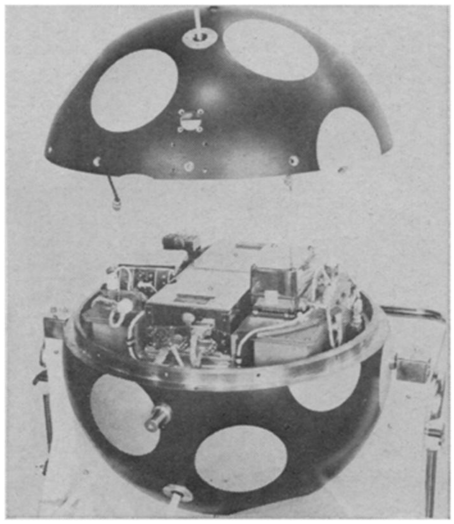
Hope for deep-dipping satellites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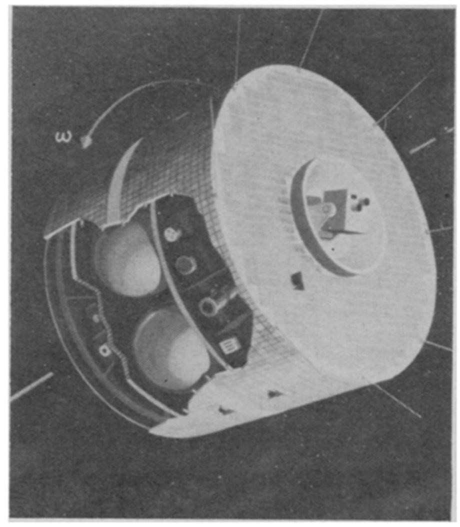
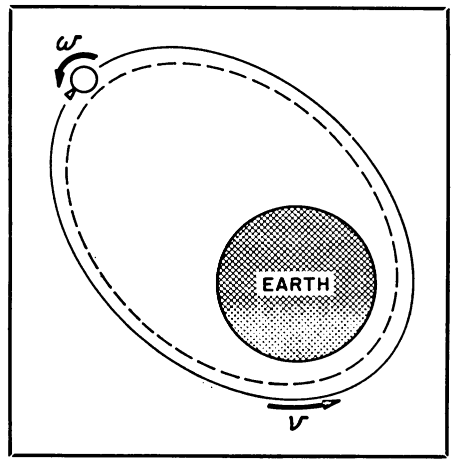

NASA

Scientists seeking to study the atmosphere by satellite at ever-decreasing heights are turning to sheer mass and a corrective rocket motor

by Jonathan Eberhart



NASA

Cannon Ball (above) bulls its way through, while Explorer (top right) uses rockets and high apogee (right) for long life.

Researchers investigating earth's atmosphere with satellites have no difficulty probing heights above about 100 miles. Reaching lower than that, however, has always meant a forced choice between longevity and minimum altitude. There, the greater drag of the atmosphere slows the probe down, in turn letting it descend still lower until speed and air density burn it up.

Of the approximately 70 unmanned satellites that have been placed in orbits with perigees of less than 100 miles, all but a few have lasted less than a month and many under a week.

Almost 80 percent of the total were research or reconnaissance satellites launched by the U.S. Air Force. The rest came from the Soviet Union, most of them tests of the Fractional Orbital Bombardment System that could afford the low perigee since they were not designed to complete more than a part of one revolution. The few remaining deep-dipping Soviet objects were apparently brought low by malfunctions.

Besides making possible reconnaissance photos having better resolution than those taken from higher altitudes, low-perigee satellites offer the chance to study the atmosphere under repeatable conditions over comparatively long periods of time, a difficult or impossible feat with balloons, sounding rockets and aircraft. The advantage has remained limited, however, with orbital lifetimes of only a few days or weeks.

In hopes of getting the most out of the technique, both the Air Force and the National Aeronautics and Space Administration are working on satellites that can swing both low and long.

The Air Force project is known as Cannon Ball 2, successor to a probe that spent 39 days during the summer of 1968 in an orbit that began with a perigee of 92 miles, finally decaying to less than 78 miles before burning up. Cannon Ball 1, which was only 23 inches across but weighed some 600 pounds, thanks to a thick brass casing, survived as long as it did by sheer mass. With its relatively small frontal area to minimize drag, the satellite—probably the densest ever launched—was able to bull its way through the atmosphere, measuring the drag with a three-axis accelerometer and transmitting the data to earth. Knowledge of atmospheric densities at these attitudes is the Air Force's chief interest in such satellites, for greater accuracy in predicting ballistic missile trajectories, satellite orbits and splashdowns.

Cannon Ball 2, says its designer, Dr. Kenneth S. W. Champion of the Air Force Cambridge Research Laboratories, will have only slightly greater density than its predecessor. Its orbit, however, will extend much farther from the earth at its apogee than did that of Cannon Ball 1—about 1,100 miles instead of 350. This will mean that the satellite will spend shorter periods of time down in the denser reaches of the atmosphere that surround its 87-mile perigee. The launch, targeted for March, 1971, should, says Dr. Champion, produce an orbital lifetime of at least six months.

NASA is taking a different approach. Design studies have just begun on a pair of satellites that will spend a full year in a low-perigee orbit, but without the aid of high density to bull them through the thicker air. Instead, Atmosphere Explorers C and D will carry small rocket motors to make periodic adjustments in both apogee and perigee.

Besides providing corrective nudges when the orbit begins to droop, the rockets will allow the orbit to be modified for scientific purposes. The present plan is for each satellite to be launched into an orbit with a high point of about 2,500 miles and a perigee of 93 miles; every 10 or 15 days, the motor will be used to bring the perigee down to 75 miles for about a day—11 or 12 orbits' worth—and

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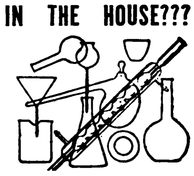

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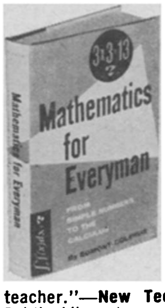

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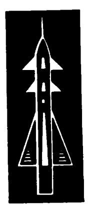

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. . . satellites

then kick it back up again. Without the motor, estimates project manager David Grimes at Goddard Space Flight Center, the 2,500-by-93-mile orbit would last scarcely two months.

The specific scientific instruments that will be included on the satellites have not yet been chosen—the first of the pair will not be launched until 1973—but they will be far more extensive than just an accelerometer. Plans call for experiments to measure the atmosphere's neutral particle and ion composition, thermal electrons, photoelectrons, airglow and other properties.

One possible problem that concerns program officials is the effect of the satellite's orbit-adjusting rocket motor on the instruments. The Air Force's Dr. Champion points out that the ionized exhaust of a rocket in such close proximity could, for example, upset readings from a mass spectrometer for days.

Frank Gaetano of the space agency's Physics and Astronomy Programs Office agrees that the effects of the motor cannot be ignored; they will be part of the next phase of work on the two Atmosphere Explorers. But it will probably be impossible to tell for certain, in advance, whether insulating, isolating or ignoring the motor is the answer. "In that sense," Gaetano says, "the first satellite will truly be an Explorer for the second."

There is some indication that the effects may not be too severe. In 1967, a satellite called IMP-E was placed in lunar orbit to study conditions in the moon's vicinity. It carried an experiment, says Gaetano, specifically intended to see whether the probe's retro-rocket motor was contaminating other areas of the vehicle. The result was favorable, although the experiment measured only degradation due to surface deposits, not always a sensitive enough index for scientific instruments.

If the rocket motor does turn out to be a serious problem, there remains Dr. Champion's Cannon Ball approach. He believes that, with enough density and a sufficiently elongated orbit, a full year's lifetime could be obtained even without periodic nudging. For elaborate scientific instrumentation, however, a spherical satellite such as the Cannon Ball would probably require a sophisticated stabilization system to keep the experiments properly aligned. The NASA low-perigee Explorers, on the other hand, are cylindrical, which enables them to be stabilized simply by spinning them on one axis, while the instruments are held steady by mounting them on a platform spinning in the opposite direction. □