NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

WASHINGTON 25, D. C.

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No. 1
8/7/59

LAUNCHING VEHICLE

Consisting of three stages, the Thor-Able III rocket stands 90 feet high and weighs more than 105,000 pounds.

This is the first time a Thor-Able has been used to boost a satellite into an earth orbit. The upper stages are similar to but substantiallly modified from Vanguard upper staging.

Earlier versions of the vehicle were used in three space probes last year. The first of them blew up after 77 seconds because of malfunction in the Thor first stage (August 17, 1958). The second, labeled Pioneer I, rose to 70,700 miles and returned valuable data (Oct. 11, 1958). The third, Pioneer II, fell back after reaching 970 miles altitude when the third stage failed to ignite (November 8, 1958).

The first two stages of Thor-Able also have been used in a number of 5500-mile nose cone re-entry test flights.

Here is a breakdown of the stages and their functions:

First Stage:

Air Force Thor, intermediate range ballistic missile, minus guidance and modified to receive additional stages.

Weight -- Over 100,000 lbs.

Thrust -- Approximately 150,000 lbs.

The liquid-fueled Thor propels the vehicle for about 160 seconds after launch. During this period of time, the rocket is controlled by roll and pitch programmers.

Upon separation, the Thor re-enters the atmosphere and disintegrates.

Second Stage:

Powered by a liquid-fueled engine, the second stage was adapted and modified from earlier Thor-Able rocket vehicles. Eight small spin rockets are ringed around the outer skin of the stage. The second stage fires immediately after first stage separation.

Weight -- Over 4,000 lbs.

Thrust -- Approximately 7, 500 lbs.

Stage two propels the vehicle for about 100 seconds. At second-stage burnout, a plastic nose fairing covering the third stage satellite is jettisoned and falls away. Also at second stage burnout, eight spin rockets ignite causing the second and third stages and the payload to rotate at the rate of 168 revolutions per minute. The spin stabilizes trajectory of the third stage and payload, now on course. About a second and a half after the spin rockets fire, second-stage separation occurs. The second stage then falls and burns up on entering the earth's atmosphere.

Third Stage:

A solid-propellant rocket, the third stage was adapted from the Able I rocket vehicle. It propels the payload to orbital velocity, about 22,000 miles and hour and injects it in orbit.

Weight -- Over 500 lbs.

Thrust -- Approximately 3,000 lbs.

The third stage, which burns for about 40 seconds, coasts into orbit still attached to the payload. Separation occurs about 20 seconds after third-stage burnout when a set of springs forces the third stage and payload apart. Burned out, the empty third-stage casing weighs about 50 pounds.

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EXPERIMENTS

The 15 major experiments in this 142-pound satellite, together with its advanced electronics, make it the most comprehensive scientific package the United States has attempted to put in an earth orbit.

The orbit alone -- programmed for 23,000 statute miles at apogee (farthest from earth) and 160 statute miles at perigee (closet to earth) -- indicates the complexity of the satellite's mission: To provide an extremely broad sampling of space information.

Such an elongated orbited is a product of launch angle plus speed, about 22,000 miles an hour or 4,000 miles an hour faster than needed for a nominal earth orbit. Each orbit should take about 12 hours.

Boosting the satellite into its highly elliptical flight path is a three-stage Thor-Able III rocket. Fueled and ready to go, the launching vehicle weighs more than 105,000 pounds and stands 90 feet high.

The body of the satellite is spheroid-shaped with a slightly flattened bottom. It is 26 inches in diameter, 29 inches deep and its aluminum skin is 1/16 of an inch thick. From its waist jut four paddles of power-generating solar cells. Hence the satellite's nickname, "Paddlewheel."

Most of the experiments ride bolted to a plastic and metal floor within the satellite. They break down into six main categories:

1 -- Three devices to map the radiation belt ringing the earth with each of the instruments concentrating on a specific radiation energy level.

2 -- A 2½-pound scanning device -- something like a TV camera -- which is designed to relay a crude picture of the earth's cloud cover. Success of the camera experiment hinges not only on the operation of the instrument but on the motion and flight attitude of the satellite.

3 -- Solar cells, 8,000 in all or 1,000 on each side of the four paddles, to create voltage to recharge the satellite's chemical batteries in flight. The electronic gear in the satellite includes three transmitters and two receivers.

4 -- A micrometeorite detector built to guage the size and speed of meteoric particles hitting the satellite.

5 -- Two types of magnetometers to map the earth's magnetic field.

6 -- Four experiments to study the behavior of radio waves, all aimed at finding out more about deep space communications.

Depending on the satellite's success, similar instrumentation likely will be used in several deep space probes in the months ahead.

Work on the program began last November under a NASA contract to the Air Force Ballistic Missile Division (ARDC). In turn BMD subcontracted to the Space Technology Laboratories, Inc., of Los Angeles with STL providing overall systems engineering and technical direction over the payload, Thor-Able III launching vehicle and the tracking and communications network. Many of the experiments were devised by STL scientists.

To nonscientific eyes, the most striking feature of the satellite is the solar paddle system. These vanes, designed by STL, extend nearly three feet from the payload's aluminum skin.

They are made of pie-shaped sections of honeycomb plastic. Coverning the honeycomb are tiny silicon-based solar cells lined up in series to generate voltage. A glass filter shields each cell from harmful ultra violet rays while letting in the proper light. The cell causes a conversion of light energy into electrical energy.

During launch, the paddles which are mounted on pivotal aluminum arms with springs at the point where they join the satellite, ride folded downward birdlike under the payload. They spring up and lock in place just before third-stage ignition after a plastic jacket coverning payload and third stage is jettisoned.

In flight, the paddles are slightly cooked so they are exposed to maximum sunlight. Each paddle surface measures about 20 by 20 inches.

The solar cell system is designed to operate throughout the satellite's lifetime -- as long as a year. Solar cells were first sed successfully as a satellite power source in Vanguard I, launched March 17, 1958. A year and a half later now, the cells are still powering the transmitter sending Vanguard I's tracking signals.

One of the heaviest components of the satellite, the complete power supply system, including batteries, weights 30 pounds.

The three transmitters aboard duplicate each other in sending information on nearly every experiment, providing three-way back-up insurance. Two of the transmitters, operating at 108.06 megacycles and 108.09 megacycles, send analogue information.

This is a continuous wavering signal which is recorded on tapes and later graphed and analyzed.

A third transmitter, broadcasting at an undisclosed but ultra high frequency is the primary transmitter. It sends digital data or coded impulses which allow fairly rapid data translation.

In addition, there are two receivers. A low-frequency receiver will be used exclusively in one of the radio wave propagation experiments. A second high-frequency receiver can command 30 different functions in the satellite, including turning off and on the primary transmitter.

The main transmitter will be used only an hour and a half out of every six hours because it requires more power (40 watts) than the solar cells and batteries can supply. So on a command from the ground, the primary transmitter will be cut off while the solar cells recharge the batteries. The other experiments, including the other wo transmitters, need very little power -- less than a watt in most instances -- so they will continue to run as directed.

While the primary transmitter is off, memory units similar to those in high-speed computers will store instrument readings. This information will be transmitted in a matter of seconds when the main transmitter is turned on again.

Kick Rocket

A small solid-propellant rocket called a "kick" rocket forms the spine of the satellite. If needed, this 5-pound rocket will be fired to lift the perigee. If it appears the satellite will come too close to the earth on an early orbit -- under 100 miles -- the rocket would be triggered which should add 50 to 100 miles to the perigee pass.

Camera

Peeping out one side of the payload is a small open lens facsimile unit consiting of two parts: a tube containing a mirror which receives and focuses light and dark impressions, and an electronic counter which computes and records the impressions before they are converted into radio signals. This is another STL experiment.

In orbit, the payload is designed to spin about two revolutions a second to give it stability. Once per revolution the facsimile unit records what it sees. The signals it transmits will be educed to dots. A row of 128 dots will form a line and eventually the lines should form a picture. At best, the picture, in TV parlance, will be "snowy." Even under optimum conditions, it may take weeks to produce a picture.

If the satellite develops a wobbling or tumbling motion, the camera data will be useless. But such motions will not effect most of the other experiments.

Radio Wave Experiments

From 50 to perhaps 2,000 miles above the earth is an area containing free electrons and ionized particles. It is called the ionoshpere. It reflects low frequency radio signals from earth by literally bouncing most of them back. It plays a vital role in all radio transmission.

Signals of high frequency penetrate the ionosphere more easily but not without some detours and distortion. To improve deep space communications spanning millions of miles, scientists need to know more about the behavior of radio waves at various frequencies.

In this area are two experiments by STL, one by the National Bureau of Standards Laboratory at Boulder, Colo., and another by Stanford University at Palo Alto, Calif. The Stanford experiment calls for a very low frequency signal from a Navy transmitter in Annapolis, Md., to the satellite where it will be rebroadcast to tracking stations.

Magnetometers

Closely related to the radio propagation experiments are two devices designed to map the magnetic field blanketing the earth from pole to pole.

Electrical "storms" occur withing this field which, in theory, extends thousands of miles beyond the ionosphere. But what are the boundaries of the magnetic field? What causes those storms? How do they effect our compasses and other magnetic tools on earth? What effect does this field have on communications?

Two magnetometers constantly gauging the field's electrical strength -- one perpendicular and the other horizontal to the satellite's spin axis -- may provide answers to at least some of these questions. Both magnetometers were designed by STL. Together they weigh a little over three pounds.

Radiation Counters

Radiation counters provided by the University of Chicago, the University of Minnesota and STL are to measure three energy levels in the Great Radiation Belt.

The counters will measure the kinetic energy or the velocity and mass of infinitestimal particles ranging from alpha through X-rays. This energy factor is rated in terms of millions of electron volts (MEV).

The four-pound University of Chicago experiment will guage the radiation bombardment of high-energy particles. Instrumentation consists of six gas-filled cylinders ranged around a seventh cylinder. The total bundle, plus a lead shielding, measures about two inches square. The inbound particles will ionize the gas creating an electrical impulse as they penetrate one or more cylinders, depending on their potency.

The medium-energy University of Minnesota experiment is a combination of two instruments, a gas-filled ion chamber to provide the energy information and a Geiger-Mueller tube to count the number of particles passing through. It weighs two pounds and rides in a four-inch square box.

The STL unit, weighing three pounds, will probe the low-energy part of the spectrum. Here the particles will pass through a crystal which will create a small burst of light. In turn the intensity of the light will be transformed in a signal. Because of the light-twinkling effect, this eight by two-and-a-half-inch cylindrical device is called a Scintillometer.

The radiation instruments are designed to compliment each other. In view of the satellite orbit, the three devices should permit a fairly complete mapping of the extent and intensity of the radiation belt which poses the single biggest hazard to manned interplanetary flight.

Micrometeorite Detector

Two shiny curved plates of metal between the arms of the solar paddles on opposite sides of the satellite should tell scientists more about the density and patterns of micrometeorites.

Behind each plate is a microphone. When a micrometeorite hits a plate, the microphone senses the collision and transmits it as a voltage.

The experiment, designed by the Air Force Cambridge Research Center, weighs less than a pound.

Tracking

A host of United States tracking outposts will take part in tracking this satellite but the principal command and data reception points will be:

Jordrell Bank, a 250-foot tracking dish in Manchester, England, 60-foot dishes in Kalae, Hawaii and Millstone Hill, N. H., and smaller dishes plus other types of antennas at Singapore, Malaya, and Cape Canaveral, Florida.

All of these points are tied together on a teletype circuit, the control point of which is STL's Space Navigation Center in Los Angeles. Into STL will be channeled early trajectory readings. After analyzing these, STL will be able to advise the various stations around the world as to when and where they should point their antennas to pick up the satellite.

The telemetered experimental information will be partially reduced at the tracking sites before moving to STL for further interpretation.

Guidance in the booster vehicle is by programmed autopilot. Precise tracking information will be furnished by lightweight transponders in the second stage as well as the payload. Transponders receive a tracking signal from the ground and in effect bounce it right back by re-broadcasting it. The change in pitch of the signal re-broadcast tells with high accuracy where the payload is and where it is headed.

Other Devices

In addition to the experiments detailed, there are a number of devices in the payload which will be checking on the performance of both the vehicle and the satellite instrumentation.

Among them is an angualr accelerometer which will monitor the "tipoff" angle -- the shift caused by the stages as they drop off. It will also tell if the satellite develops a tumbling or a wobbling motion.

Other devices will relay information on the satellite's temperature, internal and external.

A voltage guage will be measuring the output of the solar cells. If needed, a switch can be commanded which will change the battery charging rate.

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CONTRACTORS

More than 50 scientific and industrial firms under the technical direction of Space Technology Laboratories, Inc., Los Angeles, participated in the development of this satellite program.

Principal contractors and subcontractors are: Atlantic Research Corporation, Alexandria, Va.; Engineered Magnetics, Hawthorne, Calif.; Gilfillan Bros., Los Angeles, Calif.; Hallamore Electronics Co., Anaheim, Calif.; Hoffman Electronics Inc., Evanston, Ill.; Motorola, Inc., Phoenix, Ariz.; Radiation, Inc., Melbourne, Fla.; Rantec, Inc., Calabasa, Calif.; Space Electronics Corp., Glendale, Calif.; Stanford University at Palo Alto, Calif.; the University of Chicago, at Chicago, and the University of Minnesota at Minneapolis.

Here is a breakdown of major contractor responsibility:

<u>First Stage</u> (Air Force Thor IRBM)

1. Propulsion systems -- Rocketdyne, Division of North American Aviation.
2. Airframe, control, electrical, and instrumentation systems -- Douglas Aircraft Company.
3. Assembly, integration, checkout, and launch -- Douglas Aircraft.

<u>Second Stage</u>

1. Propulsion system and tanks -- Aerojet-General Corp. a division of General Tire and Rubber Co.

2. Control, electrical, instrumentation, engine shutoff, and spin rocket systems -- STL.

3. Assembly, integration, and checkout -- STL.

Third Stage

1. Rocket motor -- Allegany Ballistics Laboratory of Hercules Powder Co.

2. Structure and electrical -- STL.

3. Assembly, integration, and checkout -- STL.

Payload -- STL.

Launch Operations

1. Pad, test, checkout -- Douglas Aircraft

2. Launch crew -- Aerojet-General
   Douglas Aircraft
   Rocketdyne
   STL

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8/7/59

PROJECT OFFICIALS

Principal NASA officials involved in this program are Dr. Abe Silverstein, director of Space Flight Development, and Dr. John Lindsay, head of the solar physics program of the Space Sciences Division.

Key BMD-STL personnel in the program are Major General O. J. Ritland, commander of the Air Force Ballistic Missile Division; Dr. Ruben F. Mettler, STL executive vice president and senior project advisor; Colonel Richard D. Curtin, AFBMD deputy commander for Military Space Systems; Dr. George E. Mueller, STL vice president, associate director of the Research and Development Division, and senior project advisor; Lt. Colonel Donald R. Latham, AFBMD director of Space Probe Projects; Dr. Adolph K. Thiel, STL director of advanced Experimental Space Missions and project director; and Major John E. Richards, AFBMD chief of the Astro-Vehicles Division within the Space Probes Directorate.

General Ritland, who was recently promoted to two-star rank and who assumed command of AFBMD in April of this year, attended San Diego State College for three years before beginning his Air Force career as an aviation cadet in 1932. Since 1939, when he was assigned to Wright Field in Dayton, Ohio, as a test pilot, General

Ritland has been in the test and development field with the exception of a war-time overseas tour. From 1956 until April of this year, General Ritland served as the Vice Commander of AFBMD to Lt. General Bernard A. Schriever, now the Commander of the Air Research and Development Command.

Dr. Silverstein joined the National Advisory Committee for Aeronautics, NASA's forerunner, in 1929 after receiving his B. S. in mechanical engineering from Rose Polytechnic Institute, Terre Haute, Ind. From the same school he received a mechanical engineering professional degree in 1934. In 1958, he was awarded an honorary doctorate by Case Institute of Technology of Cleveland, O. Before moving to his present job at NASA headquarters in Washington, D. C., he served as associate director of NACA's Lewis Flight Propulsion Laboratory in Cleveland.

Dr. Lindsay transferred to NASA in November, 1958, from the Naval Research Laboratory in Washington. He received his bachelor's degree in physics from Guilford College, N. C., and his master's and PhD in physics from the University of North Carolina.

Dr. Mettler received his B.S., M.S. and PhD. degrees in electrical and aeronautical engineering from the California Institute of Technology. He presently serves on a special committee of the Air Force Scientific Advisory Board and has served as a special consultant to the Assistant Secretary of Defense.

Colonel Curtin, a 1939 graduate of West Point and holder of a M.S. degree from the University of Michigan (1950), has been at AFBMD since February 1958. He has served as the Chief of Staff for the 17th Air Force in North Africa and Turkey; Director of War Plans at Headquarters, USAF; and Executive Officer, Weapon Systems, at Headquarters, Air Research and Development Command.

A member of the German missile team that developed the V-2 rocket, Dr. Thiel received his M.S. and PhD. degrees from the Institute of Technology at Darmstadt, Germany. He has served as principal advisor to the Army Ordnance Corps on technical matters of missile systems planning development and is a former member of the Army Ordnance Guided Missile Advisory and Evaluation Committee.

Dr. Mueller, Able III Senior Project Advisor, received his B.S. degree at the Missouri School of Mines, an M.S. degree in electrical engineering from Purdue University and his PhD. in physics from Ohio University. For more than ten years he taught at Ohio State as a professor of electrical engineering and has patents in the fields of electron tubes and antennae.

Lt. Colonel Latham entered the service in 1941 and won his pilot's wings in 1942. He left active duty in 1945 to return to college, gaining a B. S. in aeronautical engineering from the University of Michigan in 1948. Later that year, he rejoined the Air Force and served in several engineering capacities until his assignment to AFBMD in February 1955. In December 1957, he was directed by General Schriever, then Commander of AFBMD, to organize Project Able.

Major Richards, a 1945 graduate of West Point, also holds a M. S. degree in aeronautical engineering from M.I.T. After graduating from M.I.T. in 1951, Major Richards served at Holloman AFB, New Mexico, as a project officer on various drone missile projects for four and a half years. In 1955, he was transferred to AFBMD, where he has served in several offices.