Space Science in the Year of the Shuttle

A number of missions are still going forward despite drastic cutbacks, but the future is clouded

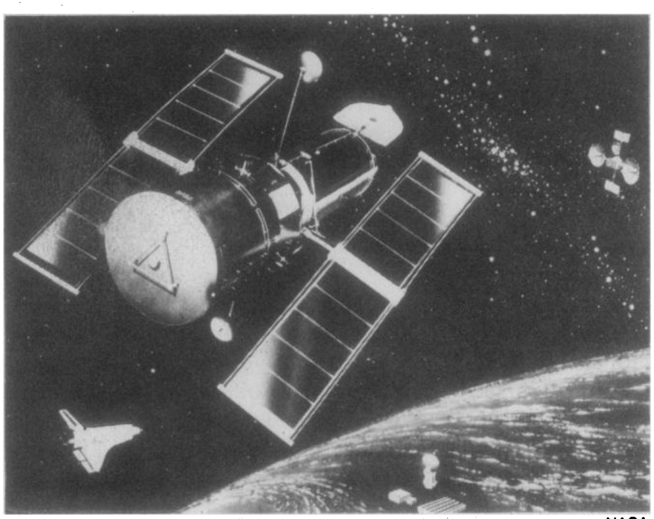
Reports of the death of NASA's space science program have been exaggerated—but perhaps not by much.

On a launchpad at the Kennedy Space Flight Center in Florida the space shuttle Columbia at last stands poised for its maiden flight. And given the years of delays, cost overruns, and technical problems that have preceded this moment, NASA is sparing no expense to make sure that this first flight goes well. Indeed, the reusable space shuttle is so essential to the agency's future that NASA officials recently found it prudent to boost this year's budget for flight testing by some $60 million—at the same time the Reagan Administration's budget slashers were telling them to cut the agency's budget overall. Thus, much of that money had to come out of such chronically hard-pressed programs as planetary science, astronomy, and solar physics, the very things that will provide a major fraction of the space shuttle's missions once it becomes operational.

Despite the anguish this decision has caused among scientists, however—and, for that matter, among the agency officials who made the cuts—headquarters is putting a brave face on things. "The cuts are serious but not devastating," says Anthony J. Calio, acting deputy administrator of NASA. "Clear across the agency, we've tried to maintain our long-range technology development, which gives us a base for future missions."

Andrew J. Stofan, acting associate administrator for space science, agrees: "In this office we've taken cuts in everything but the Explorer satellite program. But we've kept the basic core of the research teams intact. In a year or two, after the shuttle has flown successfully, I expect we'll see a resurgence of interest in funding space science. And if the Administration comes to us then and asks for new missions, we'll be able to respond."

Stofan explains that NASA's science and applications satellites—orbiting x-ray observatories, for example—typically go through four phases of evolution: instrument design in the laboratory; suborbital testing of hardware aboard balloons and sounding rockets; small Explorer-class satellites (UHURU in the early 1970's); major satellites (the High Energy Astronomical Observatory series in the late 1970's); and perhaps, eventually, even more advanced missions (the Advanced X-ray Astronomical Facility, hoped for in the late 1980's). The program outlined in the Reagan Administration's revised budget, which includes projections of spending through 1985, has its most dramatic impact on the later phases, the major missions—all of which, by the way, rely on the shuttle as a launch vehicle.



NASA

Space Telescope

Artist's concept includes the shuttle and a relay satellite.

Looking just at the missions handled by the Office of Space Sciences, there are two, the Space Telescope and the Galileo orbiter/probe mission to Jupiter, which are still proceeding on schedule; two more, the Gamma Ray Observatory (GRO) and the Venus Orbiting Imaging Radar (VOIR), have been deferred to later launch dates but are still undergoing development. ("That word 'deferred' was very important to us," says Calio.)

On the minus side, however, NASA has for the first time killed a major ongoing project, the U.S. half of the International Solar Polar Mission (it was to be a two-spacecraft mission; the European Space Agency is funding the other half). An option to send a Voyager-like spacecraft to fly by Halley's comet in 1986 could not even be considered, although this was the last year in which work could begin on the mission and still have the spacecraft ready for launch in time. And NASA had to drop the Carter Administration's valedictory proposal for a new start on the Solar Electric Propulsion System (SEPS), considered by most observers to be a key to any future exploration of the outer planets, comets, and asteroids.

"Let's look at what we still have in the current budget," says astronomer David Morrison, who is on leave from the University of Hawaii to act as Stofan's deputy. "If we were to draw a chart of the major space science missions, we'd see that things start happening in 1985 and climb from there." That is the year in which Voyager 2, headed for a flyby of Saturn this summer, is due to arrive at Uranus. It is also the year in which the Galileo spacecraft will be carried into orbit aboard the space shuttle and launched toward Jupiter with a modified Centaur booster.

Arriving in 1987, Galileo will drop a probe to sample the Jovian atmosphere, which is thought to approximate the abundance of elements in the primordial solar nebula. The Galileo orbiter, meanwhile, will be equipped with an array of advanced instrumentation that includes a solid-state camera with a much higher resolution than Voyager's, and a Landsat-like multispectral scanner for compositional mapping of the large Galilean satellites. The orbiter will remain on station for 20 months, until 1989.

"The two Voyager encounters gave us a much greater scientific rationale for going back to Jupiter," says Morrison. "Now that we know some of the extraordinary things about the Jovian system—the volcanoes of Io, for example—we

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need to investigate them with new instruments."

"Initially, Galileo was funded (in 1977) because it was the planetary mission at the top of the queue, the highest scientific priority," he adds. "But now it's assumed an even greater symbolic importance in planetary science because it's almost all we have."

The year 1985 will also see the launch of the Space Telescope. With a mirror diameter of only 2.4 meters, this instrument will never surpass ground-based "light buckets," such as the 5-meter Hale telescope on Mount Palomar, when it comes to taking spectra of very faint objects. But the Space Telescope will be free of atmospheric turbulence, as well as the background glow of the night sky. It will have a resolution of 0.1 arc second, ten times better than anything on the ground. It will resolve the disks of some of the nearby stars. It will image the cloud patterns of Jupiter almost as well as Voyager could at its closest approach. It will be able to discern whether distant quasars are really just the exploding cores of otherwise normal galaxies. It will remain one of the premier scientific instruments of the world at least until the year 2000.

Launch of the Gamma Ray Observatory has been deferred until 1987 or 1988, says Morrison. Its various instruments will cover more than five decades in frequency. Some will be able to do spectroscopy more sensitive than ever before; others will have more resolution. "GRO is a multi-instrument survey in what is still largely an unknown spectral region," he says.

The VOIR, which has now been slipped to a 1988 launch, will spend a year mapping the surface of Venus with aperture synthesis radar. Since Venus is virtually the earth's twin in size, density, and composition—everything, in fact, except rotation speed and surface temperature—a detailed study of its surface geology and tectonic history should provide unique insight into the geophysics of the earth.

Meanwhile, says Morrison, one should not forget that a number of nontrivial missions are also going forward under the Explorer program. Plans now call for Explorer-class satellites to be launched (with expendable boosters) at the rate of one or two per year at least through the mid-1980's. In 1982, for example, the Infrared Astronomical Satellite will begin the first survey of the sky at infrared wavelengths, thus filling in the last major gap between the x-ray and radio regions. A few years later, the Cosmic Background Explorer will begin

Red Star in Orbit

On 12 March 1981, the Soviet Union celebrated (a month early) the 20th anniversary of Yuri Gagarin's triumphal first orbit of the globe: cosmonauts Vladamir Kovalenok and Viktor Savinykh rode their Soyuz T-4 spacecraft into orbit, docked it at the Salyut 6 space station, entered the station, and settled in for several months in space.

Underwhelming? That's the point. The first Salyut space station was launched a decade ago. Salyut 6 itself has been up since 1977. Indeed, Soviet cosmonauts have compiled some 40,000 hours of spaceflight since 1961, compared to 22,500 hours compiled by American astronauts. So routine have their manned flights become that most newspapers in the West run the news as filler on an inside page.

It is the media-drenched U.S. space shuttle that is getting all the attention these days. But the Soviet space program, shrouded though it may be by the Russian habit of secrecy, is considerably the larger of the two. Moreover, the Soviet effort in space has been very steady, whereas the U.S. program has had its ups and downs.

"[Both programs are] large and comprehensive, competing across a broad spectrum of military applications, civil applications, orbital science, and deep space exploration," writes Charles S. Sheldon of the Congressional Research Service in his report "United States and Soviet progress in space: Summary data through 1979 and a forward look." On the other hand, he says, determining who is "ahead" involves complex, qualitative judgments.

Despite a much heavier commitment of payloads to planetary missions, for example, the Soviet record in deep space cannot compare with that of the United States. The U.S.S.R.'s Mars 6 made a successful soft landing on the red planet 2 years before Viking—but its camera failed. Reliability, in fact, has been a chronic problem with Soviet planetary missions.

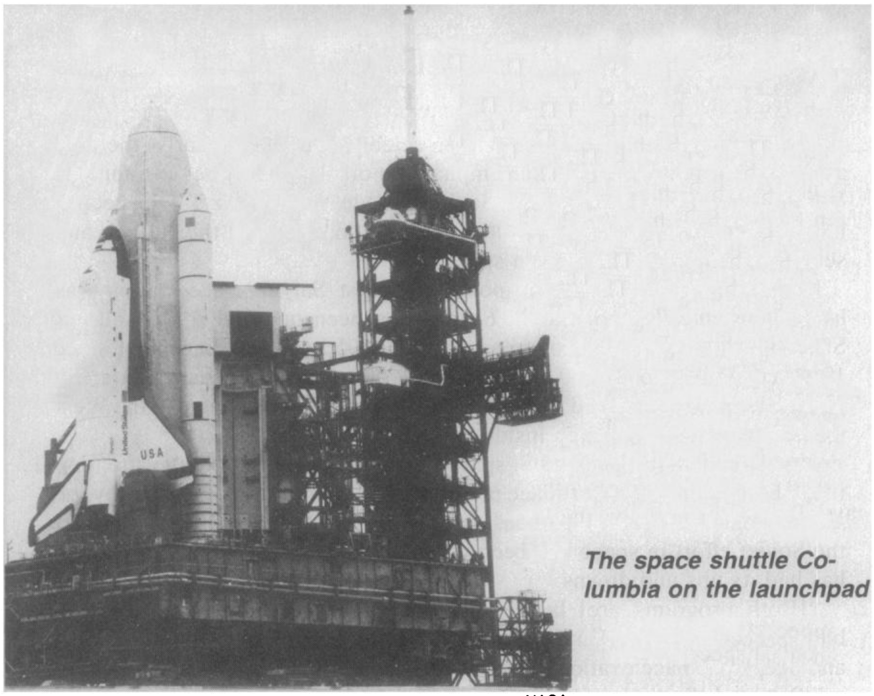
On the other hand, Soviet landers have returned numerous photographs of the surface of Venus. Three unmanned lunar landers have automatically returned core samples to Earth. And two separate lunar roving vehicles have traveled a total of 47.5 kilometers over the moon's surface. "A pretty solid record of accomplishment," Sheldon calls it.

For manned spaceflight, the Mercury, Gemini, and Apollo vehicles developed in the United States were paralleled in the Soviet program by the Vostok capsule ridden by Gagarin, the three-man Voskhod, and finally, in 1967, the Soyuz. The latter is said to provide a stay time of 30 days in orbit. A new, completely upgraded model, the Soyuz T, was deployed in the 1970's.

The Salyut space stations, starting with the 18.6-ton Salyut 1 in 1971, provide cosmonauts with about 100 cubic meters of interior space. Four of the six Salyuts launched so far have been civilian stations, with crews conducting medical, earth resources, and astronomical experiments. The other two apparently have been military reconnaissance stations. The Salyuts are periodically resupplied by Progress vehicles, robot ships capable of carrying 5000 pounds of cargo.

Where is the Soviet Union going in space? According to James E. Oberg, a flight controller at the Johnson Manned Spaceflight Center in Houston and author of a forthcoming book, *Red Star in Orbit* (Random House), the obvious next step, expected toward the end of this year, is the launch of a permanent manned space station. The follow-up to Salyut 6 is now under preparation, he says. It will probably include additional docking ports for attachment of special 8-foot laboratory modules. It will likely be manned continuously by rotating crews working in a two-shift, round-the-clock operation.

Sheldon points out that a Soviet manned lunar landing, while not imminent, is to be expected in the long run. The Russians have talked about going to the moon for so long, and prepared for it at such expense, that one must assume they will proceed as soon as they solve their present problems with unreliable hardware. It is also worth noting that the Soviets have talked much more positively than the Americans about manned flights to the planets.—M. MITCHELL WALDROP



The space shuttle Columbia on the launchpad

NASA

its studies of the spectrum and anisotropies of the 3 K microwave radiation.

The space science office also manages Spacelab. Built by the European Space Agency, Spacelab is a modular research laboratory designed to fit into the payload bay of the shuttle. Pressurized modules allow investigators to work in a shirt-sleeve environment, while open pallets carry instruments exposed to the vacuum of space.

Stofan explains that the Reagan budget revisions call for stretching out the schedule of Spacelab flights by as much as a year. "This is a new element, one we've had no experience in, so in the long term I don't think that going at it a little slower will be especially damaging."

As things stand now, NASA's Spacelab program in physics and astronomy includes several payloads that study the earth's magnetosphere, as well as two pallet-mounted (that is, not free-flying) telescopes: a solar-optical telescope in the mid-1980's and a meter-class, cryogenically cooled infrared telescope by the end of the decade. Meanwhile, the agency plans to fly life sciences packages about once every 18 months, starting with Spacelab 4 in the mid-1980's.

Morrison, who has been an active member of the Voyager imaging science team, looks over the current prospect for space science in the 1980's and calls it "minimal." Significant projects are indeed under way in solar physics, planetary science, astronomy, and the life sciences. "But it's a slowdown relative to the 1970's," he says, recalling the decade of Mariner, Pioneer, Viking, and Voyager. "And it involves a shift in emphasis away from planetary exploration. Right now we're at the lowest real budget since the program began in the 1960's."

A case in point is the cancellation of the development of SEPS. Powered by solar cells, SEPS would generate thrust with a beam of electrically accelerated mercury ions. The thrust would be feeble indeed. But by operating nearly continuously, SEPS could accelerate its payload to interplanetary velocities while expending much less fuel than would a chemical rocket.

This last point is what makes SEPS the key to the planets beyond Jupiter. "To do something like an orbiter, a lander, or a probe, it's not enough just to get there," explains Morrison. "You have to put on the brakes once you get there." And that means carrying along the extra fuel to do so. But chemical rockets are already approaching their limits. Using the Centaur, the most powerful booster that will fit into the shuttle payload bay, it will just be possible to get Galileo into orbit around Jupiter, the closest target. Beyond that, says Morrison, "you can only do flybys. And even those are difficult without the once-every-175-year lineup of planets that slings you from one to the next—a lineup which last occurred in 1977 and which the Voyagers are using."

Without SEPS, he adds, NASA will also find it very difficult to follow recommendations of the National Research Council's Space Science Board to explore comets and asteroids, which are thought to retain nearly pristine material left over from the formation of the solar system.

Development of SEPS is clearly not an urgent matter in the sense that there is no mission now on the drawing board that has to have it. But it is vitally important to planetary science in the 1990's and beyond. "Without SEPS," says Morrison, "we'd have to completely rethink our philosophy of solar system exploration. We'd have to focus the program entirely on the inner planets [the moon, Mercury, Venus, and Mars]."

Dropping the American half of the International Solar Polar Mission (ISPM) seems to have caused some very real anguish at NASA headquarters. "It hurt us the most to do that," says Stofan. "It was a well thought-out mission, with very, very valuable science. But along with Galileo and Space Telescope, we had three major missions peaking at once. We had to drop one, and ISPM was the least far along in its development."

The idea of ISPM was to send two spacecraft, one built by NASA and the other by the European Space Agency, in simultaneous arcs over opposite poles of the sun. As the first spacecraft ever to leave the plane of the ecliptic, they would gather unique information about the solar wind, the interplanetary solar magnetic field, and the polar regions of the sun itself.

As of now, NASA still intends to launch the European spacecraft. But the truncated mission has lost more than half its science, says Stofan. There is no longer any way of correlating simultaneous data from the north and south poles of the sun. Moreover, the American spacecraft was to carry the solar coronagraph, the only instrument on the mission capable of imaging the sun's polar regions—which are expected to look somewhat different from the equatorial and mid-latitudes visible from the earth. The European spacecraft will spin for stability and cannot carry an instrument that needs to point.

Numerous ideas are afloat about how to salvage something from all this. Might the Americans be able to put some of their instruments aboard the European spacecraft? Might the Europeans be willing to provide a second spacecraft (with some American financing), thereby restoring the mission to something resembling its original form? The Europeans, however, are extremely upset about ISPM, pointing out that they were not even consulted about NASA's decision. No one seems to know what the cancellation portends for the future of international cooperation in space. Any negotiations, needless to say, will be delicate.—M. MITCHELL WALDROP