

Comments on the Defense Science Board (DSB) Chemical Warfare Panel Report

M. Meselson  
Department of Biochemistry and Molecular Biology  
Harvard University  
Cambridge, Massachusetts  
8 January 1981

I. SUMMARY

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

- o It rightly emphasizes the need for
  - . upgraded intelligence
  - . 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
- o It presents data which over-estimate the military impact of chemical weapons against forces with anti-chemical protection
- o It does not appear to have considered the shortcomings of the U.S. persistent agent VX
- o 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
- o 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:

<u>Issue</u>	<u>DSB Panel</u>	<u>Comments</u>
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.

## II. 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.

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. The severe lack of evidence regarding Soviet offensive capabilities points to the need for up-grading intelligence efforts as recommended by the DSB panel. 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 times the \$2.47B 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 minutes." 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

<u>Amount (mg)</u>	<u>Time to Incapacitation</u>
<u>In the body</u>	0.6 ("pinhead")
<u>Applied to average skin</u>	10. 200.
<u>Applied to U.S. Army summer uniform</u>	100.

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 in open terrain or open foxholes would cause 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 casualties, expected to develop within the first twelve hours after the attack. Substantial casualty prevention can be achieved by decontaminating or changing clothing or decontaminating skin even up to 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 weapons, 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 today'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.) suits 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 recommended 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 ensemble 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 soon to be made serviceable 155-mm and 8-inch nerve agent projectiles in the U.S. stockpile. 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 particularly 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 chemical artillery ammunition for a 30-day full-scale war in Europe, or if 155-mm mustard rounds are

Included. This assumes an overall 30-day expenditure, chemical and HE, of  
 Although the U.S.  
 other NATO forces do, and could therefore utilize additional U.S. stocks  
 and mustard projectiles, amounting to

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 \_\_\_\_\_ 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 design 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:

o Sound. With their \_\_\_\_\_ burster charge and  
 currently designed binary rounds likely make a sound when they burst which is  
 \_\_\_\_\_ 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 dis-  
 tinguished from fragmentation shells.

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

o 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 binary munitions be used without adverse effects on their performance?

o 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?

o 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:

o 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?

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

o Deposition density. If the VX air-delivered bomb is required, is the individually low deposition density of Bigeye adequate? This is 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 or 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 non-combatants 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 probable 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.