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"Science and National Security Policy"

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Introduction

Scientists are not politicians and most politicians are certainly not scientists. Nevertheless, scientists and politicians alike agree that science affects the making of national security policy. The influence of scientists on policy making depends on the technical issues and the personalities involved. Today I will examine the theory and practice of the bureaucratic mechanisms by which high level policy makers obtain, evaluate and use scientific information in formulating national security policy.

Scientists outside of government generally see the role of science in policy as telling policy makers whether a technical project can or can't be done. In principle, the President and the National Security Council have access to the best scientific brains in the nation through the office of the Science Advisor to the President, who as of October this year, is William R. Graham. Graham is a 48 year old electrical engineer who holds a Ph.D. from Stanford and has had a career in defense research with RAND and R&D Associates. He was appointed second in command at NASA two weeks before administrator James Beggs resigned to defend himself against charges of criminal fraud. Thus, Graham found himself in charge of NASA six weeks later when the Challenger shuttle exploded. Although Graham was a newcomer to the space program, he responded to Congressional investigations of the disaster. Under normal circumstances, Graham would probably have been named administrator of NASA, but the administration decided that it needed a better known administrator and named James Fletcher to the job. On June 3, Graham was nominated to the post of presidential Science Advisor and Director of the Office of Science and Technology Policy which had been vacant since George Keyworth resigned in January. Because the White House delayed sending the nomination to the Senate, Graham was confirmed only last month. At the same time, the budget of the White House Office of Science and Technology Policy was cut to $1.6 million from $2.2 million. Recent events indicate that the Reagan administration's top advisors consider the input of this office of less than critical importance.

Each of the major cabinet officers also commands a bureaucracy in which are embedded many scientists. There are reservoirs of scientific expertise in the national laboratories, the defense contractors and the universities all of which may be consulted. Thus in principle, there is no dearth of scientific advice available to the men who run the country. Unfortunately the process of transferring technical information to the men in power is not by any means as simple as it seems on paper.

There are several reasons why scientific information does not fit easily into policy decisions. First, the better the scientist is, the more reluctant he (or she) is to express an absolute opinion. We are all trained from freshman labs on up to express our results with carefully calculated error bars. Politicians want black and white, simple answers that are anathema to scientists. For example, a policy maker might ask a science advisor whether or not the Soviets have violated the provisions of the unratified SALT II treaty by developing the SS-25 missile or whether the missile is a follow-on to the SS-13 which would be allowed by the treaty. The argument hinges on the precise definition of throw-weight of a missile and our ability to measure it to an accuracy of 5%. Few top level policy makers have the time, the technical background or the inclination to understand the details of the argument. Thus they take the word of their advisors and conclude that: "Testing and deployment of this missile violates a central provision of the SALT II treaty. . ."(1). Public information and Congressional debate are all too often limited to blunt statements that mask the technical issues involved.

Secondly, scientists may bias their results by their political opinions. The mistakes may reflect honest errors but studies have shown that results, in studies of ESP for example, follow the bias of the experimenter. Why should the situation be different in the national security policy arena? If the scientists themselves produce solid data, the data may be distorted by analysts up the policy ladder who simplify the raw scientific data so that the political policy makers can understand it in a relatively short period of time. It is axiomatic in Washington that the higher the rank of an administrator, the less time he will have available to understand the very important issues which he is judging. It is also possible that Machiavellian figures in the chain of command may deliberately distort data for their own political ends. Lastly, in the arena of national security policy, the classification of data and analysis may be so strict that lower level analysts who write the papers which reach policy makers may not even be aware of the facts.

The Making of National Security Policy in the Reagan Administration

The President of the United States has absolute control of U.S. national security policy, subject only to the advice and consent of the Senate and, of course, the budgetary control of Congress. The word of the President or his personal spokespersons is the voice of the United States in establishing foreign policy. As one senior bureaucrat put it, the littlest minnow on the White House staff overrides whales elsewhere in the national security bureaucracy. Any member of the executive branch bureaucracy must speak publicly in accord with policy set by the White House. Otherwise it would be impossible for friends or foes alike to know where the U.S. stands. It is difficult for academic scientists to get used to keep ing such a careful watch upon their opinionated tongues.

Next to the President himself, the highest decision making body for formulating U.S. policy is the National Security Council (NSC). The National Security Council chair, Vice Admiral John Poindexter, served the former chair, Robert MacFarlane, as principal deputy. He is known as a team player who shuns the press and feels his job should be low profile. Rumors abound that he obtained his present position when White House Chief of Staff, Donald Regan, grew jealous of MacFarlane's influence on foriegn policy issues. Certainly Poindexter has seemed less able to control feuding factions within the NSC than MacFarlane. The offices of the National Security Council are in the Old Executive Office Building which is territory within the temple of power in Washington. Its chairman traditionally has private access to the President. The staff of the National Security Council is directly controlled from the White House. There is a very high turn over rate because people typically work seventeen hour days, seven days a week under the worst sort of pressure, simultaneously handling several different crises. The staff varies in quality from experienced experts of unquestionable ability to political appointees who lack experience, knowledge and, arguably in at least one case, intelligence. Needless to say, all the staff reflect the views of the President in that they are conservative in international affairs and tend to profoundly distrust the Soviets.

In addition to Admiral Poindexter, the National Security Council has three full members. Secretary of State George Shultz had no background in strategic policy or arms control issues when he was appointed. Shultz's principal advisor is Paul Nitze who holds the title of Special Advisor to the President on Arms Control. Nitze has been actively involved in arms control negotiations and national security affairs since World War II. He probably understands the Soviets and the negotiating process better than any one else whose name will be mentioned here. He is respected by all political factions in this country and by the Soviets and the allies abroad. Personally he is eighty years old, white-haired, slender and very patrician. He made his fortune from scratch before he entered public service. He married a wealthy wife, rumor has it, for love and reportedly earned his first million to be worthy of her. He is highly intelligent, incisive and very, very shrewd. Nitze is not a scientist but has a thorough grasp of the technology of nuclear weapons.

The Department of Defense is represented by Secretary of Defense Caspar Weinberger who also had no previous experience in strategic policy. His principal deput is Undersecretary of Defense for Policy, Fred Charles Ikle. Ikle has served as director of the U.S. Arms Control and Disarmament Agency and has a long track record of working with strategic issues. Recently he has maintained a very low profile in public and in the interagency process. The public personage in the business of making policy in the Office of the Secretary of Defense is Assistant Secretary of Defense for International Security Policy, Richard Perle, who serves as Ikle's deputy. Perle worked for many years for Scoop Jackson as the Senator's aide on foreign policy. He influences American strategic policy to an extent that is out of proportion to his relatively low rank. He is a master of bureaucratic infighting and knows every trick in the book. (He has even written a few new chapters over the last several years.) Perle is an articulate spokesman for the policies of the far right and has a profound distrust of the Soviets to the extent that he openly advocates discontinuing the arms control process. He does not sit on the National Security Council but often represents Weinberger at the next level down in the interagency process. He treats Congressional committees like graduate students and they love him.

The last, least publicized, member of the Council is William Casey, the Director of Central Intelligence. Casey heads the CIA directly and the entire intelligence establishment indirectly. He follows the pattern of his agency in not seeking, or even actively shunning, personal publicity. He is a friend and long-time advisor to Reagan. The control of intelligence data gives him enormous power in the interagency process. All policy decisions must be based on data provided by the intelligence community. The power of the man who can sway assessment of raw intelligence data and control the way it's presented to the rest of the policy makers is enormous. Besides the CIA, there are two other major intelligence agencies, the National Security Agency and the Defense Intelligence Agency, as well as the independent intelligence groups run by each of the services and the "foreign technology specialists" in the national labs. Various agencies have their own special areas of expertise. For example, buried within the Air Force's intelligence apparatus are two or three men who specialize in the Chinese missile program. Most of the time they have little work to do and are ignored by the rest of the intelligence community. On the days when the Chinese fire off a test, they suddenly become critical members of the staff and enjoy a week of frantic work and major importance. If a crisis suddenly erupts in a little studied area of the world or with a weapon nobody has studied for a while, there can be scrambles within the community to dig up somebody who at least has an idea of what is going on. When Iraq used mustard gas to attack Iran, the intelligence bureaucracy struggled to locate the men who remembered our concern with it during World War II.

The CIA leads the intelligence community. The well-publicized covert operations are actually one of its relatively minor functions. Most of the people who work in its huge office building engage in analysis of intelligence gleaned from quite open sources. For example Russian majors spend their time reading and summarizing Soviet agricultural reports in an effort to predict crop yields. The intelligence community, call it the IC for short, packages its information in National Intelligence Estimates, NIEs, or Special NIEs, SNIE's obviously, which are argued out by committees within the intelligence community. The different agencies frequently disagree in their interpretation of existing data and arguments in committee over whether a Soviet action "almost certainly constitutes," "probably constitutes" or simply "might constitute" a treaty violation grow loud, long and bitter. Occasionally a document appears like a recent description of Soviet theft of U.S. technology which is not from the IC and has no listed author or official source although you can get it from the Office of the Secretary of Defense. Such documents should be distrusted since they have clearly not received approval of the government as a whole. They usually represent the attempt of one political faction to force its interpretation on policy makers. A similar example was the well-publicized report on Soviet treaty violations produced by the General Advisory Committee to the Arms Control and Disarmament Agency in which Soviet violations were listed uncritically without benefit of argument withn the community of intelligence experts.

In addition to Poindexter, Shultz, Weinberger and Casey, there are two advisors to the NSC, the chairman of the Joint Chiefs of Staff and the director of the Arms Control and Disarmament Agency. During this administration, neither has played a leading role in shaping arms control policy. The Chairman of the Joint Chiefs, Admiral William J. Crowe, Jr., represents the uniformed, professional military. His point of view is distinct from that of the politically appointed civilians in the Office of the Secretary of Defense. In this administration, the Joint Chiefs have often supported the State Department position on policy issues. Admiral Crowe is a submariner and thus unusual for top navy brass who are usually aviators or commanders of large surface ships. The Arms Control and Disarmament Agency is represented by Ken Adelman who is under forty years old and very young for his post. Before his appointment, he worked at the United Nations with Jean Kirkpatrick. His expertise was in African affairs. In this administration, he generally has agreed with Weinberger on policy issues. Adelman is not close to Shultz which is probably unfortunate since traditionally the director of his agency has worked closely with the Secretary of State.

National policy is made when one of the members of the National Security Council decides that we need a policy on a certain issue. One of the cabinet members or advisors or the President himself may desire a look at a particular policy. Congress may demand policy as it did on the question of Soviet compliance with existing arms control treaties. Outside events may force us to develop a policy as Iraqu's use of chemical weapons against Iran forced a new look at our policies for the prevention of the proliferation of chemical weapons. On very rare occasions, a good idea from within the bureaucracy may surface in the form of a paper presented by one of the members of the NSC who is often interested by his staff or the NSC staff.

Once the National Security Council has decided to make policy, the job of looking at options is tasked to an interagency group (IG), the best known of which is SACPG—the Senior Arms Control Policy Group or "sack pig." (It can't lose the pronunciation although the I for Interagency which used to sit between Policy and Group has been officially deleted.) Deputy heads of agencies staff the IGs. The interagency group forms a lower level group, the interagency working group, where different aspects of the policy issue at hand are assigned to the appropriate agency. Representatives at this level are bureau heads with expertise in the particular area that is needed. For example, a working group on anti-satellite weapons issues would include representatives from the Office of the Secretary of Defense, the Air Force, the Strategic Programs Bureau and the Verification and Intelligence Bureau of the Arms Control and Disarmament Agency, the State Department, the CIA, the DIA, the NSA, NASA, the Department of Energy and possibly other agencies like the Department of Commerce if it seemed the new policy could affect them. Each agency member of the working group in turn assigns the problem to a bureau which assigns the task to an individual on its staff. The staffer, who may or may not have expertise in the issue at hand, writes an initial paper that is much like a term paper in form except that it contains no references. If you cite your sources in this game, you lose them. The papers then travel back up the bureaucratic highway to the National Security Council and reach the President in the form of one or at most two page decision papers with a box to check to select the policy option he wishes and a place for him to sign. Most of the science is fed into the process at the level of the original papers prepared by the staffer who may or may not call up friends in his own or other agencies who have technical backgrounds. Personalities play a formative role as the policy climbs the ladder in the intense verbal wars in the interagency process.

There are real differences between working in a classified environment and the university. In a classified situation, you can't do a literature search. The higher the level of classification involved, the more information is stored in the heads and safes of a very few workers in the field who may or may not share it with others. Thus one often wastes time reinventing the wheel. Furthermore, experts often work for the defense contractors, the national labs, and the universities. Contracts are monitored by relatively junior military officers or bureaucrats who are honest, intelligent and well-educated but not experts in all the fields where there are contracts or there would be no need to let contracts in the first place. Any scientist worth his salt is at least half way a salesman. Certainly he can convince anyone not expert in the field that his results are correct. Open literature journals and the National Science Foundation handle this by a peer review system which does not exist in the classified community. Therefore classified technical work ranges from the very excellent to the extremely shoddy and is all taken with equal seriousness in spite of the best efforts of contract monitors. Add to this the fact that results may be suppressed for political reasons as they climb through the interagency process and it become apparent that the very best technical information is not reaching decision makers. In a classic historical case, some of the warnings of Pearl Harbor did not reach men who would have been able to correlate them with other data because lower level technical workers who did not know the other data decided they were not important enough to worry their superiors.

An Example: Nuclear Test Bans

Having examined the political mechanisms for making national security policy, it is instructive to look at a case where science and national security policy overlap. You will have to decide whether the interference should be termed constructive or destructive.

The basic idea of a nuclear test ban is that new delivery systems such as larger, higher acceleration ICBMs generally require newly designed warheads. If for example, the Soviets decided to deploy the maximum possible number of warheads on their large SS-18 missile, this would greatly increase the numbers of hard targets they could strike inside the United States. To maximize the carrying capability of the missile, the Soviets would probably design a new model warhead with the yield, weight and geometry best suited to the SS-18 in this configuration. Before any weapons designer would guarantee his work, he would wish to test it. Thus if no nuclear warhead could be tested, no new designs of warheads could be deployed and this should slow down the increase in sophistication of the delivery systems found in the arsenals of the superpowers. It seems, at first glance, to be a simple idea and a very practical one. Unfortunately a second look reveals several levels of political and technological complexity.

To begin with, various test bans have been the subject of one ratified treaty, two signed but not ratified treaties and one much-discussed treaty that has never been completely negotiated. The Limited Test Ban Treaty (LTBT) forbids nuclear testing except underground. It was signed in 1963 when the world suddenly woke up to the increasing background radiation from nuclear weapons testing by the U.S. and the USSR with help from France and the U.K. Alarming reports of Strontium 90 in milk in New Jersey circulated in this country and the pressure from non-nuclear powers to ban testing in the atmosphere increased rapidly. The road to the treaty was not a smooth one, but since its ratification, it has been observed by all nations who have signed it. Even France, which has not signed the treaty, now tests underground. All nations have occasional venting from unexpectedly large tests or poorly buried explosions. The charges leveled against the Soviet Union by the U.S. refer to debris from venting which was traced beyond the borders of the USSR. Intelligence sources probably eagerly sampled the debris since it is possible to learn much about the construction of a nuclear weapon from the radioactive debris it releases. We could tell whether a Chinese test was triggered by uranium or plutonium fission from the debris we collected on the roof of Cooper Science Complex in Muncie.

In 1974, the Threshold Test Ban Treaty (TTBT) was signed. It limited nuclear tests to a maximum of 150 kilotons in designated test sites. If it had been ratified, the signatories would have exchanged geological data on the test sites and set off calibration explosions so that each could have confidence in its ability to measure the yields of the other's tests by seismic methods. In 1976, the Peaceful Nuclear Explosions Treaty (PNET) was signed by which signatories reserved the right to detonate nuclear devices for peaceful purposes outside of designated test areas both in their own territory and the territory of third parties. Individual explosions were limited in magnitude to 150 kilotons so the peaceful explosions could not be used to covertly test large warheads. Detonations were to be announced in advance and extensive geological information and technical details on depth of the shot etc. exchanged. Observers were to be allowed limited access to the site after the detonation to make measurements, making this the first treaty among the nuclear weapons states allowing any form of on-site inspection.

In one of the great mistakes of arms control, the Carter administration failed to press for ratification of these two treaties because they felt that they were very close to agreement on negotiation of the Comprehensive Test Ban Treaty (CTBT) which would ban all nuclear testing. In the event, the negotiations for the CTBT collapsed and have been broken off under the Reagan administration. The TTBT and the PNET are observed in principle by both superpowers but the exchanges of data and observers which would have increased our ability to monitor the treaties have not taken place. The Soviet Union has recently sought to re-open negotiations on the CTBT and has observed a unilateral moritorium on nuclear testing since August 6, 1985 which it keeps extending despite U.S. refusal to match it. On February 26, 1986, the U.S. House of Representatives passed a resolution calling for immediate ratification of the TTBT and the PNET and resumption of talks on the CTBT.

There are two basic technical issues which impact the test ban treaties. First is the question of whether national security requires at least a limited number of nuclear tests. It is argued that it is necessary to test in order to insure the reliability of our nuclear stockpile. The critical part of a modern warhead is the fission trigger which starts the fusion explosion. Most experts agree that it is a sufficient test of the warhead if the fission trigger ignites and starts the fusion explosion. Therefore it is possible to test warheads adequately at a fraction of their full yield. Since the yields of the largest modern warheads (not counting the Titan missiles which carried 9 megaton warheads and have posed more danger to Arkansas than the Ukraine for several years now!) are on the order of 500 kilotons, tests at 150 kilotons are adequate to ascertain that they work. Proponents of a comprehensive test ban argue that no flaw in a warhead has ever been uncovered thorugh testing although several have been discovered by inspection. Warheads have a finite shelf life established by factors such as the decay of the tritium initiator used to start rapid fission or chemical deterioration of their conventional explosives. They must be overhauled every few years and can be inspected then. If the Soviet's relatively simple weapons give them an advantage in reliability, then our designers had better get busy and reduce the complexity of their designs.

Proponents of testing point out that we need to modernize our arsenal and must test to do so. This is the effect that opponents of testing wish to stop by the test bans so the technology here is not in question. At a more subtle level, proponents point out that testing will assist in making weapons safer to handle and less likely to detonate by accident. Opponents merely add that the safest nuclear warhead is one which has been dismantled. It should be added that the most ardent testing advocates agree that it is highly unlikely that a warhead would undergo nuclear detonation by accident. It's not all that easy to set off a fission explosion! The danger is that the conventional explosive in the warhead will detonate and scatter plutonium around the countryside making a terrible mess which is expensive to cleanup and not very healthy for local residents.

Finally, advocates of testing state that we need to test in order to avoid technological surprise from the Soviets both in warhead design and in the effects of nuclear blasts on our military hardware. Rumor has it that British and American experts met shortly after the signing of the LTBT. They were discussing the effects of nuclear detonations and the Brits remarked that just as the ban went into effect they were bringing a truckload of soil from London to their test site to see what it would do under the influence of nuclear radiation. The Americans laughed and pointed out that their truckload of soil from Washington had been caught midcontinent by the ban. Advocates add that testing will improve our fundamental knowledge of the physics of nuclear explosives and provide a cadre of experienced scientists who understand the design and construction of nuclear weapons. They imply that no designer worth his salt will stay in the field if he is not allowed to verify his designs by testing. Test ban supporters point out that the Soviets will not be allowed to test either and that surely our computer systems for design and modeling of nuclear explosives are at least as good as theirs. Bomb designers could profitably get to work on more efficient engines for automobiles or any of the interesting and practical engineering problems which exist.

Peaceful nuclear explosions have proved to be of little practical use. We tried to use them to dig harbors and to create a cavity into which natural gas would seep for pumping to the surface. The harbor could have been excavated more cheaply using conventional explosives and the gas was too radioactive to burn so we do not currently use nuclear explosives for any peaceful purpose. The Soviests do use nuclear explosions as seismic sources in prospecting for oil reserves.

Until very recently, most experts agreed that testing at yields below 150 kilotons was adequate. The invention of the x-ray laser which is Edward Teller's favorite Strategic Defense Initiative weapon has changed this assumption. X-ray lasers radiate at very short wavelengths and so do great damage to targets in a very short time. The x-ray laser pumps atoms into excited states using the radiation from a nuclear explosion. The excited atoms emit characteristic x-rays in laser action before they are destroyed by the blast wave of the explosion. It is not altogether certain that the weapon actually works as well as its builders at Lawrence-Livermore National Laboratory have claimed. Even if it does work, its military significance is open to question. What is certain is that a militarily useful model will have to be pumped by a nuclear device whose yield is on the order of megatons. Some enthusiasts advocate scrapping our agreement to abide by the unratified TTBT. Incidentally, tests of a working model of the x-ray laser will have to be conducted above the atmosphere and will therefore violate the LTBT. Nuclear tests with yields of a megaton cannot be conducted at the Nevada Test Site since their shock waves would damage buildings in Las Vegas.

The second technical question concerning test ban treaties is whether we can adequately verify Soviet compliance with them. We feel reasonably confident that we can at least monitor the LTBT with great accuracy for sites in the Soviet Union. Unexplained events, like the mysterious flash of light in the South Atlantic in 1979 which triggered our nuclear detection satellites, will be better monitored by a new detection system that is being deployed on the satellites of the Global Positioning System. Most experts are comforable with our ability to monitor that treaty using satellites or by detecting radioactive debris from tests conducted in the atmosphere.

The primary method of monitoring the TTBT or the CTBT uses global networks of seismic stations. When a nuclear explosive is detonated, it sends seismic waves thorugh the earth which are picked up by seismic stations at very great distances from the detonation. There are two basic types of seismic waves which travel by different mechanisms. S waves are side to side or shear waves and P waves are essentially compression waves. Nuclear explosions produce more pressure waves than an earthquake of similar size. By comparing the relative magnitude of P and S waves, it is possible to discriminate against earthquakes. Other factors which help to distinguish nuclear explosions from quakes are that earthquakes are usually much deeper than explosions and that the Soviets generally test only in sites set aside for the purpose.

For nuclear explosions on the order of 100 kilotons, it is virtually certain that seismic stations will tell us that a detonation has taken place. The question is considerably trickier for much smaller nuclear blasts. Most seismologists agree that we can probably detect tests down to 10 kilotons. Many argue that we can see smaller explosions but the issue of detection of blasts below 1 kiloton is open to legitimate technical questions. For example, a determined cheater might wait to set off a blast until an earthquake occurs in a convenient location and hide the nuclear blast in the siesmic signal from the quake. It is hard to imagine the test crews waiting patiently for such an opportunity when they are under pressure to get results. Communications will have to be excellent and crews at the knife-edge of readiness to get the shot off in time for its seismic signals to blend into the earthquake signals. A more realistic scenario involves exploding the device to be tested inside a large cavity to decouple the blast from the earth and reduce the seismic signals produced. This will be expensive since the cavity will have to be extremely large. High frequency seismic signals are transmitted to cavity walls far better than the lower frequency signals traditionally used for monitoring testing. New seismographs work at higher frequencies and negate much of the advantage of the cavity scheme for hiding tests. Below 1 kiloton, there can be a variety of conventional explosions of comparable yield. Therefore even if a blast is detected, it could be a test of a conventional explosive. The question thus becomes whether there is any military utility in testing nuclear explosives with yields on the order of tons. In order to protect their own troops, most field commanders would rather use conventional weapons than nuclear weapons so there is no market for extremely small tactical nuclear explosives. The fission triggers on strategic and larger tactical nuclear weapons must be considerably larger so it seems that tests below one kiloton have very little military value anyway.

A second verification problem concerns methods for measuring the yield of a nuclear detonation which again is done from a seismic signal. The yields of our own nuclear tests were plotted against the magnitude of their seismic signals. The logarithm of the yield increases linearly as a function of the seismic magnitude. A good fit was obtained for data from the Nevada Test Site. When the French gave us yields for their tests in the Sahara, it became obvious that a correction factor, called the bias, had to be subtracted from the seismic magnitude to bring it into agreement with the Nevada data. The slope of the line for the two sites stayed the same but its intercept changed. This happens since the geology of the sites is very different not only on the surface but deep in the crust. The same thing happens at the Soviet test sites.

The magnitude of the bias that is appropriate for the Soviet site has become a politically critical issue. The Reagan administration has charged that the Soviets have systematically violated the TTBT by exploding nuclear devices with yields greater than the allowed 150 kilotons. Their charges are based on yields of Soviet tests computed using a value of the bias set officially some years ago. Most seismologists, including many working for the Department of Defense and certainly those in the national labs, feel that the official value of the bias is too low. Panel after panel of experts has recommended raising the bias for the Soviet site. Because the relation of yield to seismic magitude is logarithmic, theses changes are sufficient to change the calculations of the yields of Soviet tests to show that the Soviets have observed the TTBT very well indeed. Obviously these reports are a politically hot potato. They have not been released although according to Science Magazine, the CIA has urged their release. The feud has been conducted between Weinberger and Casey themselves. Lower level technicians have ducked or been crushed in the war because as the saying goes, "When the elephants dance, the mice had better run unless they have an elephant for a partner!"

In April, 1986, Casey formally ordered a change in the numerical methods used to estimate Soviet yields which reduced their estimated values. Because the yield increases logarithmicly with the seismic magnitude, large uncertainties in yield result from small uncertainties in measuring seismic magnitude so a Soviet test whose measured yield is 150 kilotons may statistically have an actual yield as low as 75 kilotons or as high as 300 kilotons. In other words, there is a factor of two uncertainty in the measurement of the yields of Soviet tests. Yield estimates improve as seismic networks are placed closer to the test site and its geology is better understood. The yields of U.S. nuclear tests are measured by sampling the radioactive debris emitted by the explosion and are believed to be accurate to about 10%.

The Soviets have recently allowed a team of seismologists from the private Natural Resources Defense Council to tour their test sites and to establish three seismic stations in the Soviet Union. A major paper by Evernden, Archambeau and Cranswick published in the May issue of Reviews of Geophysics argues that a network of 25 high frequency monitoring stations established within the Soviet Union could monitor tests with yields down to one kiloton with an extremely high degree of confidence. Soviet seismologists working with the Natural Resources Defense Council will establish three seismic stations in this country but have not been allowed to visit the Nevada Test Site nor have they received an official belssing from the government.

The Reagan administration holds that seismic methods are not adequate for verifying the TTBT. It will consider ratifying the treaty if the Soviets will agree to the use of the CORRTEX method at their test side. CORRTEX consists of a long coaxial cable that is inserted into a hole parallel to the shaft that holds the nuclear explosive about 10 meters away from the test shaft. As the nuclear explosion takes place, the blast wave crushes the cable and the rate of crushing gives the explosive yield to within about 30% independent of the geological surroundings of the test site. Obviously the use of CORRTEX implies on-site inspection during nuclear tests. The presence of foreign technicans at the test site poses several difficult logistical problems. Rumor has it that drilling crews from the two rival U.S. weapons labs, Los Alamos and Livermore, have difficulty working together on closely spaced sites in Nevada.

This fall, experts from the two superpowers met in Geneva to discuss the technical issues relating to verification of test ban treaties. The discussions were reported to be frank and cordial. The U.S. delegation was lead by Robert Barker, a deputy director of the Bureau of Verification and Intelligence at the Arms Control and Disarmament Agency. Dr. Barker is a physicist from Lawrence Livermore National Laboratory who has been nominated as Assistant Secretary of Defense for Atomic Energy, the position in charge of producing nuclear explosives for the military. He is a well- known advocate of continuing an active nuclear testing program. The discussions have not yet lead to an agreement on verification issues.

Clearly, the judgement of how precise our measurements of Soviet test yields must be in order to protect us from militarily significant violations of nuclear test ban treties belong to all of us in a democracy. At the same time it is clear that this judgement must be based on an understanding the methods used to monitor the treaty and the errors inherent in this method. Science does not replace the political process but it is an important element in making national security policy.

The issue of nuclear test bans highlights the importance of having political leaders be scientifically literate. We, as teachers and scientists, must endeavor to see that our students, the future leaders of the nation, and the general voting public are equipped to evaluate these vital technical questions.

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