A Question of Accuracy

Ballistic missiles may seem accurate in tests, but would they hit their targets in war?

If the United States ever gets into a nuclear war, according to the black humor of the missile designers, the President can be sure of at least one thing: he will be able to blast the daylights out of Kwajalein Atoll. Kwajalein, a tiny island in the Pacific, has been the bull's-eye for Air Force practice shots with ballistic missiles for more than 20 years.

That is an old joke in the trade, known to David Hoag, an expert in ballistics at the Charles Stark Draper Laboratory in Massachusetts and former director of guidance and navigation for the Apollo moonshot program. But he could not answer a question that has been in the news recently: How much confidence can the United States or the Soviet Union have that their nuclear missiles will actually hit the *enemy* targets at which they are aimed? The joke reflects the skepticism that many people express about the military's claim to have achieved precision accuracy in guiding missiles over the 6000-mile course they would have to travel in a war. That claim has never been tested, because no missile has ever made the trip over the North Pole. This gap in information leaves plenty of room for speculation about what would happen in a real nuclear attack.

Hoag himself speculated about this in what is probably the most complete unclassified description of missile guidance, written in 1970.* At that time, he calculated that both the United States and the Soviet Union could be reasonably confident that their warheads would fall within a mile of their targets, which is interpreted to mean they were able to destroy cities but not reinforced concrete shelters. Much has changed since then in guidance systems and shelters. Hoag said recently that in matters as secret as this, a skeptic is handicapped if he tries to debate Department of Defense (DOD) officials. They now say that both we and the Soviets have enough accuracy in land-based missiles to hit one another's silos.

A handful of technical people have begun to challenge the standard Pentagon line on missile accuracy. Some, like Kosta Tsipis of the Massachusetts Institute of Technology, have been working on the subject for several years. Others are relative newcomers. In general, they aim to undermine the rationale for building a massive new shelter complex to house the MX.

The Air Force sold this $40- to $100-billion plan to the Carter Administration as a necessary replacement for the "vulnerable" shelters which now house 1000 Minuteman and 52 Titan missiles in the Midwest. In countless speeches over the last 4 years, DOD officials said that these existing bunkers would be at risk in 1982 or 1983, for that was when they estimated the Soviets could deploy new warheads accurate enough to deliver a silo-killing force.

According to Tsipis, the largest warheads thought to be atop Soviet missiles now deliver about 0.75 megaton of explosive each. These would have to explode within about 1000 feet of a Minuteman silo (assuming the silos are reinforced to withstand 2000 pounds per square inch of overpressure) to "kill" the missile inside. For such an attack to work, the attacker would have to destroy 90 percent of the enemy silos on the first try. In Tsipis' opinion, the United States does not have the accuracy to carry off such an attack. The Soviet Union's missiles are known to be less accurate than ours. So, the doubters argue, there is really no conceivable reason to rush ahead with a massive shelter building program in Nevada and Utah.

> . . . Neither the Soviet Union nor the United States would try such an attack because it is impossible to know the amount of bias error for a shot over the North Pole.

Two things have given the MX opponents a boost this year, one political, the other technical. The latter is based on new information challenging claims of missile accuracy. The more important change is that a new Administration has taken over, wiping away old strategic rationales and assumptions. President Reagan comes from the West, and many westerners who supported him do not want the Air Force to build concrete bunkers and military bases in their states. Three influential senators in this group are Paul Laxalt (R–Nev.), chairman of the appropriations subcommittee on military construction, Jake Garn (R–Utah), another member of the military construction subcommittee, and Harrison Schmitt (R–N.M.), chairman of the commerce subcommittee on science, technology, and space.

Reagan and Secretary of Defense Caspar W. Weinberger have themselves characterized the Air Force MX shelter plan as an ill-conceived relic of the Carter Administration. In addition, budget trimmers at the White House have fixed on the MX basing scheme as a high-cost, low-benefit item, making it all the more vulnerable to criticism on technical grounds. Even some retired Air Force officers have said they would rather see the money spent on bombers and conventional weapons, which might prove more useful than 4600 additional missile silos. In short, the upheaval in the political arena has given an opening to new technical reviews of the missile problem.

The technical novelty that crept into the debate this summer was a fresh appreciation of the fallibility of guidance systems. J. Edward Anderson, a former missile guidance designer at Honeywell, Inc., and now director of the industrial engineering division at the University of Minnesota in Minneapolis, put together several papers arguing that current ballistic missiles, because of inherent aiming problems, cannot be trusted to hit enough targets on the first firing to carry out a killing strike. He has not published his work yet, but many people seem to have read it. Tsipis and a colleague, Matthew Bunn, have looked it over,

*"Ballistic missile guidance," in *Impact of New Technologies on the Arms Race* (MIT Press, Cambridge, Mass., 1971).

0036-8075/81/0911-1230$01.00/0

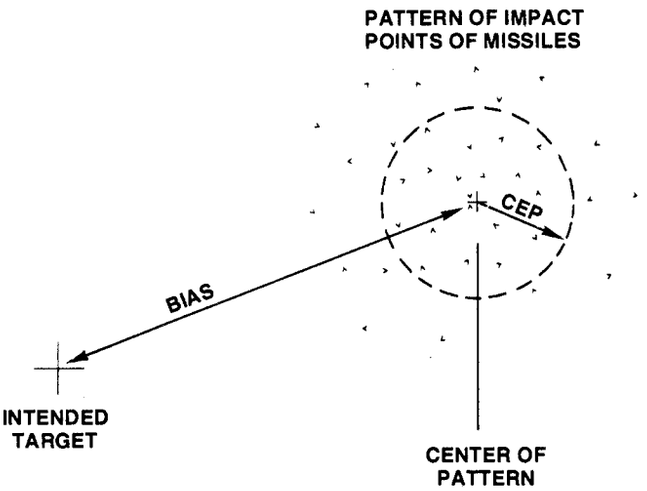
approve of the math, and say they are planning to publish a paper on the subject later this year.

Anderson's chief contribution was to reproduce a graphic representation of a "miss probability formula," which he said is "well known to defense planners but is not easy to find in the open literature." It allows him to calculate the chances that a shot of a given tonnage and accuracy will destroy a targeted silo. What it reveals, more than any discrete number, is the relative importance of an uncontrollable factor called "bias error." Shifts in this value can have tremendous effects on one's confidence in hitting a target.

A bias error is a systematic oversight in aiming, something utterly unforeseen and not included in the system's universe. The accuracy of U.S. missiles is always given in Circular Error Probable, or CEP. The term refers to the radius of a circle within which at least half the shots fall. Thus, the MX is expected to have a CEP of 300 feet, so that half of the MX warheads fired at a single target will fall within 300 feet of a center point. One hopes the center will be near the target. Minuteman III is said to have a CEP of about 600 feet. The best new Soviet missiles are supposed to have a CEP of 800 to 1000 feet.

The problem with this measure, as Anderson and Tsipis have pointed out, is that it defines the internal consistency of the guidance system and the tightness of the shot pattern, not the ability of the Air Force to hit a target. In fact, Tsipis claims that a missile can be extremely accurate in terms of CEP and still not come near the target when fired the first time. Unknown sources of error which cause even "accurate" missiles to miss are called bias errors. The bias can be removed by firing repeatedly at target and adjusting the missile trajectory. Obviously this kind of adjustment cannot be made for targets in the Soviet Union.

When a missile is fired along an untested trajectory, no one can predict with confidence how large the bias error will be. One defense consultant, not a member of the arms control community, claims that he made a study of missile shots at Kwajalein for the White House in the early 1970's. He claims that even after firing at the island for years with steadily improving guidance systems, the Air Force still could not hit targets with any regularity. Some misses were larger than the CEP radius, suggesting that in these shots the bias error was at least as significant as the CEP in measuring accuracy.



An illustration of the difference between Circular Error Probable (CEP), the standard measure of accuracy, and bias. Kosta Tsipis, who used this sketch in Arms Control Today, *says it is impossible to know whether bias will be larger (as in this case) or smaller than CEP when missiles are fired over an untested flight course.*

Using the miss probability formula, Anderson has calculated how much confidence the Soviets might have in their weapons if they were considerably better than they are. He found that knowing the amount of bias error is crucial, for no commander with a rational interest in "winning" a duel would undertake a surprise attack unless he could be certain that the bias would be equal to or less than the CEP. Assuming that the Soviets had 1.5 megaton warheads with 300-foot CEP's (they do not), Anderson figured that if the bias were merely twice the CEP, a surprise strike would fail and be a complete disaster for the attacker. He meant to show that neither the Soviet Union nor the United States would try such an attack because it is impossible to know the amount of bias error for a shot over the North Pole.

The Air Force has responded to this analysis by saying that bias errors are better controlled than Anderson realizes. Spokesmen have suggested that they are usually smaller than the CEP. Lieutenant Colonel Louis Montulli, former director of flight testing for Minuteman III missiles, told *Aviation Week and Space Technology*: "We have sufficient confidence to be able to predict a circular error probable and a maximum bias . . . within a range we're comfortable with." Recently Montulli said that Anderson's numbers for missile accuracy and destructive power today are "not even in the ball park." The real numbers are secret, and would end the debate if made public, Montulli claimed. He added that it is "poppycock" to argue that the amount of bias is unknowable.

As an institution, the Air Force has not shown much interest in this debate, although individual officers have. General Bruce Holloway (retired), former commander of the Strategic Air Command, was so impressed with Anderson's work that he persuaded Verne Orr, Secretary of the Air Force, to give it a hearing. Anderson briefed Orr and about 15 staff officers this summer.

Arthur Metcalf, editor of the quarterly *Strategic Review*, gave his unreserved endorsement of Anderson's analysis in the summer issue of his journal. This was a significant vote of confidence, for the directors and editorial board (who did not review Metcalf's article) include many of the Administration's first-rank national security advisers. Metcalf concluded that the Air Force should worry less about the unlikely possibility of a Soviet attack on Minuteman missiles and devote more funds to bombers and fighter planes. Metcalf wrote: "It is time that the whole matter of warhead targeting accuracy and Minuteman 'vulnerability' received more critical examination. . . ." The review, he said, should involve "fresh technical expertise" with no vested interest in the MX or any alternate program.

It is difficult to judge how much impact these technical arguments will have on a bureaucracy already committed to building an MX with multiple shelters. The President's blue-ribbon review panel headed by physicist Charles Townes has finished its work on the MX. The members were given copies of Anderson's analysis and other critiques of the theory of silo vulnerability, according to the staff director. The panel's recommendations have gone to the White House, but they have not been made public.

The President has said that one of the options he is considering is to put off a decision on the MX and study the alternatives a few months longer. Should Reagan wish to do this, the new debate on the question of missile accuracy could serve as a justification for pausing, studying, and even revising the current Air Force plan.—ELIOT MARSHALL