

advisory panels and the President's Science Advisory Committee disagreed on what to do beyond the moon landings. In the late 1970s, with the launching of the Soviet Salyut VI (a "salute" to Yuri Gagarin's first human flight in space) and a European satellite from an Ariane rocket, the

US monopoly on space expertise appeared to be in relative decline.

Also in the late 1970s, beset with production delays and budget overruns, the shuttle program was saved from cancellation by the Carter Administration because DOD needed it to launch satellites vital to national

security. Since Challenger, the military has moved to end its dependence on the shuttle as rapidly as possible by redesigning satellites and ordering expendable launchers—a state of affairs that is reckoned to cost about \$12 billion.

NASA will continue to rely on the

Missions on the NASA manifest

Space scientists whose research projects were grounded for at least three years after the Challenger calamity on 28 January 1986 continue to be frustrated. Despite the successful voyage of the Discovery shuttle last October, NASA has only one more flight this year—the Atlantis, which is set to carry a Defense Department reconnaissance satellite equipped with high-resolution optics and radar. The agency has 50 scientific and military payloads, all told, queued up through 1993.

From the start of shuttle operations in 1982, the Pentagon has been entitled to preempt any NASA missions on the grounds of national security—though it rarely exercised this right. The Titan III and 34-D rockets that DOD uses to launch satellites have had a run of troubles. Until the Pentagon can obtain a reliable launch capability with a fleet of expendable rockets, it must rely almost entirely on NASA shuttles.

To be sure, NASA has a squadron of three reusable orbiters, but almost all heavy lifting can be done by only two—Atlantis and Discovery. The third, Columbia, is both older than the others and heavier by 4 tons. As such, Columbia lacks the performance capability needed for the Hubble Space Telescope and the planetary probes, as well as for most of the Pentagon's classified missions. Lennard A. Fisk, chief of NASA's Office of Space Science and Applications, argued long and hard to place the space telescope into one of the Pentagon's slots for next summer. But in the ensuing battle to move up the line, neither Fisk nor the Space Telescope Science Institute could muster the necessary allies within the agency, White House and Congress to win out.

The delay came with some benefits. As viewed by Riccardo Giacconi, director of the telescope institute, the postponement allows for further tests to be made on hardware and software, along with time to make some improvements. In one change, NASA installed new solar cells, which were developed by the European Space Agency to upgrade power levels by about 15%; another alteration allowed NASA to switch from nickel-cadmium to nickel-hydrogen batteries, thereby improving energy storage and cycling capabilities. In addition, the delay has enabled astronomers at the institute to improve their ability to use at the same time two of the telescope's five instruments, such as its wide-field planetary camera and its faint-object spectrograph.

Until last October, the space telescope was set for launch in February 1990. But when DOD asked to postpone a military reconnaissance satellite reserved for flight in December 1989, NASA proposed that the classified mission swap dates with the space telescope, and the Pentagon agreed.

The schedule through 1989 includes two interplanetary probes that NASA calls "window-sensitive"—meaning that if each is not launched in a relatively narrow period it will have to be postponed a year or more to await the correct planetary alignment. During the 32-month hiatus between

shuttle flights, the agency ran into trouble preparing Columbia for its return to space. The shuttle had been expected to be ready for launch next February. It is now pushed back to July. NASA counts on Columbia for the first long flight in March 1992, when it is slated to carry a microgravity laboratory on a mission that is expected to last for about two weeks.

Here is NASA's current flight sequence:

- ▷ 1 December 1988, Atlantis—Classified military mission.
- ▷ 18 February 1989, Discovery—Launch of a Tracking and Data Relay Satellite (TDRS-4), which will operate in conjunction with TDRS-3, placed in geosynchronous orbit by Discovery last September. With two of these in full operation, NASA can maintain radio contact with a scientific satellite or shuttle as much as 85% of each orbit of Earth, thus making it unnecessary to use the agency's worldwide network of aging ground stations, which are in constant need of maintenance. The first of these communications satellites, TDRS-1, encountered difficulties soon after it was launched in 1983. TDRS-2 was destroyed in the Challenger.
- ▷ 28 April 1989, Atlantis—Flight will carry the Magellan radar mapper. The spacecraft is designed to orbit Venus, exploring the surface with a sophisticated radar.
- ▷ 1 July 1989, Columbia—Classified military mission.
- ▷ 10 August 1989, Discovery—Classified military mission.
- ▷ 12 October 1989, Atlantis—Launch of Galileo interplanetary probe, a cooperative project with West Germany to survey Jupiter and its moons.
- ▷ 13 November 1989, Columbia—Military communications satellite. This mission also calls for retrieving a scientific satellite left in orbit in 1984 that will fall back to Earth unless it is recovered sometime soon. The satellite has been testing the effects of weightlessness, radiation and cold on organic and inorganic materials.
- ▷ 11 December 1989, Discovery—Hubble Space Telescope, the complex \$1.4 billion instrument that was originally scheduled to go up on the shuttle mission just after Challenger. The space telescope costs \$7.3 million per month just to keep it operational while in storage in a dust-free hangar at the Lockheed Corporation's research center in Sunnyvale, California.

Other scientific highlights in the manifest:

- ▷ February 1990, Atlantis—Classified military mission.
- ▷ March 1990, Columbia—Astro-1, the first of two missions involving university experiments designed to collect ultraviolet radiation from various regions of space. Until the latest NASA launch schedule, Astro-1 had been listed for November 1989.
- ▷ April 1990, Discovery—Gamma Ray Observatory.
- ▷ October 1990, no shuttle designated—Ulysses, a cooperative project with the European Space Agency to investigate the properties of the sun.
- ▷ December 1991, no shuttle designated—Astro-2, postponed from January 1991 on an earlier manifest.

—IRWIN GOODWIN