replace some of the steel with a tough wound filament of plastic and graphite.

■ On 26 June 1984, the main fuel valve failed to open on engine number one after the liquid propulsion system ignited for Discovery's maiden flight. The takeoff was aborted 4 seconds before the unquenchable solid rockets were to ignite, and a vulcanizing material in Discovery's rear caught fire. There was concern that the sudden, aborted drawdown of hydrogen and oxygen from the fuel tank would cause a pressure instability and explosion. Launch controllers relieved the pressure gradually by manipulating a series of valves and extinguishing the fire. For 40 hair-raising minutes, the astronauts sat immobile in their cabin.

■ In 1984 NASA began to get the new designs it solicited for making the troublesome shuttle engines more durable and reliable. The agency said it would spend $1 billion fixing them over 10 years. One of the leading contractors, Pratt & Whitney, said it was submitting a refurbished 13-year-old design.

■ The year 1985 was by far the best for the program, with three shuttle orbiters in use and nine successful flights. The first classified mission was flown by Atlantis on 3 October.

■ A near accident occurred with Challenger on 29 July 1985 when a sensor indicated that a turbopump was overheating, making a computer shut down one of three main engines 6 minutes into an 8-minute lift-off. The shuttle barely made it into orbit, flying at an initial altitude of 122 miles rather than 400. Had the engine cut out sooner, a NASA official said, the craft would have landed near Greece. Observers noted that a landing on water might well kill the crew.

■ On 12 January 1986, Columbia began a successful 6-day flight after seven non-starts, making this the most-delayed launch on record. The delays were caused by bad weather.

■ On 28 January 1986, Challenger exploded 74 seconds after lift-off, and a technical inquiry focused on a "burn-through" in a solid rocket casing. ■ ELIOT MARSHALL

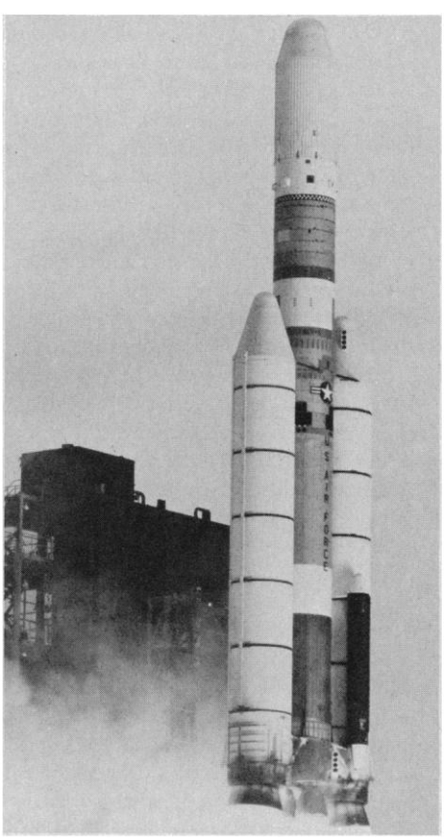
A Crimp in the Pentagon's Space Plans

By launching some payloads on expendable rockets, DOD may mitigate long-term impacts of the shuttle disaster

Two years ago, after watching the space shuttle experience a series of false starts and minor mishaps, Secretary of Defense Caspar Weinberger concluded that it was simply not fit to transport the most important military payloads into space. Over the National Aeronautics and Space Administration's bitter opposition, he sought and obtained congressional permission to construct some new, expendable rockets, each capable of carrying payloads of the same size and weight as the shuttle.

Weinberger's foresight will help protect the military from any long-term adverse effects of the recent shuttle calamity. But none of the rockets may be available before 1988 and in the meantime, the Pentagon will have a tough time getting its vital experiments and satellites into space on schedule.

This bind is not created by the destruction of the Challenger itself. Although it was a tragic loss for the civilian space program, it will not seriously disrupt the Department of Defense plans. Only 3 of the 11 DOD shuttle missions scheduled for the next 2 years were to have used the Challenger, and none of them would have deployed critical intelligence satellites. Still, DOD technically has the right—under a policy set by the President in 1982—to bump civilian payloads on the remaining orbiters so that it can fly the missions approximately on schedule.



The military's workhorse

The Pentagon is maintaining an independent launch capability with a successor to the Titan for launching some military payloads.

There is little the Pentagon can do if all shuttle flights remain suspended, due either to uncertainty about the explosion's cause or to a need to modify the orbiters. Even a slight additional delay is apt to affect the next three military flights, now scheduled for July, August, and December. The first is to conduct a key "Star Wars" experiment and deploy an experimental sensor designed to track military aircraft. The second is also believed to be related to "Star Wars," while the third will apparently deploy a sophisticated new photoreconnaissance satellite.

Two of these are to be launched from a new $3-billion complex at Vandenberg Air Force Base in California, which stands as a potent symbol of the Pentagon's tie to the shuttle's fortune. A more modern and compact version of the existing shuttle launch site in Florida, the Vandenberg site was constructed so that the shuttle could ferry a series of military satellites into polar orbits, which are optimum for intelligence gathering. Although the military presently launches several expendable rockets from Vandenberg—the Atlas and the Titan 34D—neither is capable of ferrying payloads as big or as heavy as the shuttle can, and both are being phased out. Thus, any lengthy delay in shuttle operations could have substantial national security implications.

At present, six military shuttle flights are scheduled for launch from Vandenberg by

late 1989, as well as 12 from Florida. Another 24 largely civilian flights are scheduled to ferry DOD payloads to low earth orbit, and more than 30 DOD scientific experiments have also been designed to fly aboard the shuttle. These range from measurements of auroral effects, dust, and radiation during the first Vandenberg flight to a major "Star Wars" pointing and tracking experiment presently scheduled for next year. New early warning satellites, defense communications satellites, and navigation satellites have all been designed to fly on the shuttle, although some will undoubtedly be transferred to Weinberger's large, new, expendable rockets when they become available. (Thus far, the Air Force has contracted for only ten at the rate of two per year, but will probably buy more in the wake of the accident.)

The rationale behind the new expendable rockets was explained by Air Force Undersecretary Edward Aldridge in an interview with *Science* in early January. "We felt, and still do, that the shuttle should have a complement. This country could not be dependent upon having only four vehicles for an entire space program. . . . In case we have some difficulties with the shuttle, we'll have some other way to get to space for some of the more critical of the national security payloads, the ones that require launch on demand." These payloads include communications and early warning satellites, "and a lot of classified systems that I can't go into," Aldridge said.

"Suppose the shuttle went down for a year and then all of a sudden you had a failure you didn't expect with a national security payload," Aldridge added. "You'd be bumping everybody off of the shuttles." In retrospect, the assignment of classified payloads to the shuttle in the first place may have been a mistake, he said. "These kinds of missions are better performed where man is not required . . . so that you don't have to worry about bumping people and throwing all kinds of havoc into an already unbelievable schedule."

Ironically, the Pentagon's commitment to the shuttle may increase after 1990, with the completion of a new flight control room behind barbed wire fences at a military base east of Colorado Springs, virtually identical to that used by NASA at the Johnson Space Center in Houston. The purpose of this facility, according to Colonel Robert Dickman, vice commander of the the Air Force's 2nd Space Wing, is to facilitate more routine operations with classified shuttle payloads, including potential shuttle repair missions. In the interview, Aldridge also noted that according to an Air Force edict, all new military satellite systems must be designed with shuttle repair and refurbishment capabilities in mind.

The biggest uncertainty in the military's use of the shuttle may be the "Star Wars" missile shield program. Its director, Lieutenant General James Abrahamson, told the House Appropriations Committee last May that "It is likely . . . that any future SDI deployment would require a space lift system significantly more capable and cost-effective" than either the shuttle or the new DOD expendable rocket. But many are skeptical that the funds to create such a vehicle will be available, particularly in the Gramm-Rudman fiscal environment. The likelihood that the military will remain the shuttle's largest customer is probably high. ■ **R. JEFFREY SMITH**

Local Opposition Halts Biotechnology Test

After 2 years of winding its way through a regulatory maze, a plan to release genetically modified bacteria into the environment is again on hold

Salinas, California. IN December, champagne bottles popped at the laboratories of Advanced Genetic Sciences (AGS), a small biotechnology company in Oakland, California. Company scientists were celebrating the fact that, after 2 years of scrutiny, federal and state authorities finally had given them the green light to conduct the first biotechnology experiment of its kind. In the experiment, microbes, which have been genetically altered to prevent frost damage to crops, would be tested outdoors.

"We felt we had jumped through the final [regulatory] hoop," company scientist Trevor Suslow recalls. But now, to its surprise and frustration, the company has suddenly run up against strong opposition to the test from many residents of Monterey county where the test is planned. The experiment is once again on hold.

On 27 January, the Monterey county board of supervisors held a public hearing here and heard a capacity crowd of constituents express fear and suspicions about the test. Representative Leon Panetta (D–CA), whose district includes Salinas Valley, testified that he was concerned. By the end of the day, the board indicated it would use its zoning authority to place a moratorium on the experiment and hinted strongly that the experiment will have to be relocated. AGS officials voluntarily agreed to postpone the test for at least another 30 days and to consider conducting the test at another site.

AGS officials blame themselves for what they describe as a complete failure to inform local citizens about the nature of the test. Scientists and regulators generally agree that this particular experiment poses little, if any, hazard to public health or the environment. But because it would constitute the first deliberate release of genetically engineered organisms into the environment, the test was subjected to lengthy review by government agencies. The experiment gained notoriety because Jeremy Rifkin, an activist and author, asserts that the bacteria to be tested are potentially dangerous to human health and could conceivably alter rainfall patterns. Though his contentions related to this test have been dismissed by most experts (*Science*, 29 November 1985, p. 1015), Salinas citizens reiterated them at the hearing.

"We've been pretty damn naïve about how these issues can be misinterpreted," says Douglas Sarojak, AGS director of marketing. To AGS, the controversy illustrates how the public can become understandably, but unduly fearful when a new technology is not explained and when people feel they have been excluded from making regulatory decisions. The company's problems at the local level, in turn, have made other biotechnology companies nervous about what kind of reception they can expect in the future and highlights a need to explain biotechnology.

The experiment that AGS wants to conduct outdoors is based on extensive testing in the greenhouse. The bacteria, *Pseudomo-*