DEPARTMENT OF DEFENSE AUTHORIZATION FOR APPROPRIATIONS FOR FISCAL YEAR 1983

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AUTHORIZING APPROPRIATIONS FOR FISCAL YEAR 1983 FOR PROCUREMENT, FOR RESEARCH, DEVELOPMENT, TEST, AND EVALUATION, AND FOR OPERATION AND MAINTENANCE FOR THE ARMED FORCES, TO PRESCRIBE PERSONNEL STRENGTHS FOR THE ARMED FORCES AND FOR CIVILIAN PERSONNEL OF THE DEPARTMENT OF DEFENSE, AND FOR OTHER PURPOSES

PART 7—STRATEGIC AND THEATER NUCLEAR FORCES

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STATEMENT OF MATTHEW MESELSON, PROFESSOR OF BIOCHEMISTRY, HARVARD UNIVERSITY, CAMBRIDGE, MASS.

Dr. MESELSON. Thank you, Mr. Chairman. It is a privilege to be invited to appear before the subcommittee in connection with its consideration of the administration's request to begin production of binary nerve gas weapons.

SOVIET CHEMICAL WARFARE CAPABILITIES AND INTENTIONS

Today there is concern about Soviet chemical warfare capabilities and intentions. We do not know whether the Soviets have or have not increased their stockpile of lethal chemical weapons over the last 12 years during which we have refrained from producing such weapons. Similarly, estimates of Soviet chemical weapons stocks are extremely variable and uncertain. There are no reliable estimates. It is prudence, not definite knowledge, which requires that we assume the existence of a substantial Soviet chemical threat. This assumption would be appropriate with or without the disturbing reports of the use of toxic weapons in Afghanistan and of possible Soviet involvement in their use in Southeast Asia. It does not in itself, however, provide a sound basis for deciding specific procurement issues.

M687

Because of the brief time, I will focus my presentation on the issue of whether to start production of the M687 155-mm binary GB nerve gas artillery projectile. As you know, the M687 is the only binary munition thus far certified ready for production. The other nerve gas weapon for which the administration has requested production funds in fiscal year 1983 is the Bigeye bomb. But since its developer, the Navy, now states that the need for further development will postpone the first possible production to fiscal year 1984 or beyond, it would seem wise to concentrate our present considerations on the M687 and deal with the Bigeye next year when the as yet incomplete DOD studies of its effectiveness and deliverability are farther along. In this connection and as general background I would like to submit for the record the sanitized version of a paper I prepared last year as a consultant for the Department of Defense, Manpower, Reserve Affairs, and Logistics. It is entitled "Comments on the Defense Science Board [DSB] Chemical Warfare Panel Report," and is dated January 8, 1981.

The points I would like to present regarding the M687 are as follows:

First, the already existing quantities of 155-mm and 8-inch GB and VX nerve gas artillery projectiles, namely the M121 and the M426 are more than ample for U.S. artillery requirements for 30 days of chemical warfare in Europe.

Let me explain. For causing casualties to well-trained, well-protected troops, as the Soviets certainly are, chemical artillery fire will generally be much less effective than conventional high explosive artillery fire. This is because a soldier wearing a modern gas mask and other protective gear is nearly invulnerable to chemical weapons, whereas no comparably effective protection is practicable

against the effects of conventional artillery. By forcing troops into protective posture, however, chemicals will degrade mission performance and slow the tempo of enemy operations to an extent which is uncertain but may be substantial under certain conditions.

Since firing more chemical rounds means firing fewer conventional rounds, there will be an optimum ratio, depending upon the amount required to force the other side into protective posture. Firing more chemical rounds than this optimum will reduce, not increase, U.S. combat effectiveness. Thus, as stated in a recent DOD report to the Congress, the objective of U.S. retaliatory use of chemicals would generally not be to obtain casualties but rather to force the other side into protective posture. Avoiding additional casualties to unprotected civilians downwind is a further reason for not exceding the optimum.

Calculations based on munitions effectiveness data show that the inclusion of just a few percent chemical rounds in total artillery fire would provide opposing forces with a powerful incentive to assume a high degree of chemical protection. The number of chemical artillery rounds needed to comprise 5 percent of all rounds fired by the United States during 30 days of all-out war in Europe would be about 200,000. Essentially the same estimate can be reached by a different approach, namely, detailed target analysis.

It has been estimated from unclassified sources by Dr. Julian Robinson of Sussex University that the existing stockpile of M121 and M426 nerve gas artillery projectiles is substantially greater than this requirement.

It should not be forgotten that the United States maintains, in addition, a large number of 155-mm mustard rounds designated M110, which, although usually requiring higher ammunition expenditures, can, in situations in which it is desired to create a persistent vapor hazard to the lungs, eyes, and skin be superior to rounds containing the presently stockpiled nerve agents GB and VX. The Army is currently planning to upgrade the M110 stockpile, increasing the number of ready-to-issue rounds. In addition there are large stocks of 105-mm GB nerve gas artillery projectiles, the M360. Although the Army is phasing the 105-mm howitzer out of Europe, it will remain a standard artillery system for the Marine Corps. The current upgrading program also includes these 105-mm nerve gas munitions.

The second point I would like to emphasize is that stocks of serviceable M121 and M426 nerve gas artillery projectiles are not significantly deteriorating. Tests done several years ago were mistakenly interpreted to suggest deterioration of nerve agent in U.S. artillery munitions. The tests were later found to have been done incorrectly. Subsequent tests show no deterioration. On the basis of still more recent tests, the Army has assigned all lots of nerve agent in its 155-mm and 8-inch artillery projectiles to "Condition Code A," defined as "Serviceable—fully meets all military characteristics. Issuable without limit or restriction." The same holds true for all lots of mustard gas in M110 155-mm projectiles.

As of last summer only 33 of the very large number of stockpiled M121 and M426 projectiles were classified as leakers. The leaks are minuscule. They present no real hazard. In past years some of the

stocks were not adequately maintained. Also, burster charges were not supplied for many of the rounds. Due to improved maintenance, burstering and inventory programs, the stockpile of serviceable munitions is now substantially increasing.

While it is true that some types of chemical munitions are deteriorating or obsolete, these do not include the M121 and the M426. Contrary to continuing misconceptions, even among high-level military and civilian officials, the serviceable stockpile of M121 and M426 projectiles is in excellent condition and with proper maintenance can remain so.

I have here a recent photograph of a small portion of our current stockpile of 155-mm nerve gas artillery shells at the Tooele Army Depot in Utah. One can get some idea from this of the excellent condition in which these rounds are kept.

Third, the M121 and the M426 nerve gas artillery projectiles are not obsolete nor are they becoming so. Contrary to prevalent misunderstanding, these rounds are fully compatible with currently deployed artillery weapons and can be fired to their full range.

The fourth point to consider is that the proposed binary projectile has not been adequately field tested. In contrast, the presently stockpiled U.S. nerve gas artillery projectiles have been extensively field tested.

Due to restrictions on field testing enacted by Congress, the M687 binary projectile has never been field tested in its actual configuration. In spite of extensive field tests with simulated agents, and a single test shot with a live round of a binary munition of significantly different design, field testing with live rounds in the present configuration has yet to be done.

In addition to revealing possible unsuspected design faults, field testing is needed in order to develop munitions effectiveness tables which presently do not exist for the M687 binary. Only such testing can provide fully dependable information as to whether the M687 is reliable and equal in effectiveness to the currently stockpiled M121 GB round.

In this regard the former Director of Development at the Army Chemical Systems Laboratory, Dr. Saul Hormatz, has stated that, and I quote:

> When I developed and introduced into production the presently stockpiled munitions I chose a straightforward approach and merely adapted and modified the designs of existing suitable munitions for which we had a very large number of static and then dynamic (field) trials. We had to make numerous design changes as these trials progressed and in some cases critically important changes they were. We would never have gone into production without all this engineering data, even on as simple an adaptation program as we could have devised. The proposed binary munitions are not a simple change from other rounds, but are an entirely new design. Their functioning will be entirely difference from their predecessors. Engineering data must be obtained on cloud size and shape, rate of formation, yield droplet size distribution persistency, et cetera, et cetera, statically and dynamically and in statistically significant numbers. These must be with live, not simulant rounds. This is a large program. A few tests just will not do.

My fifth conclusion is that presently stockpiled chemical artillery munitions can be safely stored and transported.

Binary chemical munitions are intrinsically less likely than single-fill munitions to cause unintended release of nerve agent

until they are assembled, which would be done normally in or near the battlefield.

In considering the safety of existing chemical munitions, which are of the single-fill type, certain extremely improbable accidents, such as the crash in a populated area of a plane carrying nerve gas munitions may be envisaged. Even then, however, with their fuses packaged separately, the release of nerve agent from single-fill chemical artillery shells is very unlikely. Drop tests of the M121 from thousands of feet confirm this expectation.

The already stockpiled nerve gas artillery projectiles have a long and excellent safety record, as expected for their rugged and simple design. They have been and can continue to be stored and transported with a high degree of safety.

Finally, Mr. Chairman, is that production of the M687 risks undermining the NATO political balance on which European defense planning ultimately rests.

The Governments of Norway and Holland have recently stated that they would not allow their forces to use chemical weapons or permit chemical weapons deployment on their territory. The stated policy of the Federal Republic of Germany is not to train its troops in the use of chemicals now or in the future. There is no evidence that the FRG will permit replacement of U.S. chemical weapons already deployed there with binaries, let alone permit the deployment of increased quantities.

Indeed, there are recent indications that U.S. production of short-range nerve gas weapons such as the M687 which are perceived as being most likely to be used on German soil could force the Government of the Federal Republic to request withdrawal of U.S. stocks presently positioned on its territory. This would leave the United States with no stocks whatever in Europe for prompt retaliation in case of chemical attack.

Much of the opposition to chemical weapons in European NATO countries is based on awareness that even a few weeks of major chemical war on their territory could cause tens of millions of civilian casualties, a catastrophe of strategic proportions for Western Europe.

There is also concern that NATO emphasis on chemical weapons, as opposed to emphasis on chemical protective measures, may lead the Soviets to doubt NATO resolve to use nuclear weapons, on which the deterrence of war itself is felt ultimately to depend.

In conclusion I would say that there is no need for the M687 and that a decision to produce it at this time would waste defense resources and would jeopardize our present forward-based chemical retaliatory capability and would risk undermining NATO cohesion on even larger issues.

Thank you.

Senator WARNER. Professor, have you had an opportunity to study why the Soviet Union has expressed an almost total unwillingness to come to the negotiating table and continue discussions in this area and perhaps reach a verifiable and balanced treaty in this area?

Dr. MESELSON. Senator, it is the United States, not the Soviet Union, which has declined to resume the bilateral chemical weapons talks.

The problem with the Soviets is not that they won't sit down and talk. It is that they have not as yet agreed to the kind of systematic onsite inspection which the United States has sought, to insure that the declared stocks under any treaty agreement are actually destroyed. In August 1979, the United States and the Soviets did announce agreement on the principle of international onsite inspection by challenge. The Soviets have not made it clear to us, however, under what conditions such challenge inspections would actually be permitted.

The talks were started only in 1977. I see nothing to be lost by resuming them. I would hope that our Government will see fit to resume bilateral negotiations on chemical arms control in the near future.

Senator WARNER. You express, and accurately so far as I know, the reluctance of NATO to even go to the extreme, as you say, in some instances of training to defend against the use of such weapons. In view of the only substantial experience, the exception being what we heard today by the first panel, but the only experience is World War I right on the very soil which we are now defending today with NATO, why are they so reluctant?

Dr. MESELSON. There are two different issues here. One is preparedness to protect their forces against chemicals. The other issue is having a chemical retaliatory capability.

Senator WARNER. Also, in view of the fact that experiences in World War I, and I have read this history as you have, show that as soon as both sides began to have an equal competence and capability, the chemical warfare subsided, and in World War II it was never even initiated.

Dr. MESELSON. I believe that the major deterrent to chemical attack is a good protective posture. The European NATO allies, for example the British, the Dutch, the Belgians, the West Germans, and the French, train in protecting their troops against chemical attack. They have suits and masks, and other protective equipment and they train. In fact, one of the British Army chemical experts, C. N. Donnelly, in a recently published article states that the British Army is better trained and equipped to protect itself in a chemical atmosphere than is the Soviet Army.

However, neither the British nor any of the continental NATO allies have evidenced any interest in possessing nerve gas weapons except for the French who do possess them.

As to why the West Germans and certain other NATO allies do not seek any chemical retaliatory capability, I suspect that the reasons are the ones I mentioned earlier. From their point of view, and you almost have to imagine what it would be like to have a nerve gas war in a densely populated part of the United States, but from their point of view poison gas weapons pose an immense threat to their own populations without offering any commensurate military utility. To put it bluntly, Germans tend to feel that chemical weapons would kill only Germans. That may account in large part for their disinterest in relying on chemical retaliation.

In World War I, I believe it is fair to say that it was the effectiveness of the gas mask and other defenses which blunted the effect of chemical weapons and not retaliation. This view is supported by official U.S. studies, the official British history of the

war, by Capt. Basil Liddel-Hart and other authorities. Because of defensive measures, gas was not a critical factor in World War I. The British official history states that "gas achieved but local success, nothing decisive; it made war more uncomfortable, to no purpose."

Senator NUNN. Didn't the wind switch some causing backlash on some of that?

Dr. MESELSON. Yes.

Senator NUNN. Wasn't that a prime factor in it not being used more?

Dr. MESELSON. Well, it was used a lot even with the wind blowing. But after defenses, even the crude defenses available in World War I, were put into use, the impact of chemical weapons was greatly blunted, to the extent of making their utility marginal.

Since the masks and other defenses have improved a very great deal since World War I and since the competitor weapons such as fragmentation and flame have also improved, the improvement in chemical weapons themselves has probably been more than offset. Therefore, if chemical weapons are ever used again in a European war, I expect that, except for the possible surprise of the first attack, they would be even less effective against military forces than they were in World War I.

Senator WARNER. Do you believe the Armed Forces of the United States are well trained and well protected when it comes to chemical warfare?

Dr. MESELSON. I wish I could say yes, Senator. We have pretty good equipment. We have a good protective suit. We could have a better one. We could have better gloves. The mask has been criticized much more than it ought to be, but we could have a better mask. I don't think the equipment is the weak point, however. I say that for broad reasons, namely, that in World War I the equipment was a disaster compared to what we have today, but with training it made the whole difference. Except for certain special units, such as the 82d Airborne and some units in Germany, training is not adequate. But training is improving.

Also, it seems to me difficult to argue that we can impress the Soviets with our chemical resolve by buying more chemicals if we aren't even willing to field test under controlled and safe peacetime conditions a number of chemical rounds.

Senator WARNER. Well, Doctor, your testimony has been very helpful.

Do you have questions, Senator Nunn?

Senator NUNN. Just one question, Doctor.

Can you imagine having a verifiable and enforceable treaty with the Soviet Union on chemicals without onsite inspection?

Dr. MESELSON. No; I can't. But I think there are some ways in which onsite inspection can be made minimally intrusive. An example is the idea of separating the problem of inspecting what is declared from what is not. The Soviets really ought not to have much objection to letting us verify the destruction of stocks they themselves declare.

As for production facilities, if they are declared, we can see from satellites if they are destroyed. We may need some inspections to make sure that it is what they really were, but if they are declared

I would think that we are on sound ground to argue that we should be able to make some of those visits.

Now you get into the problem that after everything that is declared is gone, and that might take 10 or 15 years, what do you do about suspicious events or suspicious sites afterward, in the post-destruction environment? There you need to have some sort of challenge onsite inspection as already agreed to in principle. The negotiating position the United States had beginning in the summer of 1977 and which was devised essentially by the Joint Chiefs seems to me a good one. As you would have with any negotiating position, there are some ways in which we might make certain adjustments or concessions if there was evidence of getting motion on the other side. But unless the United States agrees to resume the talks, we risk losing whatever such prospect there may be.

I would hope that we haven't retreated from our 1977 position. I worry, I must say, that if we are not going to be talking to the Soviets about this, that even if there were a possibility of an agreement, that we put ourselves in a position where we are not going to be able to achieve it.

I don't see anything to be lost from talking. I think we should resume the talks. In the context of those talks we could also bring up, I would think, the compliance issues which are important and need to be discussed with them.

Senator NUNN. Thank you very much.

Senator WARNER. Thank you very much, Doctor, we appreciate your coming and participating in this panel. You exhibit a great deal of knowledge on the subject.

[Dr. Meselson's comments on the DSB Chemical Warfare Panel Report follow:]

COMMENTS ON THE DEFENSE SCIENCE BOARD [DSB] CHEMICAL WARFARE PANEL REPORT BY M. MESELSON, DEPARTMENT OF BIOCHEMISTRY AND MOLECULAR BIOLOGY, HARVARD UNIVERSITY, CAMBRIDGE, MASS.

I. DISCUSSION

Specific comments on the DSB panel report are organized below under several headings:

1. Soviet threat.
2. War in a chemical environment and anti-chemical protection.
3. U.S. chemical weapons, stockpile and requirements.
4. Binary chemical weapons.
5. Civilian casualties.
6. Future trends.

1. *Soviet Threat.*—[Deleted.] We know a considerable amount about Soviet anti-chemical protective posture. It is pervasive and well exercised. This, however, provides no measure of Soviet offensive chemical preparations. A strong defense is to be expected in view of their WWI experience and the large U.S. chemical weapons buildup of the '50s and '60s, coupled with the fact that we were not then parties to the 1925 Geneva Protocol and had officially refused Congressional requests to reaffirm our WWII policy of no-first-use. [Deleted.] The panel's own report, however, in some sections perpetuates worst-case interpretations, the basis for which is highly questionable. The trouble with this is that it tends to obscure the questions, when awareness of them could be important in policy formation and in intelligence efforts. Prudence, not definite knowledge, dictates that we assume the existence of a substantial Soviet chemical threat.

2. *War in a Chemical Environment and Anti-Chemical Protection.*—The DSB panel report recommends major expansion of currently planned defensive and retaliatory chemical programs at a five-year cost estimated by the panel to be three or

more times the $3.47B projected for current programs. However, the panel report provides almost no data and analyses on the basis of which its recommendations can be evaluated in competition with other options for utilizing defense resources. Moreover, the panel report reflects unfamiliarity with available data on matters of critical importance to its recommendations regarding defensive and offensive chemical programs.

For example, in order to illustrate the potency of nerve agents the panel states that "A drop the size of a pinhead can cause death in [deleted]. "Appearing by itself, this statement suggests a serious overestimate of the percutaneous threat of nerve agents, particularly in the case of the U.S. persistent nerve agent VX. While it is correct that the lethal dose of VX is about a pinhead's worth, this refers to the dose actually absorbed into the body. It is the amount estimated to be lethal if injected directly into the bloodstream. If applied to average skin or clothing, the amount of VX required to kill or incapacitate and the times required are very much greater, as shown below:

ESTIMATED EXPOSURES AND TIMES TO INCAPACITATION FOR AGENT VX

	Amount (mg)	Time to incapacitation
In the body	[1] 0.6	
Applied to average skin	10	
	200	[Deleted.]
Applied to U.S. Army summer uniform	100	

[1] "Pinhead."

Even troops in considerably less than full protective posture can be directly exposed to VX artillery fire without necessarily suffering heavy casualties. For example, field manuals state that a battery volley of airburst 155-mm VX (6 projectiles) on a platoon size target (100 meter radius, receiving [deleted] in open terrain or open foxholes would cause [deleted] casualties among troops wearing masks, hoods, gloves, and the equivalent of ordinary U.S. Army winter uniforms but no protective suits. Four volleys are estimated to [deleted] casualties, with [deleted] expected to develop within [deleted] after the attack. Substantial casualty prevention can be achieved by decontaminating or changing clothing or decontaminating skin even [deleted] or more after exposure (although the sooner the better). Furthermore, the self-administered antidote carried by Pact forces is particularly effective against VX poisoning, because of the prolonged period during which the enzyme-VX reaction can be reversed by oximes. Moreover, if troops are not directly exposed but instead are protected by a barrier against liquid spray, they would face only the lesser threat of indirect pickup of VX from contaminated surfaces. Limited exposure can be risked because casualties are delayed and can be averted by decontamination and antidotes. Protective suits are standard issue on both sides and will be worn if chemical war occurs. But VX may not often make it necessary to button-up fully. If only the highest levels of protective posture impose substantial performance degradation, the utility of VX against Pact forces on the battlefield and in rear areas may be marginal. These considerations call into question the DSB panel recommendation for production of ground and air-delivered VX weapons.

It should be noted that neither VX nor GB present much of a percutaneous vapor hazard under average field conditions. Mustard, the WWI "king of gases", does present such a hazard and may therefore in some circumstances be competitive with nerve agents. It is, therefore, of interest that in WWI, the only case of large-scale chemical warfare, German artillery fired approximately 9000 agent-tons of mustard over a period of 14 months in 1917–18 when the Allies had nearly intolerable gas masks, little or no protective clothing and no agent nearly so effective as mustard with which to retaliate. Gas, however, was not a decisive weapon in WWI, due to the availability of primitive but sufficiently effective protective equipment and tactics. Of course, today's conditions are different. On the one hand, the nerve agents are more toxic than WWI agents and delivery rates are higher. On the other hand, today's protective equipment is superior and non-chemical competitor wapons, such as improved conventional munitions, have greater effectiveness than did the HE munitions of WWI. The use and effects of gas in WWI should be studied. While that conflict may not provide definitive answers to day's questions, it can provide a

useful guide for analysis and it raises important questions that may otherwise be overlooked. A careful study is that of D. K. Clark done under contract with the Department of the Army; "Effectiveness of Chemical Weapons in WWI," Operations Research Office Staff Paper, ORO-SP-33, November, 1959.

Another case in which the DSB panel seriously overestimates the impact of chemicals occurs in their statement that "Existing (U.S.) suites are designed to a six-hour specification, but persistent agents remain effective for longer than individuals can remain encapsulated in protective clothing." In fact, the suit is much better than the design requirement. Under continuously contaminated battlefield conditions simulated by the specification test, the suit is good for more than 70 hours.

The DSB panel may also be unduly pessimistic regarding the operational degradation imposed by the U.S. protective ensemble, given by the panel as 30 to 50 percent. These percentages are approximately equal to the amount of rest time in currently recommended work/rest cycles chosen to minimize heat stress among men doing heavy work in protective gear (MOPP-3) in warm (70-85° F, wet bulb) to hot (85-100° F) weather. In central Germany, the mean early afternoon temperature for July and August is about 60° F, with a standard deviation of ±5 F. The recomended rest time percentages do not tell us the actual impact on combat performance. For example, for combat activities characterized by alternating periods of high and low work rate, the work/rest cycle requirement may in many cases be accommodated with little degradation. Also, it must be remembered that the Army has a graded system of four levels of protective posture from which commanders select in accordance with the situation. Typically, only a fraction of the units will be in full protective posture at any one time. This discussion is not meant to imply that the current U.S. individual protective ensenble is fully satisfactory. It is not, although further improvements can be expected. The DSB panel, however, appears to have operated under an exaggerated impression of its shortcomings.

3. *U.S. Chemical Weapons, Stockpile and Requirements.*—There are approximately [deleted] serviceable or soon to be made serviceable 155-mm and 8-inch nerve agent projectiles in the U.S. stockpile. [Deleted] of these are deployed in Europe. We need to know how these numbers compare with requirements in a chemical war. For causing casualties among well trained troops wearing good protective gear, chemicals will generally be much less effective round-for-round than other kinds of shells, such as improved conventional munitions. Wearing masks and chemical protective garments, however, degrades mission performance to a degree that depends on the protective equipment, the level of training, the nature of the mission and the temperature. Firing more chemical rounds means firing that many fewer HE rounds. If the objective of chemical retaliation is to force active enemy units into a high degree of protective posture, there will be an optimal mix at or below the proportion of chemical rounds needed to do so. Under conditions when the degradation imposed by protective posture is particulrly low, the optimum tradeoff may be close to firing no chemicals at all. Firing a higher proportion of chemicals than the optimum will actually reduce our combat effectiveness.

Our present stocks of 155-mm and 8-inch nerve agent artillery projectiles could provide U.S. forces with a mix of [deleted] chemical artillery ammunition for a [deleted] full-scale war in Europe, or [deleted] if 155-mm mustard rounds are included. This assumes an overall [deleted] expenditure, chemical and HE, of about [deleted]. Although the U.S. does not maintain 105-mm artillery in Europe, other NATO forces do, and could therefore utilize additional U.S. stocks of 105-mm GB and mustard projectiles, amounting to [deleted] rounds.

I know of no reason to consider that existing U.S. stocks of nerve agent and mustard artillery ammunition are significantly deteriorating or becoming obsolete. Fewer than [deleted] is classified as a "leaker" and the leaks are generally miniscule, presenting no great hazard. The nerve agent itself should be stable indefinitely if there are no defects through which moisture may enter. Tests on agent drawn from munitions confirm this expectation. The 155-mm and 8-inch shells are compatible with currently deployed artillery tubes and can be fired to their full range. Unless existing U.S. stocks are quantitatively inadequate, there is no pressing need to produce additional chemical artillery projectiles.

4. *Binary Chemical Weapons.*—If further analysis suggests that it is necessary to produce additional nerve gas artillery munitions, it may be questioned whether binaries of current desig n or single-fill munitions are the better choice. Binaries are intrinsically less likely to cause unintended release of nerve agent. But the safety argument has often been exaggerated. Single-fill projectiles can be stored and shipped without fuzes or even bursters inserted, precluding detonation. In the more than twenty-five years that the Army has had nerve agent weapons, there has been

no serious accident. Certain accidents such as the crash of a plane carrying single-fill artillery projectiles could conceivably release considerable amounts of nerve agent. Such risks should be considered analytically to reach some rational basis for estimating their likelihood and severity. If a suitable batch incineration method of demilitarization is available by the end of this century, as seems likely, the demilitarization benefits now seen for binaries could largely disappear. The greater ease of manufacturing binaries is not an impressive advantage in our advanced industrial economy. Nor is it something we wish to advertise to less advanced nations for whom nerve agent weapons might seem more attractive if their production were more readily accomplished.

Regarding military performance, there are several questions concerning artillery munitions that deserve further examination than that given by the DSB study:

Sound. With their much smaller burster charge and thinner casing, currently designed binary rounds likely make a sound when they burst which is distinctively lighter than that of conventional HE fragmentation rounds. This could provide target personnel with prompt warning of gas attack. In WWI, this situation existed with early German mustard shells. Allied troops are reported to have been distressed when these munitions were superseded by mustard shells with heavier casings and larger bursters, the sound of which could not be distinguished from fragementation shells.

Odor. Odorlessness is cited as a useful property of the nerve agent in single-fill munitions. Because of incomplete mix or biproducts, does the mixture released by binaries of various current designs present a distinctive odor that might serve as a warning to unmasked target personnel?

Temperature dependence. Temperature effects on viscosity and on chemical reaction rates will influence the time course of the binary reaction. Over what temperature range can currently designed binarymunitions be used without adverse effects on their performance?

Range limitations. Early in its flight, the binary projectile contains little nerve agent. As the binary chemical reaction proceeds, the amount of agent builds up. In the case of VX, however the amount of agent may reach a maximum and then decrease, due to thermal decomposition. What performance reductions, if any, are imposed at short and long range by these effects?

Complexity. Binaries are intrinsically more complex in having several parts that must be properly assembled on the battlefield. What difficulties may arise from this feature?

The first air-delivered chemical weapon for which a production decision will be needed will probably be the Bigeye binary VX bomb, still in engineering development. There are three questions specifically concerning the Bigeye which I would suggest for consideration:

Deliverability. Bigeye was designed in the early 1960's. The Soviet air defense it would face will be very different from what may have been envisaged then. Recent discussions of air-delivered chemical weapons place emphasis on the attack of certain fixed targets in Pact territory far behind the front. What penetration and return probabilities can be estimated for Bigeye delivery to such targets in the decade or two ahead?

Agent. Is VX a sufficiently effective agent, taking into account the possibilities for casualty avoidance, non-disruptive decontamination, and antidote therapy discussed above in section 2?

Deposition density. If the VX air-delivered bomb is required, is the individual low deposition density [deleted] of Bigeye adequate? This is [deleted] the design density for the TMU-28 spray tank or the density achieved even in the single-volley artillery attack envisaged in section 2.

5. *Civilian Casualties.*—There is agreement within NATO on the need for adequate chemical defense. Some NATO countries have given the matter considerable attention for many years. But there is wide policy divergence regarding chemical retaliatory capability. The stated policy of the FRG is not to train its troops in the use of chemicals "now in the future" and there is little indication that the FRG will permit any expansion of the U.S. chemical weapons stocks now there. Judging from writings of German defense planners and statements of senior German officials, much of this reluctance stems from fear of civilian casualties, a subject not discussed in the DSB panel report.

Estimates suggest that a 30-day chemical war in Europe could kill millions of noncombatants while killing far fewer soldiers. Nerve agent poisoning is essentially cumulative over a period of days or weeks so that sub-lethal doses received at different times over that period can combine to become lethal. This cumulativeness also means that along-wind dilution of nerve agent clouds does not reduce the threat

posed to persons down-wind. The subject of civilian casualties is of high importance, both because of the lives at risk and because unless European perceptions change, additional forward deployment and joint retaliatory use of U.S. chemical weapons may be impossible.

6. *Future Trends.*—We should ask whether chemicals are likely to be of increasing or declining importance over the next two decades. The last twenty years have seen a major increase in the effectiveness of HE anti-personnel weapons. During the rest of this century, the main development in conventional arms is likely to be the large-scale introduction of precision-guided weapons. Both of these trends act to make chemicals less competitive for many missions. For example, chemicals will probably become less attractive for suppressing sortie rates of air bases as precision-guided weapons able to wreck the runways become available. Greater effectiveness and much-reduced areas of unintended casualty production will favor the precise weapons in such cases. Seeing the choice, Europeans are likely to be more reluctant than ever to see chemicals integrated into NATO defense. Also, chemical protection is sure to improve substantially. Even without any break-throughs in the development of effective antidotes, steady progress in the design of masks, suits, and detectors will substantially improve the defense. Major offensive improvements seem less likely, but need to be considered and watched for. Overall, it seems probably that chemicals will be of declining importance. Still, there may well be missions for which this isn't so. What is needed, and does not appear to have been done, is a mission-by-mission analysis of the pros and cons of chemicals, done for the present situation and also projected ahead.

II. SUMMARY

1. The principal conclusions of this review of the DSB panel report are that:

It rightly emphasizes the need for:

[Deleted.]

New, mission-oriented estimates of chemical weapons requirements.

Stepped-up field exercises to evaluate combat performance on the chemical battlefield.

Studies of low cost demilitarization methods.

It presents data which over-estimate the military impact of chemical weapons against forces with anti-chemical protection.

It does not appear to have considered the shortcomings of the U.S. persistent agent VX.

It over-states the disadvantage of existing single-fill chemical munitions and does not appear to have examined possible limitations of binary weapons of current design.

It does not discuss the possibility and implications of very high levels of civilian casualties from chemical war in Europe.

2. These conclusions lead me to the following differences on major, near-term policy issues:

Issue	DSB panel	Comments
Bigeye	Accelerate Bigeye VX programs to produce concurrently or ahead of 155mm binary artillery munitions.	Defer Bigeye production. Review military requirement for specific missions. May have low deliverability and inadequate target effects.
Binary artillery munitions	Produce	No pressing need for new production of artillery munitions. Maintain and upgrade existing stockpile.

Senator WARNER. We will now proceed to the final panel consisting of Dr. John M. Deutch, dean of science, Massachusetts Institute of Technology and Dr. John Baldeschwieler, professor of chemistry, Cal Tech, California.

Dr. Deutch, we welcome you. You may proceed.

STATEMENT OF JOHN M. DEUTCH, DEAN OF SCIENCE, MASSACHUSETTS INSTITUTE OF TECHNOLOGY, CAMBRIDGE, MASS.

Dr. DEUTCH. Thank you very much, Mr. Chairman.

Let me make my remarks brief. I know you have had a long day here and it will give us an opportunity to discuss some of these very important and complicated issues.

Senator WARNER. That is all right. We have been at it all day, that is for sure, but this is an important subject and you take all the time you feel you need.

Dr. DEUTCH. Thank you, Mr. Chairman.

I am a professor of chemistry at the Massachusetts Institute of Technology and dean of science. I am also a member of the Defense Science Board and have been so since 1975.

During the summer of 1980 I was requested to chair a study of the Defense Science Board concerning all aspects of chemical warfare and the complex issue that this very difficult subject presents to us.

That study covered a great variety of subjects. Let me mention them to you because I believe that it is important to keep in mind the range of subjects that are of importance in chemical warfare.

First and foremost, the nature of the chemical warfare threat that we and our allies face.

Second, intelligence issues concerning events which take place by our adversaries in the area of chemical warfare.

Third, a wide range of policy considerations, including arms control questions and questions having to do with the proliferation of chemical weapons capability to other nations.

Fourth, the needs for improving our defensive posture in chemical warfare, both in the United States and within the NATO allies.

Fifth, the requirements that we have for improving our offensive chemical warfare capability.

Sixth, research and development needs both in short-term and long-term technology bearing primarily on defensive protection.

Finally, the very important issue of demilitarizing our old stocks of chemical agents, both in the United States, Johnson Island, and in Europe which are no longer of importance to us.

We made a wide range of recommendations to the then-Secretary of Defense which I believe have had an impact on the Department of Defense in examining their chemical warfare policy and programs.

Today I am here to give you some of my personal views on these matters. I am not representing the Defense Science Board, the Department of Defense, or MIT.

Let me begin by stating that I believe chemical warfare is abhorrent. Our problem is to assure that it will not be used in the future. Therefore, the principal issue that we face is how to adopt policies and supporting programs that would lead to deterrence to chemical weapons use.

Now chemical weapons can be used for two reasons.

First, as in the case of Afghanistan and Southeast Asia, to strike terror in unsophisticated military units or in an undefended civilian population.

However, chemical weapons can also be used against a sophisticated military adversary in order to cause him to suit up, to don protective equipment, to put on the paraphernalia needed to defend oneself against contact with nerve agents.

This process of suiting up significantly reduces, in my judgment, military force effectiveness despite the presence of adequate training and despite the presence of the best available defensive protection equipment both for units and for individuals.

Let me remind you that in NATO, of course, such training and such defensive protection is in fact neither available nor presently programed for most of the NATO countries.

Therefore, given the fact that we do not have the capability and, indeed, in principle it is not possible to deter CW use on the basis of defensive protective measures alone, we face the question of how do we deter Soviet chemical weapons use.

There are those who might argue that we should rely on nuclear weapons. I would consider such a course of action neither credible nor wise. There are others who would say that we should improve our conventional force posture in Europe in order to offset whatever decrement we might suffer from having to suit up in the face of a chemical weapons attack. I wish that that were possible to do, but I am not sure that that is a realistic proposal at this present time given the balance of forces in Europe.

Let me just point out to you that it is my judgment that Soviet capability is improving in the area of chemical weapons and their doctrine does call for its use. There are gaps, important gaps, in our knowledge about Soviet doctrine and capability. Nevertheless, the evidence is quite overwhelming in their capability and their intent to use CW in a NATO war.

In contrast, the United States and NATO capability for CW conflict is weak and declining. We have no adequate exercise program or doctrine for fighting chemical warfare. We do not have a reasonable mix of CW weapons which can be used to threaten the Soviet Union with suiting up, just as we are threatened at the present time. We have inadequate provision for defensive protection equipment and training and its use.

Let me turn next to arms control very briefly, Mr. Chairman. I regard the prospects as extremely dim. Let me just make two remarks about that. It would require, in my judgment, extensive onsite verification. The verification issues, however, would still remain formidable, and at the present time I regard them as insurmountable.

Moreover, we have progressive amounts of evidence that I am sure you have heard about here today of Soviet misconduct in the area of chemical weapons and biological warfare which I think must influence our views toward the possibility of such arms control negotiations.

I conclude, Mr. Chairman, that our allied capability is very weak and that it is an invitation for further Soviet adventures into chemical warfare. Our principal objective must be to deter Soviet chemical weapons use. The best way I see of doing that is first and foremost to improve our defensive posture, but this will not be enough by itself. We must strengthen our retaliatory capability by building some chemical warfare agents that are credibly deployed as weapons systems, especially those which reach toward higher value, deeper range targets. Thus, in my view, chemical warfare capability must accompany improvement in defensive posture.

Once one recognizes the need for an improvement in our chemical warfare weapons capability, it seems to me that binary chemical weapons are the choice. This is primarily for the reasons of safety, their transportation, their deployment, and from the demilitarization point of view.

Chemical warfare is a problem that NATO can solve. It is not an easy problem, it is not a pleasant problem, but I do hope that this Nation takes the leadership in company with our allies to address these important and complex questions.

Thank you very much, Mr. Chairman.

Senator WARNER. Thank you very much.

We would like to hear from the other panelist before we proceed to questions.

Dr. Baldeschwieler.

STATEMENT OF JOHN BALDESCHWIELER, PROFESSOR OF CHEMISTRY, CALIFORNIA TECH, PASADENA, CALIF.

Dr. BALDESCHWIELER. My name is John Baldeschwieler. I am professor of chemistry at Cal Tech in Pasadena, Calif.

My background and experience are outlined in an attached CV to the prepared comments that I have today. Although I was quite familar with chemical warfare programs and issues during my service on the President's Science Advisory Committee from 1969 through 1971 and as Deputy Director of the Office of Science and Technology from 1971 to 1973, I have not been directly involved in this area since 1973. So I am here today to give you some of my personal views only.

In the early 1970's it was evident that the Soviets had devoted major efforts to both offensive and defense aspects of chemical warfare. Although there was considerable uncertainty as to the exact magnitude of the Soviet stockpile of chemical munitions, the capacity of their production facilities, and the size of their research and development effort, it was clear that these activities were large and were an integral part of Soviet offensive doctrine.

Soviet activities in the defensive areas were understood in greater quantitative detail and involved, for example, fundamental design practices for combat ships and armored vehicles to provide positive control of ventilation and filtering systems to allow continuing operations in contaminated environments.

Soviet defensive practices also involved widespread issue of decontamination systems, masks, protective clothing, and individual antidote kits as standard items of equipment. Operations with this equipment were frequently exercised. The Soviet force structure in 1973 was configured for a significant offensive and defensive chemical war fighting capability.

In contrast, the U.S. stockpile of chemical munitions in 1973 was small compared with estimates of the Soviet inventory. Much of the U.S. reserves consisted of obsolete munitions such as chemical land mines and agents such as mustard or phosgene. Production of agents has ceased, production facilities had been decommissioned, and it was estimated that 18 to 24 months would be required to resume agent production.