 12 hours. The white light flashes 52 to 75 times per minute.

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 retrofire at the precise time on orbit to reach the planned recovery point. It is started by ground command, timed to one-tenth of a 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, retrofire, and despin. 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 camera, 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 for 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.

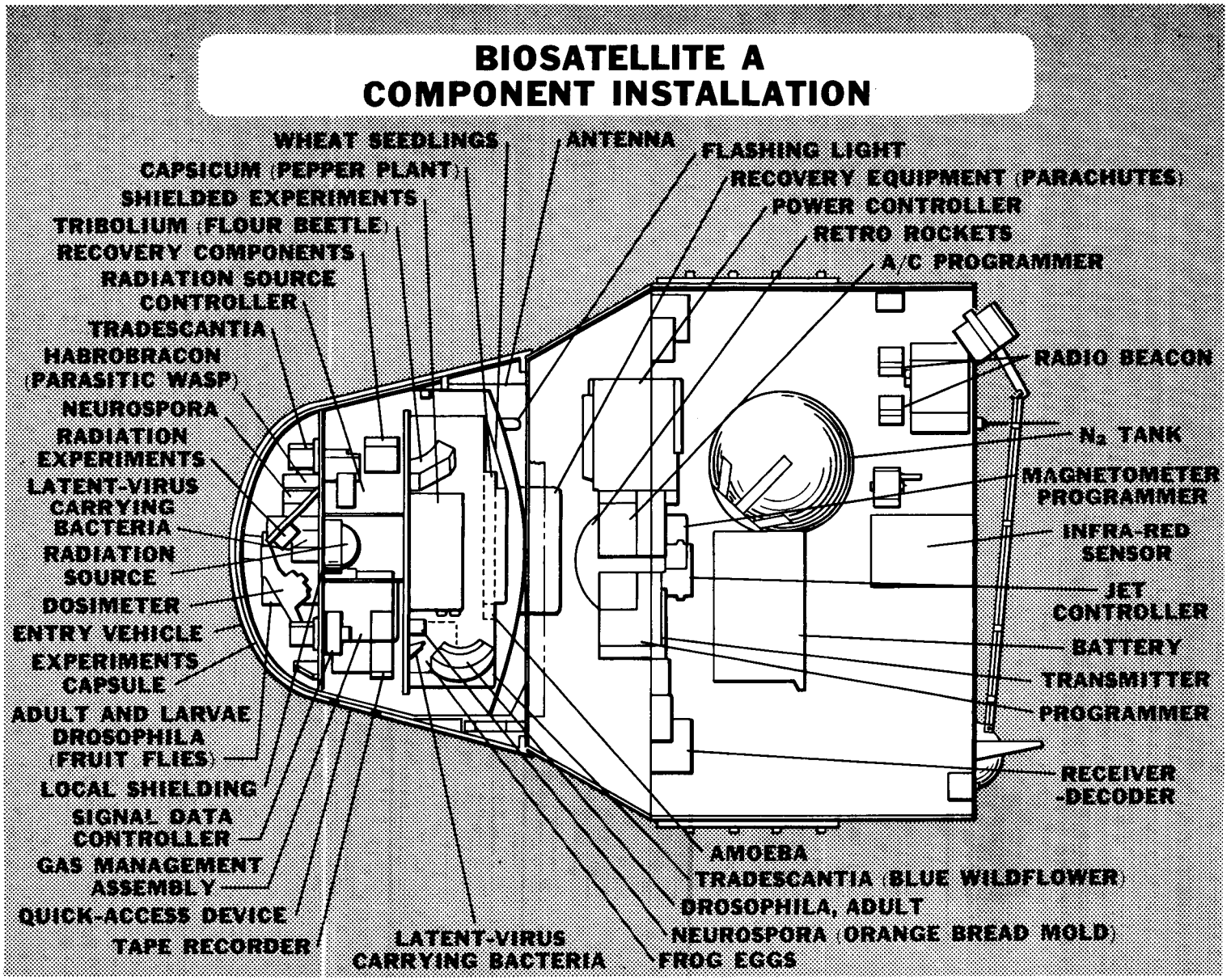
Data returned reports: spacecraft attitude, nitrogen gas storage temperature and pressure, temperatures throughout the spacecraft; electrical voltage levels and current distribution; Experiments Capsule air supply; and fixing, feeding, temperatures, and camera operation of individual experiments.

Deorbit telemetry is sent at 240.2 mc in an FM-FM mode. It reports spin-up, retrofire, and despin.

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 milliwatt via an omnidirectional antenna. Tracking stations measure position of the spacecraft, and this data 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.



-10A-

-more-

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
AMES RESEARCH CENTER, MOFFETT FIELD, CALIFORNIA

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 Strontium 85 radiation source. The source is isolated in a tungsten-nickel-copper sphere, which is opened on command by spring mechanism in orbit (releasing a 180° 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 5000 rads) during 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 degrees 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 Experiment Capsule walls, and controlled by thermostats maintain about 70 degrees F. interior temperature on 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 ten-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 retrofire operations, four smaller silver-zinc batteries in the Experiments Capsule to provide power during recovery---including six hours of life support and 12 hours of radio beacon and flashing light.

SCIENTIFIC EXPERIMENTS

To evaluate the genetic effects of radiation under 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.

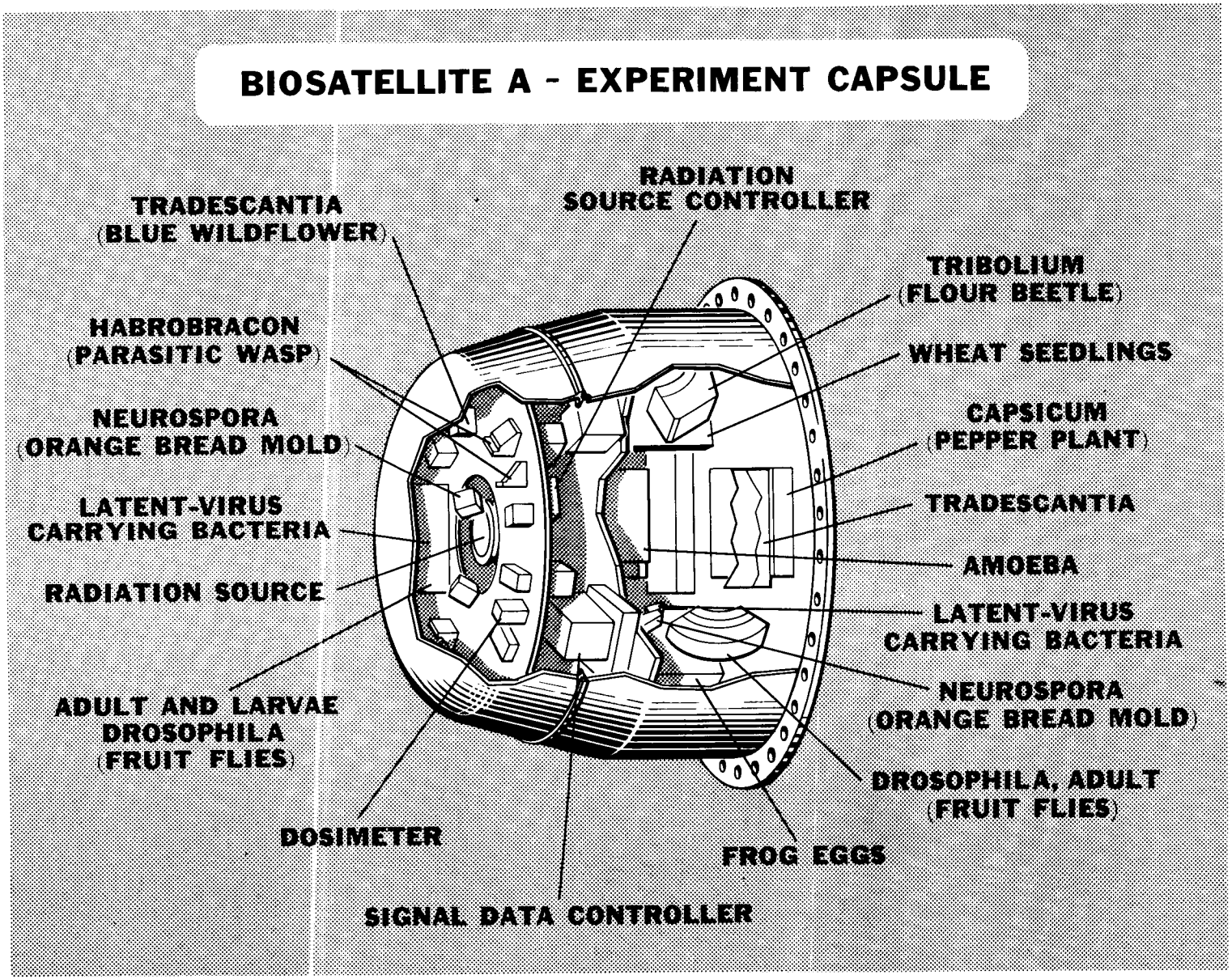
All 13 experiments will have identical control versions on the ground, subjected to conditions close to those of the flight experiments, except for weightlessness. The radiation experiments will also have non-irradiated replicas aboard the spacecraft. These experiments will supply further data on the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



-more-

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
AMES RESEARCH CENTER, MOFFETT FIELD, CALIFORNIA

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 Neurosporo (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 discs and the sandwich consisting of these filter papers and thin lithium fluoride disc 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 sheild 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 during 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 Parasitic Wasp) - Atomic Energy Commission, Oak Ridge National Laboratory; North Carolina State University, Raleigh; Southwestern University, Memphis; and Osaka University, Japan

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 chromosomes aberration 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 (Fruit Flies) in the Adult and Pupae Stages - Rice University

This experiment combines known genetic changes in succeeding generations of fruit flies 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 fruit fly 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 fruit fly adults 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 8 cubicals will receive about 2,000 roentgens of radiation. The other package of 8 cubicals will be shielded from the radiation. Each cubical contains an agar-based nutrient to feed the Drosophila.

Embryo Development in Drosophila (Fruit Fly) Larvae - Bowling Green State University

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

Fruit fly 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 around 500 larvae will be mounted at the point at which it will receive about 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 rads to sensitize them to the relatively small dose of about 100 to 200 rads 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°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 amoeba. Throughout the three-day mission, different groups of amoeba will be preserved. Some of these amoeba 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 amoeba and amoeba recovered alive.

Examination of the preserved amoeba 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 amoeba 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 amoeba subjected to various periods of weightlessness will be analyzed to determine whether synchronous nuclear division continues in space.

-more-

The experiment package contains 24 cylindrical plastic chambers, each divided into three compartments. One compartment contains amoeba, another paramecia (one-celled animals on which the amoeba feed), and the third contains preservative. A spring-driven piston triggered by a timing mechanism first mixes amoeba 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, Mountain View, Calif.

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 down 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 seedling 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. North American Aviation, Inc.

The NAA experimenters will study the wheat roots, shoots and remaining seeds for biological 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 grown 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 if the leaf will remain in a normal position under the conditions of 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 during 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.

DELTA LAUNCH VEHICLE

The Biosatellite A will be launched into orbit by a two-stage, Thrust-Augmented Delta launch vehicle. All previous Deltas have used three stages.

The 92-foot-tall Delta will carry three strap-on solid rockets on its first stage to give it a lift-off thrust of 328,000 pounds. The Delta and the Biosatellite spacecraft will undergo a countdown of 14 hours and 40 minutes at Complex 17 before lifting off on an azimuth of 109 degrees from true North.

Special facilities and procedures allow insertion of live organisms into the Experiments Capsule, using an air-conditioned environment, within the last five hours before launch.

Delta will go over Cape Kennedy's horizon about seven minutes after lift-off and a radio command at that time will set an accelerometer in the second stage to activate the cut-off system at the orbit injection point.

Thrust-Augmented 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, 45 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 2-1/2 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.

Nominal Delta Flight Events

EVENT	IGNITION (seconds)	BURN OUT (seconds)	ALTITUDE (naut. mi.)	SURFACE RANGE (mi.)	VELOCITY (mph)
Strap-on solids	T minus 0	+43	6.2	3	1,900
First stage (Thor)	T minus 0	+150	53	88	10,600
Second stage	T + 154	+551	170	1,076	17,350

TRACKING AND RECOVERY

Tracking, command, and data readout for Biosatellite A 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 Meyers, Fla.; Quito, Ecuador; Lima, Peru; and Santiago, Chile. A fifth at Johannesburg, South Africa, will be used on the first and final orbits, and on others in case of emergency.

The STADAN stations at Rosman, N. C.; Mojave, Calif.; and Ororal, Australia, are trained and will assist on request, as will the manned spaceflight station at Canarvon, Australia, and the United States Air Force station at Kaena Point, Hawaii.

On the last few orbits, if the main deorbit programmer fails, Johannesburg will start the backup 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.

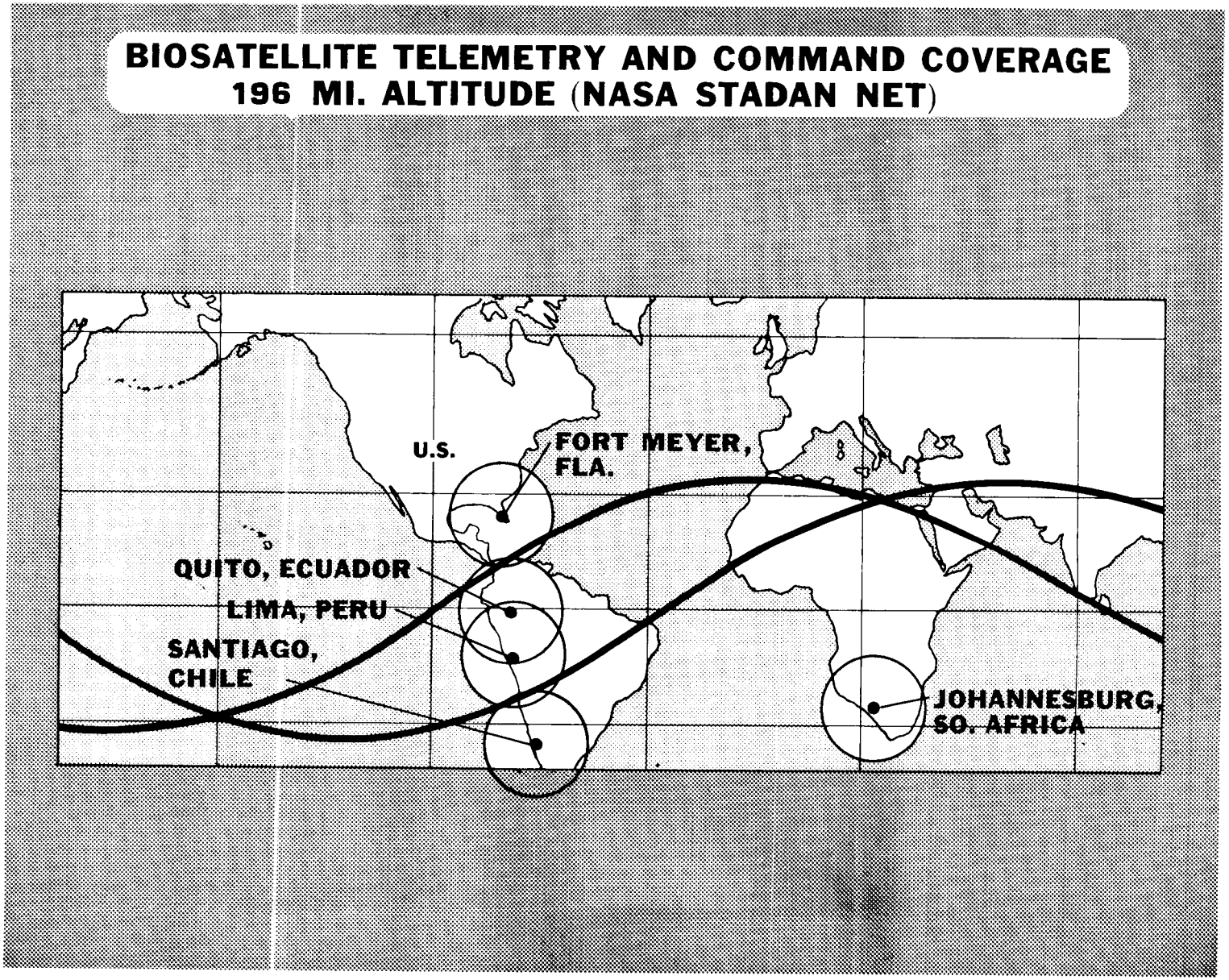
On each orbit, one STADAN station will send commands and receive tracking and performance data.

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

On passes over Fort Meyers, data will be returned to Biosatellite Control via high speed (1,792 bits-per-second) data link instead of being recorded at the station for later transmission.

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

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



-more-

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
AMES RESEARCH CENTER, MOFFETT FIELD, CALIFORNIA

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 organizations and other government 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.

Recovery operations are as follows: The Goddard Center will compute recovery areas. The Biosatellite mission director at Goddard will order time and place of recovery from 4.5 to 7.5 hours in advance. Planned orbits put all recovery areas in the region of the Hawaiian Islands.

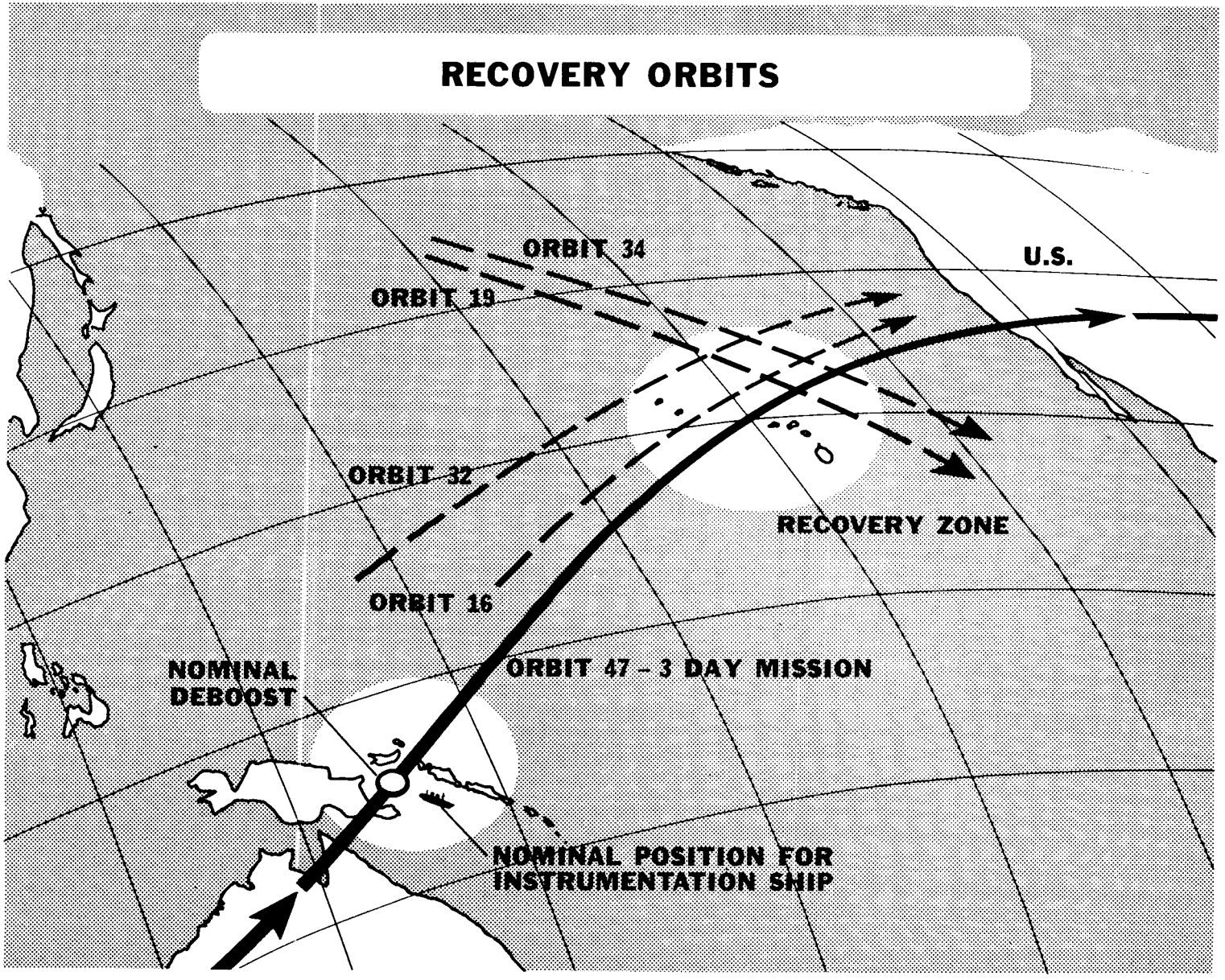
Aerial recovery will be by an aircraft of the designated USAF recovery agency. If aerial recovery does not take place, search aircraft will locate the Capsule by its radio beacon, light, and dye marker.

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



-more-

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
AMES RESEARCH CENTER, MOFFETT FIELD, CALIFORNIA

Facilities include: fixed-wing aircraft; two recovery ships with helicopters; one aircraft based at Samoa; balloon kits for direct sea-pickup; voice and teletype links between all ships, aircraft, bases and control centers.

FLIGHT SEQUENCE

These are the planned events in the Delta-Biosatellite A 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 amoeba is fixed and others are fed. The first pair of frog eggs is fixed.

At 96 minutes, the Fort Meyers 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 Meyers 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

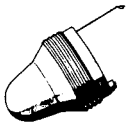
One and a half orbits before separation, ground command arms the separation sequence.

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.

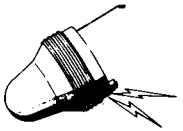
At 15 seconds before separation, the programmer turns on the recovery beacon, and at four seconds, it orders electrical disconnect of Adapter Section and Experiments Capsule. At three seconds, it activates capsule batteries.

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

BIOSATELLITE RECOVERY SEQUENCE

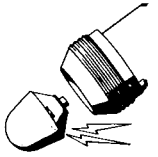


T_{PD} – 24.97m
T_S – 400s
1. ACTIVATE RECORDER
2. RECOVERY TLM ON
3. RESET RECOVERY PROGRAMMER RELAYS



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

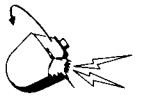
T_{PD} – 18.38m
T_S – 4.7s
FEEDLINE DISCONNECT



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

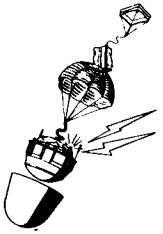
T_{PD} – 18.25m
T_S + 3.30s
1. RETRO ROCKET IGNITION

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

-27A-

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, retrofire slows the capsule by 420 mph.

At 14 seconds, despin occurs, and at 16 seconds, the burned-out retrofire 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; light and radio beacon continue to operate. Ten minutes later, recovery telemetry stops. Life support batteries operate for six hours. Radio and light function for 12 hours after sea-landing.

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, Calif.

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 Experiments and Life Support Manager
Dr. Lester W. Wolterink, Biosatellite Project Scientist
John W. Dyer, Biosatellite Assistant Operations 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 of the Missile and Space Division.
Mark Morton, General Manager, Reentry Systems Department
Nicolas J. Dragann, Biosatellite Program Manager
V. C. Deliberato, Systems Integration Program Manager
John T. Glancey, Biosatellite Spacecraft Program Manager
Milton Ostrander, Flight Operations Program Manager

Biosatellite Experimenters

General Biology Experiments

Amoeba

Principal Investigator: Dr. Richard W. Price
Colorado State University
Fort Collins, Colorado

Co-Investigator: Dr. Donald E. Ekberg
General Electric Company
Philadelphia, Pennsylvania

Frog Eggs

Principal Investigator: Dr. Richard S. Young
Exobiology Division
NASA Ames Research Center
Moffett Field, California

Wheat Seedlings (three experiments)

Principal Investigator: Dr. Charles J. Lyon
Dartmouth College
Hanover, New Hampshire

Principal Investigator: Dr. Stephen W. Gray
Emory University
Atlanta, Georgia

Co-Investigator: Dr. Betty F. Edwards
Emory University
Atlanta, Georgia

Principal Investigator: Dr. Herbert M. Conrad
North American Aviation
Downey, California

Co-Investigator: Dr. Samuel P. Johnson
North American Aviation
Downey, California

Pepper Plant

Principal Investigator: Dr. Samuel P. Johnson

-more-

Radiation Experiments

Tradescantia (Blue Wildflower)

Principal Investigator: Dr. Arnold H. Sparrow
Brookhaven National Lab.
Upton, L.I., New York

Co-Investigator: Mr. L. A. Schairer
Brookhaven National Lab.
Upton, L.I., New York

Neurospora (Orange Bread Mold)

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

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

Habrobracon (Parasitic Wasp)

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

Tribolium (Flour Beetle)

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

Adult Drosophila (Fruit Fly)

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

Co-Investigator: Dr. Luolin Browning
Rice University
Houston, Texas

Drosophila Larvae (Fruit Fly)

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

Lysogenic (Rupturing) Bacteria

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

Biosatellite A Industrial Team

Biosatellite A Contractors and Sub-Contractors

Prime Contractor:

General Electric Company
Reentry Systems Department
Philadelphia, Pennsylvania

Major Sub-Contractors & Vendors

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

CTS Corporation
Ridgefield, Connecticut

Eagle Picher Industries, Inc.
Joplin, Missouri

Fairchild Camera and Instrument Corp.
Fairchild Controls Division
Bayshore L.I., New York

Midwestern Instruments, Inc.
Tulsa, Oklahoma

Schoenstedt Instrument Company
Silver Spring, Maryland

Systron-Donner Corporation
Concord, California

Electro Mechanical Research, Inc.
Sarasota, Florida

Stellar Metrics Inc.
Santa Barbara, California

United Aircraft Corp.
Hamilton Standard Division
Windsor Locks, Connecticut

Data Control Systems, Inc.
Danbury, Connecticut

Avco Corporation
Electronics and Ordnance Division
Wilmington, Massachusetts

General Devices, Inc.
Princeton, New Jersey

Columbia Research Laboratories, Inc.
Woodlyn, Pennsylvania

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

Sterer Engineering and Manufacturing Co.
Los Angeles, California

Barnes Engineering Co.
Stamford, Connecticut

Thiokol Chemical Corp.
Elkton, Maryland

Experiment Flight Hardware

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

General Electric Company
Reentry Systems Department
Philadelphia, Pennsylvania

Recovery Operations Hardware

Irving Air Chute Co., Inc.
Lexington, Kentucky

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

Launch Vehicle Contractor

Douglas Aircraft Company
Santa Monica, California

-End-