Deployed U.S. weapons systems are rated equal or superior to those of the Soviet Union in 25 of 31 areas, roughly the same as last year. No comparison is made in two of the areas—ballistic missile defense and surface-to-air missiles—where the United States has chosen not to deploy any weapons system, and the imminent deployment of a superior U.S. antisatellite weapon will eliminate an existing Soviet lead. Artillery and mines are thus the sole areas in which the United States is clearly inferior.

The report again notes that the Soviets have assigned more personnel and a far greater portion of their gross national product to defense than the United States, to little avail. One problem is that "Soviet capital investment has not kept pace . . . advanced equipment has not been provided, automated support systems are not available, and as a result productivity may be lower. Moreover, the nature of Soviet society tends to stifle innovative and imaginative thinking—key elements in the pursuit of research," the report states. It optimistically predicts that the Soviets will have trouble closing existing technology gaps and that "new ones are likely to emerge." ■

R. JEFFREY SMITH

Thiokol Had Three Concerns About Shuttle Launch

Officials of the National Aeronautics and Space Administration (NASA) had three sound reasons to postpone the ill-fated launch of the space shuttle Challenger, according to engineers and officials of Morton Thiokol, Inc. One was a warning about potential leaks in the joints of the shuttle's booster rockets due to low temperatures. As *Science* reported last week, Thiokol engineers explicitly warned of such leaks on the evening before the launch, but senior NASA and Thiokol officials chose to disregard the warnings.

A second reason, which was considered more of a budget concern than a safety hazard, was the existence of unusually rough seas offshore, which might have jeopardized recovery of the boosters after launch. Several ships in the recovery area reported 26-foot waves on the day before the launch, several Thiokol engineers say, and some equipment needed to reel in the booster parachutes had fallen overboard.

At the moment that Thiokol first learned about these conditions, the ships were moving out of the recovery area into calmer waters. Had they been unable to recover the boosters after their splashdown, it would have cost the government an extra $40 million to replace them.

A third potential reason to postpone the launch, according to Thiokol officials, was the presence of ice in a network of water troughs used to suppress acoustic reverberations from the boosters at lift-off. According to a Thiokol engineer, "there were substantial uncertainties" about how well the ice-filled troughs could protect the shuttle orbiter, as well as the struts supporting various fuel tanks, from acoustic shock.

Fourteen Thiokol engineers gathered in a conference room in Brigham City, Utah, to discuss these concerns shortly after 1 p.m. on 27 January when they learned of the weather forecast for the launch. "We fought like hell all day to get permission for a presentation to NASA," a senior engineer told *Science*. By the time it was made, the engineers had done an analysis predicting that rubber gaskets used to seal the booster joints would probably be between 27 and 29° F. Since the coldest temperature that the gaskets had ever been tested was 47° F., in a static firing in Utah, the engineers could not predict exactly how they would perform in such a cold environment.

During a teleconference that evening, NASA officials and engineers, including Larry Mulloy, the manager of booster programs at the Marshall Space Flight Center, asked Thiokol to quantify how much and how quickly gasket performance might be degraded. "Although we had no data, we knew their performance was going from good to bad as the temperature dropped, and we were afraid that it was worse than ever before. There was not one positive statement in an engineering sense to support a launch that night," a Thiokol engineer said. All 14 engineers, as well as four others from Thiokol, supported a recommendation that the launch be postponed. Included in this group were Robert Ebeling, the manager of solid rocket assembly; Arnold Thompson, supervisor of the booster structures section; and Allan McDonald, the solid rocket motor program manager.

Mulloy and others challenged Thiokol's presentation, claiming that it was insufficient to support a conclusion that gasket performance would sharply decline at low temperatures. Apparently, no direct pressure was applied to Thiokol to reverse its judgment. Instead, aspersions were cast on the soundness of the company's technical judgment, and a request was made that its engineers reexamine their data. "It was a pro-launch meeting, and this tone was recognized by our management," one engineer told *Science*.

After a heated internal debate, and consultations with other corporate officials, Thiokol's Joseph Kilminster, the vice president of space booster programs, decided to reverse the initial recommendation for a postponement. In a document transmitted to Marshall and the Kennedy Space Center at 11:45 p.m. (EST), he took the agency's viewpoint and called the data "not conclusive on predicting primary O-ring blow-by [gasket failure]." Although the cold would clearly slow the movement of the gaskets into the joints, a backup would operate even if the primary fails, he said. Moreover, it would do so before pressures from the booster begin to force the joint apart, a phenomenon first discovered in 1982.

The presidential commission investigating the shuttle accident has reported that details of these disputes were never reported up the line to senior NASA officials, including Jesse Moore, who was then the agency's associate administrator for space flight. (Moore has since been replaced by Rear Admiral Richard Truly, the former head of the Naval Space Command and twice a shuttle pilot.) "Over time, we have found them to be one of the most conservative groups in the world," a Thiokol official says. "But on the night before that launch, they had a lapse of corporate memory." ■

R. JEFFREY SMITH

CERN Agrees to Independent Review Committee

The governing council of the European Laboratory for Particle Physics (CERN) in Geneva has accepted a proposal from the British government to set up an independent review committee to look at the implications of "alternative levels of funding" from its present budget.

This proposal had been made by Britain's minister responsible for science and higher education, George Walden, following last year's report by a separate committee chaired by Sir John Kendrew, which suggested that Britain should reduce its contribution to CERN by 25 percent in order to free up funds for other areas of research (*Science*, 17 January, p. 216).

The CERN review will be carried out by a group of five to seven members, to be appointed by council president Wolfgang Kummer after consultation with its 14 member states. The committee has been asked to report its findings and recommendations within a year.

A resolution passed unanimously by the council last week stated that the members