Strategic Weapons: Verification Keeps Ahead of Arms Control

The military technology spawned in the laboratories of the United States and the Soviet Union since the beginning of the nuclear era generally has been no friend of humankind. There is, however, one important exception—the observation satellites and other related intelligence technology that has allowed each of the two superpowers to know much about the other's weaponry. Yet this impressive capability in intelligence technology has not moved the superpowers to accept arms reductions. The agreement in principle reached at Vladivostok is the latest case in point.

On the one hand, this agreement (*Science,* 21 February) would establish ceilings on strategic arms at such high levels as to ask little sacrifice from those Russian and American military officers who equate national security with bigger stocks of nuclear weapons. On the other hand, the agreement would make great but seemingly confident demands on intelligence or verification technology, especially in the matter of verifying compliance with the numerical ceiling for MIRV'ed missiles—that is, missiles carrying multiple independently targetable reentry vehicles, or warheads. Although verification is less important at high levels of weaponry than at low levels, neither the United States nor the Soviet Union would enter into this agreement without knowing that observance of its ceilings could be confirmed.

The terms of verification for the Vladivostok agreement are now under negotiation in Geneva. If these negotiations succeed, a SALT II agreement will follow the 5-year accord of 1972, which ended the first phase of the strategic arms limitation talks, or SALT I. But, even if the present favorable odds prove wrong and the Geneva talks fail, the difficulty is likely to lie more in the uncertainties of détente than in the limitations of verification technology. Indeed, the challenge to verification technology presented by the SALT I agreements was nearly as great as that posed by the agreement in principle at Vladivostok.

Verification technology has of course seen enormous advances since 1956 when the United States initiated the U-2 photographic reconnaissance flights. Although a remarkable intelligence innovation for its time, the U-2 represented no real breakthrough or quantum leap forward. Its capabilities were inherently constrained by the secrecy and high risk of its mission and by its limited endurance, range, and altitude. Consequently, the U-2 could give the United States no more than an indication of the state of Soviet weaponry.

The breakthrough came with the reconnaissance satellite, heralded by the first sputnik in October 1957. It overcame both the legal and technological constraints of the past.

The Russians Set Precedent

Ironically, it was the Russians who, despite their traditional fear of espionage and their habits of secrecy, set an enormously significant precedent in international law by launching that first sputnik without seeking overflight permission from the United States and other nations. Although the Russians would for a time voice lame protests about American reconnaissance satellites, they were themselves committed to such reconnaissance. Outer space was thus assuming the same legal status as the high seas, with all nations free to use it and to make observations from it.

Technologically, the reconnaissance satellite, together with the high-resolution cameras that were becoming available, would make it possible for the United States and the Soviet Union each to survey every square mile of the other. Further, such surveys could be repeated frequently enough to give ample warning of any impending changes in weapons deployment great enough to tip the strategic balance.

Although much about the superpowers' intelligence technology remains hidden by official secrecy, some fascinating details have been reported unofficially. For instance, in the February 1973 *Scientific American*, Ted Greenwood described the 20,000-pound "Big Bird" first flown in the early 1970's as the *fourth*-generation U.S. photographic reconnaissance satellite. Big Bird is capable of performing in rapid sequence both wide-area surveillance and "close-look" inspection. Data from the relatively low reduction area-surveillance photographs are relayed from orbit more than 100 miles above the earth to ground stations by a high capacity transmitter. Film from close-look inspections, which reveals objects as small as one foot or so in dimension, is recovered in special capsules that are picked up by aircraft as they parachute earthward.

As one knows, photographic reconnaissance is complemented by a number of other highly sophisticated technical means of intelligence. Infrared and multispectral techniques can sometimes give useful indications as to what may be inside structures which photography cannot penetrate. Conventional and over-the-horizon radars monitor Soviet missile tests. They can even distinguish, if not always with certainty, between multiple reentry vehicles that have each been independently targeted (MIRV's) and reentry vehicles that have merely been released together in a tight cluster, like buckshot fired from a shotgun.

In addition, satellite-borne electronic ferrets can identify the powerful and continuous emissions of large radars used in antiballistic missile defense systems. Also, by such means as seismic arrays and satellite- and aircraft-borne radiation sensors, nearly all nuclear explosions can be detected, whether conducted underground, underwater, in the atmosphere, or in outer space.

Much less is publicly known about the Russian intelligence technology than about the American, but, to judge from the confident attitude of the Soviets in the 5 years of SALT negotiations, their technology has advanced pretty much apace with U.S. technology. Furthermore, the Soviets have the advantage of almost a surfeit of information about U.S. military programs. Since 1964 the annual military "posture statement" presented to Congress by the Secretary of Defense has discussed U.S. weapon programs—and even Soviet programs—in considerable detail.

The Russians can check such official information against that available in the American press, in technical and trade journals, and, to some extent, from their own personal observations. As one wag at the U.S. Arms Control and Disarmament Agency puts it, "All the Russians need is a subscription to *Aviation Leak* and a Hertz rent-a-car."

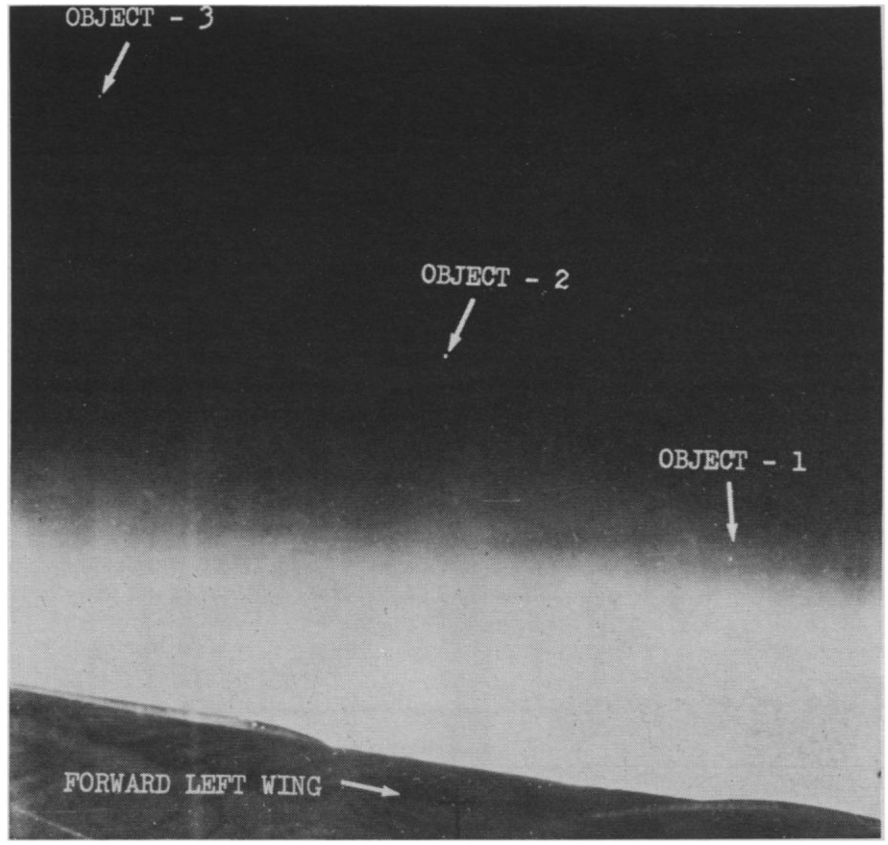
(The allusion was to *Aviation Week & Space Technology*, a leading aerospace trade magazine. As for the suggestion that the Soviets are free to tour U.S. air bases and missile installations, this stands correction. As noted in the 22 November 1974 issue of *Science*, there are restrictions on Russian travel within the United States.)

Verification capabilities have been taken full advantage of only in the several agreements prohibiting strategic weapons or nuclear testing from particular areas or environments. In particular, there have been the Antarctic Treaty of 1959; the Limited Test Ban Treaty of 1963, banning nuclear testing undersea, in outer space, and in the atmosphere; the Outer Space Treaty of 1967; and the Seabed Arms Control Treaty of 1972.

The verification of all these agreements except the Antarctic Treaty—which is unique in that it provides for on-site inspection—depends solely on such "national technical means" (to use the current euphemism) as reconnaissance satellites, radars, acoustic listening devices, and so on. If the limited test ban treaty is excluded, these agreements have involved only areas or environments where neither of the superpowers had on-going programs of weapon testing or development. And, in the case of the test ban treaty, the superpowers simply moved their test programs underground.

Neither the still relatively undeveloped seismic verification capability of that time, nor the Soviets' fears about on-site inspection, explains fully why underground explosions were excluded from the 1963 treaty. In part, the explanation lies in the fact that both the U.S. and the Soviet military were eager to continue testing as an important aspect of weapons development.

Moreover, if the inadequacy of seismic monitoring itself did give reason for excluding underground testing from the 1963 treaty, that inadequacy was to be largely overcome by the 1970's. For, by then, nuclear detonations at yields down to 12 kilotons could be detected and distinguished from earthquakes even if set off in dry alluvium to muffle the seismic effect; in hard rock, identification was possible down to 1½ kilotons. Such a verification capability argued, if not for a ban on all testing underground, at least for a ban on testing at yields that permit unambiguous identification. Yet, what the Nixon-Brezhnev summit of last July produced was a treaty (not yet ratified) to ban tests above a threshold of 150 kilotons, which is at least 10 times higher than the threshold that verification capabilities would allow.



Department of Defense photograph, taken in 1970, shows three reentry vehicles from one Soviet missile. At bottom is part of the wing of the aircraft from which the picture was taken.

The SALT I agreements signed in Moscow in 1972 formally confirmed the existence of verification capabilities relevant to curbing or reversing the race in strategic weapons deployment. The Antiballistic Missile (ABM) Treaty and the 5-year interim agreement on offensive weapons, both limiting but not reducing deployments, included these three provisions:

1) Verification would be by national technical means, used in a "manner consistent with generally recognized principles of international law."

2) Neither superpower would "interfere" with the verification efforts of the other. "Deliberate concealment measures" were specifically forbidden.

3) A "Standing Consultative Commission" would be established in which any problems of verification could be discussed.

In effect, the superpowers were getting around the old issue of on-site inspection by relying on national means of verification, and—quite important—reinforcing them by mutual cooperation. They were doing this with high confidence, even though verification involved challenging problems of discrimination and measurement.

For instance, under the interim agreement, no ICBM silo could be enlarged by more than 15 percent. Also, with respect to its missile forces, each side would be free to phase out some of its older land-based missiles and replace them with submarine-based missiles. The superpowers were satisfied that they would be able to keep track of and verify such changes in the mix of forces, at least in a gross sense.

The ABM treaty posed even greater challenges to verification. For example, no air defense missiles or radars were to be upgraded either for testing or deployment in an ABM mode. To verify this, U.S. intelligence would have to evaluate continually both the capabilities of the Soviets' widely deployed aircraft defense installations and the nature of activities at the Soviets' missile test ranges.

If the superpowers were up to verifying compliance with the foregoing provisions, they could have also verified compliance with a ban on MIRV's.

Yet, as pointed out previously (*Science*, 21 February), there was really no serious attempt to achieve a MIRV ban, and this despite the fact that no MIRV's had been deployed when SALT began.

The irony is that, now, under the Vladivostok principles for a SALT II agreement, the superpowers would have to verify compliance with not a relatively simple MIRV ban, but rather a MIRV limitation under conditions of considerable complexity. Each side could deploy up to 1320 MIRV'ed missiles, representing a little more than half of all the strategic delivery vehicles allowed them. To detect a missile silo obviously is easier than to determine whether the missile hidden inside that silo carries a single warhead or multiple warheads. Verification capabilities equal to that task must be very good indeed.

Actually, such determinations would not be feasible if it were not for two factors. One is the ability of intelligence to identify MIRV'ed missile systems as they undergo testing. The other is that any installations for the present generation of U.S. or Soviet MIRV'ed missiles have certain exterior—and plainly visible—characteristics that distinguish them from un-MIRV'ed missiles.

In this connection, senior American officials revealed during the weeks after Vladivostok essentially what the United States would ask for in the negotiations about verification that are now under way in Geneva. Barring some unexpected change that may have escaped the notice of unofficial observers, the U.S. position is that, once a missile has been successfully tested in a MIRV'ed mode, all missiles of that type would be counted as MIRV'ed. Some new Soviet missiles have been tested with both single and multiple warheads. (No MIRV'ed model has yet been reported by the Pentagon as definitely operational.)

Furthermore, inasmuch as none of the Soviet missiles tested with MIRV's will fit into any but a few of the existing silos, the United States would assume that any silo that undergoes substantial modification will carry a MIRV'ed missile. Under both the Vladivostok principles and the 5-year interim agreement of 1972, construc-

Briefing

Science Adviser May Return to White House

There are now some clear signs that President Ford is likely to appoint a science adviser to the White House soon. Sources close to Vice President Rockefeller say that he has put at the top of a recent list of options for the President the appointment of a single science adviser who, with a White House office and a small staff, would coordinate the activities of existing science committees attached to the National Security Council and the Domestic Council. Rockefeller has been studying the science advising issue for the President since December.

According to knowledgeable sources, the recommendations made by Rockefeller give low priority to the formation of a council of science advisers modeled on the Council of Economic Advisers, a proposal which has received wide support among spokesmen for the scientific community.

Unresolved, however, is the question of whether the upgraded science adviser's job will go to H. Guyford Stever, Director of the National Science Foundation, who became science adviser when former President Nixon decided to abolish the White House science office in January 1973. A previous report stated that the White House had backed off from putting Stever in the job (*Science*, 14 February); now it appears that, although some members of the White House staff do not want Stever to move in with them, this option is still a possibility.

There has even been a body hunt for a good candidate, according to knowledgeable sources. Although no names have been mentioned, President Ford's recent appointment of the head of the University of Chicago to the post of attorney general, and Vice President Rockefeller's lifelong habit of surrounding himself with academics and scientists, make it likely that they will make a concerted effort to find someone of eminence for the job.—D.S.

$8.8 Million Sought for Binary CW Production

Last year when the House and Senate defeated proposed military funding for binary weapons production in a rare display of legislative coordination, perhaps the legislators thought they had nipped in the bud any military ambitions for constructing a new chemical weapons arsenal. This year, however, the Department of Defense (DOD) in its proposed 1976 budget requested $3 million more than last year, or $8.8 million for binary weapons production. The DOD is also requesting funds for binary weapons research, which has aroused little congressional opposition in the past.

A binary weapon operates by storing less-than-lethal chemicals in separate compartments of a projectile which do not mix and become lethal until after the munition is fired. Although safer to store and transport than ordinary chemical weapons, binary weapons nonetheless represent an entirely new generation in the larger family of chemical weapons. The United States renounced nearly all first uses of chemical weapons when it ratified the Geneva Protocol of 1925; other possible uses of chemical weapons in war are the subject of disarmament negotiations now going on in Geneva.

Opponents of escalation of U.S. binary weapons research into the production stage argue that manufacture of the weapons will call into question the country's good faith at the Geneva disarmament talks, and that binary weapons are not all that useful militarily, anyhow. Proponents argue that the United States will need a defensive chemical weapons capability in the future and that the existing arsenal of chemical weapons should be replaced by the safer, binary munitions at a cost of approximately $100 million.

A new congressional fight against the binary procurement item is expected this year and some Congressmen's offices are already, so to speak, arming themselves.—D.S.

tion of additional ICBM silos is not allowed.

Also, if a submarine has been built or modified to carry MIRV'ed missiles, it would be assumed that all submarines of that class are armed with MIRV's. The American Polaris submarines modified to carry the MIRV'ed Poseidon missile have a distinctive appearance; the new Trident submarine, which will also carry MIRV'ed missiles, will be huge and unmistakable.

The Soviets thus far have not built any MIRV'ed missiles for submarines. An impossible verification problem might arise if the Soviets ever built a MIRV'ed missile to fit the launch tubes of submarines now carrying missiles with single warheads. American negotiators presumably will seek guarantees against such an eventuality. In such a situation, collateral guarantees are essential; as Amron Katz of the Arms Control and Disarmament Agency has said, "finders" can be at an inherent disadvantage against resourceful "hiders."

To take the standpoint of the Soviet negotiators at Geneva, they know that the MIRV'ed and un-MIRV'ed versions of the U.S. Minuteman missile fit into silos of the same size. They could see this as a factor complicating their verification efforts even though each Minuteman type does require distinctive, and visible, support equipment. Recently, the United States, after some hesitation, added another complicating factor by proceeding with deployment of 50 MIRV'ed Minuteman III missiles at Malstrom Air Force Base in Montana, the same installation where 150 un-MIRV'ed Minuteman II's will remain deployed.

Yet the decision to go on with the mixed deployment at Malstrom presumably signified that the Soviets were sounded out about it at Geneva and that they raised no strong objection. In addition, the Malstrom deployment clearly meant that the United States had abandoned a position which it seems to have unwittingly adopted earlier—namely, that, if any missiles at a particular installation were MIRV'ed, then all missiles there would be counted against the MIRV ceiling. Whatever else this peculiar episode signifies, it stands as further evidence that U.S. and Soviet confidence in their verification capabilities is strong enough to overcome problems that would probably have seemed insuperable even 5 years ago.

The trouble is, from the standpoint of all who lament the lack of progress in offensive arms reduction, verification thus far has been called upon only to police partial freezes and measured escalations. If verification is ever called upon to police reductions, its capabilities will inevitably undergo severe reappraisal by American and Russian military leaders worried that their opposites may cheat and get away with it. This is so because, the smaller the forces deployed, the greater the possibility that successful cheating could be militarily significant.

But there is no doubt that, given appropriate collateral guarantees, verification capabilities will be good enough to allow substantial arms reductions if the U.S. and Soviet governments ever agree to get off the strategic arms escalator.

—LUTHER J. CARTER

Harvard, MIT Face Limits to Growth

Harvard University and Massachusetts Institute of Technology are contemplating staff reductions next year as a means of trimming rapidly rising budget deficits. Both schools have dwindling special funds to cushion them, and the staff cuts being proposed are likely to be relatively small. But that such measures are being taken by these traditionally wealthy institutions is a grim indication of the problems facing science and engineering schools which are less well-off.

Department heads at Harvard's central graduate and undergraduate Faculty of Arts and Sciences have been ordered to reduce their teaching staffs for academic 1975–1976 by 3 to 4 percent from 1973–1974 levels, which would total a reduction of 15 to 19 people and approximately $400,000. MIT, for its part, is reviewing all nonacademic activities to find projects it can reduce or eliminate. "We'll certainly end up with some staff reductions, since 75 percent of that budget is salaries," says MIT Chancellor Paul E. Gray. "But whether they will be achieved through layoffs or attrition we don't know."

Spokesmen at both schools say that inflation and rising energy costs, combined with the shrinking income from endowments and the inherent limits on raising tuition, mean that chronic gaps are developing between expenses and incomes.

Harvard's Faculty of Arts and Sciences, for example, has had deficits of $100,000 or more per year since 1969 and has tightened its belt somewhat while covering the shortfall with funds from a special rainy day reserve, the Instructional Fund, set up during the prosperous 1960's. But a record deficit of $1.7 million, expected for the academic year ending this June, led Dean Henry Rosovsky to report to the faculty that the series of deficits "has begun to assume the pattern of an upward spiral." He said previous attempts to economize had been inadequate and warned that "there can be no lingering doubt that considerable staff reductions are in the offing." The alternative of cutting salaries while maintaining staff levels, Rosovsky said, would make Harvard less competitive with other schools.

At MIT, the 1974–1975 deficit of $6.6 million will be met this year with funds from the Research Reserve, a rainy day fund similar to Harvard's, and from other, miscellaneous sources of income. But in a series of briefings to the faculty last fall, Chancellor Gray warned that the long-term financial prospects for the institute could be grim. Even if MIT does not expand at all, it will continue to experience a gap between operating expenses and income which continues to grow by $1.5 to $2.5 million each year. "The problem is serious only if we don't do something about it," Gray told *Science*. "In a very few years we'd be having to deal with $10 to $15 million [in excess expenses] and that would be very serious." Hence the present review of the institute's support activities, which Gray says will be extended next year to a study of how the academic side can be more economical in the long term.—DEBORAH SHAPLEY