THE AFTERMATH OF A SINGLE NUCLEAR DETONATION BY ACCIDENT OR SABOTAGE: SOME PROBLEMS AFFECTING US POLICY, MILITARY REACTIONS, AND PUBLIC INFORMATION

Fred Charles Ikle
In collaboration with J.E. Hill

RM-2364 (ABRIDGED)

May 8, 1959

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AFFECTING U.S. POLICY, MILITARY REACTIONS,
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SUMMARY

The United States should be prepared for the event of a single detonation of a nuclear weapon occurring in the West or the Soviet bloc as a result of an accident, or an enemy act to simulate an accident. There might be no evidence left of the cause, and in some situations it would be uncertain whether the detonation was not the beginning of an enemy attack.

A DETONATION IN THE WEST

A destructive accidental detonation in the West would create a severe political crisis which could jeopardize the security of the United States and its allies. The specific consequences, of course, would depend on the amount of damage and the political-military climate at the time. The reaction in countries with U.S. bases might range from a request that nuclear operations be curtailed to a cessation of the alliance with the United States. The latter would probably occur only in a country where a disaster could lead to a communist coup d'état or a popular-front government. Throughout the West the public and governments would suddenly have acute anxieties
about nuclear weapons, and the resolve to stand firm against enemy pressures might be weakened since the horrors of nuclear war would have become so awesomely real.

The Soviets (or Chinese Communists) would try to maximize whatever gains the situation offered. Their most effective policy might be to propose extensive nuclear disarmament without effective controls so as to favor their own position. Since the West would suffer from moral dismay, internal opposition to nuclear weapons, and fear of war, the Soviet Union might well obtain quick agreements largely upon its own terms.

In view of the potential gains, the Soviets might be tempted to detonate a nuclear weapon in the West, so as to simulate an accident for which the United States (or United Kingdom) seemed to be responsible. Although one can think of techniques that might leave no evidence, the Soviets would face grave uncertainties which may always deter them from such a stratagem. Should an accidental detonation take place in the West, however, nuclear sabotage would surely be more tempting to the Soviet Union, since the risks would seem smaller and the gains much greater.
POLICIES AND MEASURES AFTER A SINGLE DETONATION

Some measures can be suggested to mitigate these political and military consequences, but can at best provide broad guidelines, since it is obviously impossible to anticipate a detailed policy.

The measures described below do not apply to an accidental detonation which causes no damage. If such an accident occurred in a remote area, so that leakage to the press could be prevented, no information ought to be made public; if it occurred in an area where explanations would be demanded, it might be depicted as a failure during an experiment, an event which did not reflect on nuclear weapons safety.

Military Alert Measures.

If the Detonation Immediately Appears to be Accidental. Low alert measures would be indicated because: (1) during a crisis it is generally prudent to take alert measures; (2) the alert should avoid operations that might induce the enemy to attack or lead to incidents; and (3) the enemy's intelligence would analyze the Western reaction, so that a fast and determined response would bolster deterrence.

If the Cause of the Detonation is not Immediately Known. High alert measures for all forces would seem appropriate because: (1) as above, an effective response would bolster
deterrence in the future if the detonation turned out to be accidental; (2) the detonation might signal an enemy attack (a ragged attack, or a premature detonation in the context of a planned attack). Quick alert measures would improve the outcome of the war if the enemy went through with its strike, and they might well cause cancellation of the attack. However, the alert should minimize the risk of misunderstandings and incidents. In particular, inappropriate reactions by military elements in the field should be prevented between the time the detonation becomes known locally and the time when instructions have been transmitted from higher authorities.

**New Safety Measures.** The services would probably have to make some immediate changes in nuclear operations in response to fears of another unauthorized detonation. Public pressures might necessitate some temporary compromises (e.g. rerouting of SAC flights) to avoid more serious degradations (e.g. grounding of all SAC planes).

**Public Information Policies**

The news of a large nuclear disaster would spread almost instantly, but public clarification of its cause and of the question whether it might mean war would not follow automatically. Furthermore, the detonation might be reported
through several channels so that it would be uncertain whether one or more explosions had occurred.

An initial announcement by the U.S. government could speedily accomplish many objectives: (1) communicate to U.S. and allied military headquarters -- to the extent that they could not be reached immediately through internal channels -- that prepared alert measures should be taken, but all actions avoided which would be appropriate only for the event of war; (2) indirectly inform the Soviet government that the United States is not publicly alerting its population and forces for war, but is quickly improving its alert posture in a non-provocative way (if the detonation was the beginning of an attack, such an announcement might lead to its cancellation); (3) convey to the country of occurrence (if the detonation occurred abroad) that the U.S. government does not think this disaster means war, and promise immediate help; initiate civil defense measures locally (for a domestic disaster); (4) communicate to neutral governments and the public at home and abroad that the U.S. government is doing everything to maintain world peace; and avoid a commitment on the exact cause of the detonation until an investigation was completed.

One or two messages could communicate all these points. For example, a non-military announcement might originate from
the White House, and a message regarding military aspects from
the Department of Defense. If the necessary alert measures are
minimal, the latter might be postponed or omitted.

The initial announcement should also state that a board
of inquiry is being set up to investigate the cause. The
question of the cause would become the main issue for the long-
range public information program. It would have to be dealt
with very carefully because of the sabotage possibility and
the necessity of restoring some confidence in weapon safety.
But uncertainties as to the cause might also have a certain
beneficial effect, by providing a reason for temporizing poli-
tical decisions on nuclear weapons until the initial emotional
reactions had subsided.

**Disarmament Initiatives and Policies for Foreign Bases.**

Some of the above-mentioned Soviet moves might be countered
with U.S. or Western initiatives on disarmament. These initia-
tives should emphasize inspection and vigorously attack secrecy,
to force the issue into a broader context more favorable to the
West than the Communists. Thus, domestic pressures in the
United States and allied countries might be reduced and neu-
tralist nations be kept from siding with the Soviet bloc.
However, since the time right after the detonation would be
inopportune for actual negotiations, the early proposals should
serve only to counter Soviet propaganda.
Possible requests from foreign countries that the United States abandon its bases, or at least withdraw all nuclear weapons, might be mitigated with local adjustments such as temporary inactivation of some bases. The objective would be to deprive elements hostile to the United States of their principal issue and maintain friendly relations with the foreign governments. Rehabilitation of the bases might be feasible after the inquiry was completed and new safety measures instituted.

A DETONATION IN THE SINO-SOVIET BLOC

The cause of an accidental detonation of a Soviet weapon might initially be unknown to the Soviet government. Regardless of cause, the Soviet government would have to react publicly, unless the detonation could be concealed or passed off as a test. It could accept blame for the disaster; it might try to blame the United States or accuse vaguely defined "enemies" or "saboteurs". The Soviet government might well feel that, if it blamed the United States outright, the latter would be alarmed to the point of pre-emptive action. Should the Soviet Union choose to regard a nuclear accident as a provocation by one of the lesser allied powers and to make this an excuse for limited, local aggression, it would still have to face a powerful U.S. reaction. Hence, Soviet leaders might rather blame "saboteurs."
The United States would probably first learn of the detonation through its test detection system. The Western military alert problem would be less critical than in case of a detonation of unknown cause in the West, except if the Soviet Union accused a Western nation and/or took threatening alert measures. However, warning facilities should be placed on highest alert, and additional low alert measures might be indicated for SAC and NORAD, for example.

The U.S. public information program would have to adapt itself to the Soviet policy. In case of Soviet concealment, the United States would stand to gain from announcing the nuclear accident. If the Soviet government blamed the United States, the latter should demand an international investigation. If the Soviet government accused unnamed "saboteurs", the United States might also insist on an international investigation, offer aid teams, and attempt to expose the Soviet charges as a cover-up for irresponsible practices with nuclear weapons.

Hypothetically, a nuclear detonation within Soviet territory could be due to an accident in the West, for example, an accidental missile launching. Obviously, the most extensive precautions have been taken to prevent such a disaster. If such an exceedingly unlikely event does occur, however, the United States (or its allies) should avoid public self-implication until it has completed an investigation. This would
permit the United States to start secret negotiations (without assuming explicit responsibility) to discourage the Soviet government from committing itself to unacceptable demands which might lead to all-out war. In these negotiations, the U.S. might offer to discuss the question of liability, but should refuse to negotiate about political or military Soviet demands. The West should not disregard the possibility that a third power was involved, or even that Soviet agents instigated the "accident" to cause dissension in the West and to obtain vast concessions. The Western military reaction should avoid confirming Soviet fears that the detonation signalled a U.S. attack, but consist of fast, defensive alert measures, to cope with the risk of nuclear war by misunderstanding. But after the first day or so, the dominant danger would be that the Soviet Union might have previously planned local aggression and might choose this moment of dissension and self-incrimination in the West to launch a limited war.

CONTINGENCY PLANNING AND PREVENTIVE MEASURES

Preparations for the Military Reaction.

Probably no new types of alert are needed, since local commanders could choose the most appropriate alert measures among those already prepared. It may be
undesirable to commit higher commands to a specific reaction, as long as inappropriate reactions in the field -- either precipitate or sluggish -- have been precluded. The over-all response would, of course, not only involve Air Force commands but also joint commands and allied commands, for example SHAPE.

**Preparations for Public Information.**

Ready made news releases are not the full answer for public information planning; they might even increase the risk of leaks. For the lower levels, the preparations merely require instructions that no information should be released in the field, except what is necessary for public safety.

The over-all U.S. information program after a single detonation would have to be controlled at the highest level. For this control and co-ordination, advance preparations seem desirable since speed would be essential. The program would involve the White House, the Department of Defense, the Department of State (communications with allies, possible United Nations initiatives), and the U.S. Information Agency. The initiative for planning, however, can come from the U.S. Air Force or the Department of Defense.
Gains from Contingency Planning.

A detonation which caused many casualties would have a severe emotional impact, not only upon the public but also upon government leaders. Advance planning could condition people for a prudent reaction in the moment of crisis; it would make the difficulties known to command posts and selected information offices; it would point out pitfalls and opportunities that might be overlooked during the immediate emergency; and the knowledge that a plan existed would in itself give some strength.

To some extent these benefits from contingency planning might even be extended to allied headquarters. The risk of an accidental detonation of a U.S. weapon, however, should be de-emphasized, and the uncertainties of Soviet weapons and Soviet attack instead be used to justify the planning.

With the United Kingdom it might be feasible to establish a joint safety board, which could be helpful for minor incidents with nuclear weapons and would create a precedent for shared responsibility.

A considerable amount of information has been made available to the public about the problems of weapon safety, reaction times, nuclear sabotage, etc. Thus, it would seem unjustified to argue that the basic issue was being withheld from the public. More detailed information might endanger classified aspects of weapon design and alert measures.
Additional Preventive Measures.

The prevention of any unauthorized detonation obviously has absolute priority over preparations for the aftermath of such an event. The services and the A.E.C. maintain a large and continuous effort to attain the highest degree of safety compatible with the military mission. This study does not deal with the safety effort, except to re-emphasize its importance and to make some tentative suggestions in two special areas.

First, against the risk of sabotage, two measures might be considered: (1) renewed publicity for the Atomic Weapons Reward Act of 1955 (without implying increased U.S. vulnerability to sabotage), and possible extension of the Act to apply to U.S. military installations overseas; (2) the incorporation of tracer elements in (selected) U.S. weapons to deter sabotage with a smuggled weapon.

Second, another preventive measure that should be evaluated is the adoption of a precautionary rule to keep high yield weapons away from the largest cities, unless the weapons contribute substantially to the defense effort by being in these cities. Depending on where the line is drawn with regard to city size, such a rule might require little change in current operations.
Finally, it must be stressed that the risk of nuclear accidents must be balanced against the risk of nuclear war. It would be unfortunate if excessive concern with the safety of weapons increased the likelihood of enemy attack.
INTRODUCTION:

THE RISK OF NUCLEAR ACCIDENTS VERSUS THE RISK OF NUCLEAR WAR

The United States government has long made it clear that it favors an international agreement on disarmament to reduce both nuclear and conventional forces, provided the agreement is safeguarded against violations through an effective international control and inspection system. The necessary inspection system may well be feasible technically -- if not for the nuclear stockpiles then at least for the delivery capabilities -- but it would represent such a radical break with the communist policy of secrecy and totalitarian controls that its adoption unfortunately seems extremely unlikely. At least at present, no disarmament inspection system is even being negotiated, and the slow progress during the last half year in the discussions on safeguards against surprise attack and in the negotiations on atomic test suspension make it doubtful whether even the most minimal inspection procedures will ever be accepted by the Soviet Union.

Given this situation where the Soviet Union possesses a strong and growing nuclear capability in combination with all the conventional forces of the communist bloc, the United States must maintain a nuclear retaliatory capability in order to deter an attack. But a retaliatory force which could not
survive an enemy surprise strike would invite rather than deter military aggression. Hence, the United States must protect and maintain its nuclear weapons in such a condition that they can be delivered to enemy targets before they are destroyed. This means they must be ready to be detonated at enemy targets in a rather short time. Some technical system must exist to effect launch and detonation relatively quickly either through a number of human actions or the combination of human actions and environmental influences (such as acceleration in a missile warhead). Carefully designed technical systems will be relatively free of malfunction, and well-trained, responsible human operators will rarely, if ever, commit serious errors. As long as there are nuclear weapons that can be detonated, however, the probability is not zero that a detonation might occur when it should not, that is without the intent of the proper authorities. In theory this probability increases with the number of weapons. *

It must also be remembered that the United States can exercise only a limited influence on the safety of British weapons, and that it has no control over the safety of Soviet nuclear weapons. Furthermore, it cannot make nuclear sabotage

impossible, it can at best render it difficult and try to deter it.

One might seek to reduce the risk of an unauthorized detonation further by keeping the weapons in a more disassembled state, carrying out fewer peacetime operations with them, and storing them more centrally. This would decrease the probability of such a detonation by an uncertain amount, at the expense of an increase in the vulnerability of the retaliatory forces and hence an increase in the probability of nuclear war. Not all safety measures, of course, degrade the retaliatory capability. Generally it is the operational restrictions which do so, rather than the technical safeguards.

A certain compromise is always necessary, however, and many safety measures have indeed been accepted in spite of the fact that they do degrade the military capability. In other words, some increase in the risk of nuclear war is being tolerated in order to decrease the risk of a nuclear accident. The great danger is that this delicate compromise might be ignored if an unauthorized detonation actually occurred. In such an event, the danger of enemy attack might seem no more apparent than before, but the danger of an unauthorized detonation would have become terribly real. It might appear more urgent to make another unauthorized detonation forever impossible than to maintain full retaliatory strength. This reaction could
jeopardize the sole protection against the enemy's capability totally to destroy the nation.

Some weapon systems and nuclear operations would be affected more than others. The system in which the unauthorized detonation occurred would probably suffer the greatest curtailments. If the detonation occurred, for example, in connection with SAC's airborne alert, this operation might be stopped precisely at a time when its deterrent value against enemy attack was most needed. Likewise, a detonation in connection with a submarine might set back the Polaris program, or a detonation of a Nike warhead might cripple the entire Nike forces.

The government must be prepared to cope with the military and political crisis that a single detonation would precipitate. This problem is the subject of the present study. It is recognized of course that the primary objective of the services and the AEC in this connection is -- and must be -- the prevention of an unauthorized or accidental detonation. However, the fact that reduction of the risk of such a detonation has priority in the field of weapons safety should not result in failure to consider measures that might mitigate the consequences of such a disaster, should one occur.
PART I. A NUCLEAR DETONATION IN THE WEST

THE QUESTION OF THE CAUSE

If a single nuclear detonation occurred, news of it would travel speedily. If civilian damage was large, this news would be flashed all over the world almost instantly. But in many circumstances the cause of the detonation would remain unknown for some time, if indeed it ever became known. This time lag would be of decisive importance for the initial policy after the detonation.

Immediately, the most crucial question for government leaders and military commanders would be whether the single detonation should be interpreted as a signal of enemy attack. If so, the detonation could be due to a premature launching of an enemy missile, to the first bomb drop of a sneak bomber raid, or to the premature explosion of a clandestinely planted weapon. (This weapon, of course, might be only one of many so planted.) Further detonations at SAC bases, control centers, or other likely targets would confirm that the detonation was part of a deliberate enemy attack.¹ So would, of course, the sighting of enemy missiles or bombers.

¹When ballistic missiles become the major part of the strategic force, nuclear detonations from the first arriving
As more time elapsed after the single detonation it would appear more likely to the decision makers that this detonation was not part of a deliberate enemy attack. However, without further evidence as to the true cause of the detonation, the passage of time would not rule out the possibility that the single detonation was a prematurely exploded enemy weapon, to be followed by the full weight of an attack -- or, indeed, that such a premature act had led the enemy to cancel his attack or to postpone it until the Western alert measures declined. Thus, unless the cause of the detonation were immediately and unequivocally established, the decision makers would initially have to proceed in a way appropriate for both contingencies: (1) an enemy attack (i.e., war); and (2) a single detonation caused accidentally or by sabotage.

In the event that the single detonation was not part of an enemy attack it might be due to one of the following causes:

enemy missiles may be the only warning of an enemy attack that is decisive enough for the United States (and its allies) to commit itself irrevocably to an all-out war by launching its retaliatory missiles before they are all destroyed. The crucial question that will have to be answered is how many detonations -- two or more -- would constitute sufficient indication that an enemy attack was under way and rule out the hypothesis of a nuclear accident.

2In certain circumstances the location and yield of the detonation may strongly suggest an accident and permit one to rule out an enemy attack, although the actual cause of the detonation may still be unknown. E.g., a low-yield, high-altitude detonation in an area where air-defense weapons exist.
A. Internal cause, within U.S. (or U.K.) weapon system and/or personnel.

1. Technical malfunction.
   a. Random failure of weapon components without identifiable external influence (e.g., short circuit in fuzing and firing system).
   b. In connection with external influences during normal operations (e.g., stray voltages from other equipment).
   c. In connection with external violence to the weapon (e.g., plane crash).
   d. A combination of above (a more likely cause for a full detonation than any single type of technical malfunction).

2. Human errors. Probably only a combination of several human errors and technical malfunction could produce a full detonation.

3. Deliberate irrational human act.

B. External cause, outside U.S. (or U.K.) weapon system and personnel.

1. Sabotage instigated by a foreign power.
   a. Through a clandestinely smuggled Soviet
weapon. (Conceivably, near the Soviet border, the weapon might be covertly delivered by missile.)

b. Through an agent who gains access to a U.S. (or U.K.) weapon, either with or without implication of authorized personnel.

2. Delivery of a Soviet weapon in the West not authorized by the Soviet government. For example, a missile might be launched accidentally on a U.S. target. Another possibility might be a deliberate missile launch by a dissident group in an attempt to force the government's hand.

3 Later, when there are other potential enemy powers which possess nuclear weapons, they might also cause sabotage with a smuggled weapon or have an accident which leads to a detonation in the West. Already, however, other governments than the Soviet could theoretically detonate a U.S. weapon through an agent; for example the might try to have an agent detonate a U.S. weapon. Popular discussions have mentioned the possibility that a "neutral" power might want to start a nuclear war between the United States and the Soviet Union to advance its own objectives, by causing a detonation in the United States (or Soviet Union) that would be taken as a signal of enemy attack. There are three uncertainties which would make this bizarre act rather unattractive even to the most reckless independent nuclear power: (1) the uncertainty whether the victim country (say the United States) would in fact blame the detonation on the other major nuclear power (say the

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ATOMIC ENERGY ACT—1954
As mentioned before, the actual cause of a single detonation would not be immediately known in most circumstances. We must give further consideration to situations where the cause would remain uncertain for some time or would never be known. These situations obviously introduce important complications for U.S. policy. Moreover, they are a relatively likely outcome of a single detonation, because the detonation itself may well destroy the evidence of the cause. In order to give the reader a feeling for the many possible combinations of causes and for the difficulties of interpreting the evidences of these, we will now list some examples. These examples are only illustrative and do not exhaust the possibilities.

Soviet Union) rather than on the independent nuclear power; (2) the uncertainty whether this would lead to the bipolar war desired by the independent power, even if the victim country did blame the other major power; (3) the uncertainty whether the outcome of such a war would in fact be advantageous to the independent power.
## Table 1.
ILLUSTRATIVE EXAMPLES OF CAUSES AND EVIDENCE OF SINGLE DETONATIONS

<table>
<thead>
<tr>
<th>Cause of Single Detonation</th>
<th>Interpretation of Cause that Can Be Made from Available Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. Internal Cause within U.S. (U.K.) Weapon System or Personnel</strong></td>
<td></td>
</tr>
<tr>
<td>(1) and (2) Technical Malfunction and Human Error</td>
<td></td>
</tr>
<tr>
<td>Aircraft jettisons a live weapon which was accidentally armed due to human errors in combination with malfunction.</td>
<td>Aircraft radios back description of accident; cause known in principle.</td>
</tr>
<tr>
<td>Malfunctions, perhaps combined with human errors, lead to a full MT detonation during ground handling at storage site or base</td>
<td>Cause unknown.</td>
</tr>
</tbody>
</table>

---

This illustrative list of causes is purely hypothetical and does not imply any estimate as to their relatively likelihood. If there was a known significant risk from any of these causes it would obviously be eliminated by the continuous safety efforts of the services and the AEC. Also, operational and technical changes may make some of our illustrations inapplicable.
<table>
<thead>
<tr>
<th>Cause of Single Detonation</th>
<th>Interpretation of Cause that Can Be Made from Available Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Immediate (within first hour or so)</td>
</tr>
<tr>
<td>(3) Deliberate Irrational Act</td>
<td>Cause unknown</td>
</tr>
<tr>
<td>Unauthorized take-off of a fighter plane which was on ground alert with live weapon and subsequent armed bomb drop</td>
<td>Unless the weapon was detonated on the base from which the plane took off, the unauthorized take-off would immediately be known</td>
</tr>
</tbody>
</table>

B. External Cause outside of U.S. (U.K.) Weapon System or Personnel

(1) Sabotage Instigated by a Foreign Power

Soviet agents smuggle a megaton weapon under or alongside an aircraft carrier

<table>
<thead>
<tr>
<th></th>
<th>Immediate (within first hour or so)</th>
<th>Delayed (after inquiry of several days)</th>
<th>Final (after inquiry of many months)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cause unknown&lt;sup&gt;b&lt;/sup&gt;</td>
<td>Cause unknown&lt;sup&gt;b&lt;/sup&gt;</td>
<td>Cause unknown (analysis of radioactive debris, yield, and remnants of the carrier may suggest sabotage)</td>
</tr>
</tbody>
</table>

<sup>b</sup> In this case the Soviet leadership, of course, would know the cause. The problem of sabotage will be further discussed below.
<table>
<thead>
<tr>
<th>Cause of Single Detonation</th>
<th>Interpretation of Cause that Can Be Made from Available Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agent(s) instructed by foreign power gain access to U.S. weapon and bring it to detonation</td>
<td>Immediate (within first hour or so)</td>
</tr>
<tr>
<td>(2) Accidental Delivery of S.U. Weapon in the West</td>
<td>Cause unknown</td>
</tr>
<tr>
<td>An armed Soviet missile is accidentally launched against U.S. target</td>
<td>If U.S. weapons were kept at this target, the detonation might first suggest a U.S. accident.</td>
</tr>
</tbody>
</table>
AMOUNT OF DAMAGE AND POLITICAL CIRCUMSTANCES

We cannot discuss how the adverse political and military consequences of a single nuclear detonation might be mitigated without some perspective of the range of circumstances in which such a detonation could occur. The important variables are: (1) the political-military climate that prevails at the time the detonation occurs, (2) the yield, (3) the location, (4) the amount of civilian damage, and (5) the amount of military damage. Variables (4) and (5) are in turn determined by yield and location.

The political-military climate can be divided into the following broad categories:
(a) a relatively quiet situation
(b) a political crisis
(c) a limited war not involving nuclear weapons
(d) a limited nuclear war.\(^4\)

The problem of an accidental or unauthorized detonation which occurs during a limited war is outside the scope of this study. In order to make suggestions for such an event one would have to develop many scenarios of possible limited war situations. Nor is it possible to examine here how the

\(^4\) In case of a limited war in which tactical nuclear weapons are employed locally, a single detonation might occur outside of these geographical limits.
single-detonation problem would be modified by the many possible forms and degrees of political crises. However, our general observations should have validity both for a relatively quiet situation and for a political crisis. Furthermore, some of the basic aspects would also be pertinent for a limited war situation.

Outside of the question of cause, the yield and location are all-decisive for the consequences of a single detonation.

On the other hand, if a megaton explosion occurred in an urban area it could lead to momentous changes in existing political and military arrangements.

The probability of an accidental or unauthorized detonation cannot be estimated. Yet in some situations this probability seems less remote than in others. Generally, the risk would tend to increase with: (1) the number of weapons, (2) the amount of handling of weapons, and (3) the readiness of the weapon system.
This comparison, however, does not consider the relative probability of sabotage. The same considerations apply to the location of a single detonation: it is more likely in places where there are many weapons and where they are handled frequently.

A limited war would increase the risk of an unauthorized detonation since the amount of weapons handling and the state of readiness would increase. This is also true, perhaps to a lesser degree, of a political crisis.

The likelihood that a single detonation signals the beginning of an all-out enemy attack would seem much greater to the decision makers in a tense situation than it would in a relatively quiet period. Yet in fact the probabilities may lie in the opposite direction, since the enemy could achieve the greatest surprise by attacking during a quiet period. On the other hand, the heightened expectation of all-out war may be justified, since a crisis situation may force the enemy's hand for political reasons and prevent him from postponing the attack until a more opportune moment.

Before we consider the political and military consequences of a single nuclear detonation we ought to have an idea about
the possible damage in terms of destruction and casualties under different circumstances:

(1) At the low end of the scale would be an accidental detonation which caused practically no damage at all. Examples

(2) They would certainly attract considerable public attention, which might lead to adverse political

(3) In the event of a ground burst, fallout might cause an additional 500 to 2,000 casualties, mostly nonfatal, and contaminate an area of over a hundred square miles so as to require temporary evacuation for a couple of days.
(4) The extent of destruction which would be wrought by a detonation in the 15 to 20 KT range in an urban area is well known from Hiroshima and Nagasaki. In the event of a groundburst, fallout could produce lethal radiation 5 to 10 miles downwind, unless people were protected in basements or stone houses.

(5) At the upper end of the scale would be groundburst detonations in the megaton range in populated areas, for example:  

A westerly wind could spread the dangerous fallout area from Louisiana through Mississippi towards Alabama. The number of fallout injuries would, of course, depend strongly on wind direction and the extent to which people responded to post-detonation warnings by either staying in their basements or promptly evacuating (in the right direction!).

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5It must be strongly re-emphasized that these examples are for illustrative purposes only, to convey a picture of the kind of disaster that might be caused by some of the worst cases of single accidental or enemy-caused detonations.
A north-easterly wind would spread fallout into the more densely populated London metropolitan region, whereas a wind in the opposite direction would blow the fallout over the North Sea and keep the number of casualties much smaller.

(c) If a 1 megaton weapon detonated full-scale in or under an aircraft carrier (sabotage) while it was anchored off the harbor of Naples, Italy, about a million people might be killed and half a million seriously injured.

In the above cases the yield ranks inversely with the number of casualties, the latter being highest in case (c) and the former in case (a). This illustrates the importance of the population density in the area of the detonation.  

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6 For the possible long-range contamination effects, see Appendix I.
POSSIBLE POLITICAL AND MILITARY CONSEQUENCES

U.S. and Allied Reactions.

An accidental or unauthorized nuclear detonation which caused substantial damage would suddenly create acute anxieties about peacetime operations with nuclear weapons, not only among the public, but also in Congress and the services. If the detonation was found or suspected to be due to faulty U.S. equipment or actions by U.S. military personnel, it might result in demands for far-reaching restrictions on nuclear weapons, which could endanger the country's ability to respond to surprise attack. Congress might pass new legislation regarding the control and handling of nuclear weapons for the purpose of reducing the risk of another similar catastrophe. This would probably be preceded by a Congressional investigation of the disaster and of nuclear weapon safety in general.

A secondary political effect within the United States might be an increase in public pressures for concessions in international negotiations on nuclear disarmament, atom-free zones, or similar measures which might seem to reduce the risk of an accidental nuclear detonation. Fear of nuclear weapons and in particular, of another accident could seriously weaken United States bargaining power in such negotiations during the time immediately following a nuclear disaster.
Abroad, the United States would suffer both military and political losses from an unauthorized nuclear detonation in the West, regardless of whether it took place on U.S. soil or overseas. Obviously the greater the civilian damage the more far-reaching would be the political consequences. The damage to the U.S. position would be the more severe, the more definitely U.S. personnel or equipment were considered responsible for the detonation. The reaction would not be confined to the country where the detonation occurred. If the cause of the disaster were known or surmised to be connected with a U.S. (or British) weapon system, the political reaction would extend to other countries where similar nuclear weapon systems were known or thought to be located.

A particularly dangerous reaction, for example, could follow from a single detonation that appeared to involve the SAC airborne alert if it occurred at a time when the U.S. retaliatory capability was strongly dependent on this operation. The Canadian government might withdraw its permission for the overflight of its territory. This could effectively and suddenly cripple the airborne alert, especially if there were also strong tendencies within the U.S. government itself
to discontinue the operation until the cause of the disaster was found and eliminated.\(^7\)

Almost all overseas base rights would be jeopardized by a nuclear detonation on one of these bases which was attributed to a U.S. weapon. Similarly the arrangements for the weapon transport and storage would be threatened.\(^8\) In addition to these military consequences, the political composition or the general attitude of foreign governments might become less favorable to the United States. For example, if there was an election shortly after a nuclear accident in West Germany, the Social Democrats might come into power with a program of partial or total neutrality. In other countries the communists might even succeed in forming a popular front government (e.g., in case of a large disaster in Italy).

Finally, a large nuclear disaster in the West would have a profound influence on public and governmental attitudes toward nuclear war since it would make the horrors of such a war much

\(^7\)After the harmless accidental bomb drop at Florence, S.C., on March 11, 1958, all flights with weapons of the B-47 and B-52 were discontinued until changes in the bomb suspension system could be made. (At that time these flights were not part of the airborne alert.)

\(^8\)We may recall here that Denmark canceled a scheduled visit of the U.S. atomic submarine Skate on August 21, 1958, because of the risk of an accident in the power plant. (There had never been a serious accident with such power plants.)
more real and frightening. It might weaken the resolve to stand firm against enemy pressures and result in appeasement or defeatism, among both the public and government officials. It is often said that the memory of Hiroshima and Nagasaki tends to strengthen the neutralist outlook of many Japanese and accounts for their strong opposition to nuclear weapons. Yet these nuclear detonations occurred over thirteen years ago and in the context of war! As a corollary to the cramping effects on defense, however, some countries might put a greater effort into civil defense and thereby strengthen their willingness to defend themselves.

Possible Soviet Exploitations

It is to be expected that a single detonation of a nuclear weapon outside the Sino-Soviet bloc would be exploited by the Soviet Union (or Communist China) to maximize political and military gains. At first the Soviet Union might well initiate military alert measures in case the detonation should lead to war. This might simply be done as a standard military response to such a moment of crisis, or it might be due to the the more specific fear of Soviet leaders that the United States
might strike against the Soviet Union if it mistook the single detonation for the beginning of a Soviet attack.\textsuperscript{9}

In most circumstances, however, the Soviet leaders would soon realize that a U.S. attack was scarcely more imminent than before the single detonation.\textsuperscript{10} Hence, they would probably de-emphasize their military alert measures and turn their attention to the enormous opportunity offered by this disaster for weakening the military and political position of the West. For this purpose they could choose among a number of available strategies.

Perhaps the most effective policy for the Soviet Union would be to assume the role of a champion of peace and appear to be genuinely interested in a settlement of international tensions. With such a position it might hope to divide the Western alliances and align political support behind its initiatives. For example, the Soviet government might make dramatic proposals for a summit meeting for the purpose of

\textsuperscript{9}Soviet sources frequently have expressed the idea that an accidental nuclear detonation on the territory of the United States or another Western country might be mistaken for a surprise attack on the West (e.g., Khrushchev in a speech in Moscow on May 24, 1958, and a Pravda editorial of July 6, 1958). But these statements were probably made for propagandistic purposes rather than as genuine warnings.

\textsuperscript{10}Below we will discuss measures that might make a contribution in further dissuading the Soviet leaders from initiating an "accidental" war because of a single detonation.
"agreeing" on immediate disarmament measures, such as abolition of foreign bases, setting up of atom-free zones, prohibitions on the transport of atomic weapons into or over foreign soil, or even a worldwide "renunciation" of nuclear weapons. Such measures would promise the world safety from nuclear detonations and would be in accord with what the Soviet Union has long advocated and propagandized.

If the single detonation occurred on an overseas base, the Soviet Union could invite the country of occurrence to the summit meeting, and this country might be forced to accept the invitation as a result of the post-disaster turmoil and domestic pressures. Other countries with U.S. military bases might be sympathetic towards such a dramatic attempt to solve the danger of nuclear weapons, a danger that would now suddenly appear so awesomely real and immediate. Thus, the Soviet government might use its disarmament and denuclearization proposals to undermine the unity of the Western alliances. It might try to press the United States and its allies into accepting disarmament proposals that would favor Soviet military strength and be without adequate inspection procedures.

Apart from such a political offensive on a global scale, the Soviet Union (and Communist China) could approach individual countries to encourage neutralism. If the disaster occurred in
a country with strong pro-communist elements, the Soviet Union might offer aid teams which could be used to strengthen indigenous communist forces and perhaps foster a coup d'état or popular front government.

Another strategy that the Soviet Union could pursue after a single detonation in the West would be to exert military threats rather than subtle political pressures. This strategy seems less likely, except when the detonation has occurred close to the Sino-Soviet bloc (e.g., West Germany, \[\text{[redacted]}\]). In those areas the Soviet Union might threaten military action unless certain demands were met, such as withdrawal of U.S. nuclear weapons, troops, or bases. It could try to justify this threat (perhaps plausibly among neutralist elements) by maintaining that it had to protect its population from the risk of accidental war, from fallout of another accident near its border, or from the unauthorized or accidental delivery of a U.S. nuclear weapon into Soviet bloc territory. The Soviet government might calculate that the heightened fear of nuclear war in the post-disaster world would force the West to give in.
THE SPECIAL CASE OF SOVIET SABOTAGE

We have seen that the Soviet Union could gain overwhelming political and military advantages from an accidental nuclear detonation within a U.S. or allied weapon system. In view of this, the Soviet leaders might be tempted to have a nuclear weapon detonated so that it would look like an accident for which U.S. (or U.K.) personnel or equipment were responsible. In principle, there are two ways in which this could be accomplished: through an agent using a U.S. or British weapon, or by means of a Soviet weapon exploded at a U.S. or allied nuclear-weapon base.

The former method would offer two advantages for the enemy: (1) the penalties of discovery before the detonation occurred would be smaller since the implication of an individual would be less definitive evidence against the enemy than the discovery of a smuggled weapon (the enemy could claim that the individual was irrational and the plot a figment of his imagination); (2) after the detonation was accomplished all the evidence would point to a U.S. (or U.K.) weapon (assuming that the plot was properly executed). On the other hand, the recruitment of a saboteur for this purpose would be difficult and uncertain, the detonation could not be exactly timed, and
the risk would be considerable that the saboteur would "defect" before executing the plot.

If the Soviet Union used one of its own weapons it could easily control the timing, arrange the plot on short notice, and call it off at the last moment. The two important risks would be: (1) that the weapon would be discovered before the detonation, and (2) that the investigation after the detonation would show that sabotage was involved. In order that the detonation could not be traced to the smuggled weapon, the latter would have to destroy a U.S. weapon of comparable yield.\(^\text{11}\) In addition, its fallout composition should not differ too markedly from that expected of the U.S. weapon, and the center of the crater would have to be located at a point where the U.S. weapon might have been when the detonation took place. This last requirement might be the one most difficult to meet. It might look fairly easy to the enemy to carry one of his weapons near a U.S. overseas storage area (e.g., in a truck), but it might seem too difficult to get it close enough so that the location of the crater would not give it away.

\(^{11}\)If the smuggled weapon exceeded the programmed yield of the U.S. weapon by more than about 30 per cent it would give cause for serious suspicion, if it was below the programmed yield the implication would be less certain because some technical malfunction which might have caused an accidental detonation in the U.S. bomb might also have led to a lower yield.
The enemy could avoid or minimize the problem of the crater location if he knew that nuclear weapons of a certain yield range were stored on a particular aircraft carrier. While the carrier was in a deep port he could place the weapon under it in the form of a mine.\textsuperscript{12}

Evidently the over-all risks of such a sabotage plot would be considerable and the Soviet Union would never embark on it lightly. By far the most serious risk that the enemy would have to evaluate would be whether a single detonation might not start an all-out attack by the United States "accidentally", because the United States mistook the detonation for the beginning of a Soviet attack. As mentioned before, the Soviet leaders would probably consider such an outcome unlikely, but all the same the risk would have to enter their calculations. In addition to the risk of starting an "accidental" war, the enemy would have to consider the risk that sabotage might be detected, either before or after the detonation. Detection would force the United States to take retaliatory action of some kind. However, the enemy might feel confident that his military capabilities...
and American self-restraint would prevent the United States from starting an all-out attack in retaliation for this act of sabotage, and he might think the United States could do little short of that. \(^{13}\) Furthermore, he might expect to sew doubt among neutralist forces concerning any evidence of sabotage that the United States government might produce. He might even expect to convince many elements critical of the United States government that the accusation of sabotage was nothing but a subterfuge to avoid blame for an accident.

Should an accidental nuclear detonation occur in the West, the prospects for nuclear sabotage would be radically improved. If the United States (or British) government publicly declared that its men or equipment were to blame, the enemy's risks would be substantially diminished and his prospective gains enormously increased. In fact, the enemy's risks would be smaller and his gains greater even if the cause of the first detonation remained unestablished and an internal accident seemed no more than likely. The risks would be smaller for two reasons: (1) the first single detonation would have established a precedent for the U.S. military reaction so that

\(^{13}\) An increase in the U.S. defense budget, similar to that following the communist attack in Korea, might be the most likely major effect that the enemy would fear.
the enemy could be much more confident than he could be before that another detonation (caused by his sabotage) would not start an accidental war; (2) U.S. findings that the second disaster was due to sabotage would meet with wide disbelief, or at least distrust. Hence the United States government, even if itself convinced that sabotage had caused the second detonation, might find it most difficult to mobilize support for the sacrifices that any retaliatory measures would entail. The enemy, anticipating this, could expect to lose little if his act of sabotage were discovered after the detonation. The main risk that he would still run would be that his attempt at nuclear sabotage might be detected before the detonation. Yet even the consequences of such detection would be somewhat lessened after the first nuclear accident had occurred, since the enemy might convince many people that it was a lie fabricated by the United States military to divert world attention from their "guilt" for the first disaster.

It is easy to see that the communist gains from a second accidental detonation in the West would be even greater than from the first one. After the first disaster the Soviet Union would probably use political pressures to try to force the West to accept various one-sided disarmament measures (see above). After the second disaster, the defenses of the West against
such concessions might well crumble. U.S. allies might refuse to have anything to do with nuclear weapons, and domestic opinion in the United States and the United Kingdom might demand drastic restrictions of these weapons. The Western military effort and alliance system would be discredited among many politically influential groups in the West.

U.S. POLICY AND PUBLIC INFORMATION: (1) IN THE EVENT THAT THE DETONATION CAUSED LITTLE DAMAGE

As mentioned above, some types of accidental detonation would create few if any casualties and little or no civilian property damage. This would be the case, for example, if a weapon detonated at high altitude or over the ocean. In spite of the absence of serious damage, such an accident would obviously be considered a most serious event by military and other official personnel concerned with nuclear weapons. Whether or not the world public and other governments became alarmed would depend entirely on the information they received. Hence, the U.S. public information policy could make a great difference in the political and military damage that the United States would suffer as a result of such a detonation.

The political reaction might be really serious if the public or foreign governments saw in this accident a precedent for more catastrophic unauthorized detonations and suddenly
felt that all nuclear weapons were unsafe. If public information media treated the accident very dramatically they would provide material for political elements who are hostile toward the U.S. defense effort. Given details about the detonation it would be easy for newspaper men to compute how much damage this weapon might have done had it exploded in an inhabited area.

It is therefore in the public interest that no information be released about such an accident if it has not already been compromised.\textsuperscript{14} If the accident has been compromised and public statements become necessary, they should depict the accident as an occurrence which has no bearing on the safety of other nuclear weapons. In some circumstances it might be treated as if it had been an experiment, or as if something had gone wrong in a unique experimental situation. If questions should arise as to why the experiment had not been carried out at one of the traditional atomic proving grounds,\textsuperscript{15} it might be suggested that

\begin{itemize}
\item[\textsuperscript{14}] Internally, of course, information about the accident should not be suppressed. Within classified channels pertinent data should be made available to all agencies which are concerned with weapon safety and could benefit from this experience.
\item[\textsuperscript{15}] If an international agreement existed for the suspension of weapon tests, the detonation might be discovered by the international control organs and a public explanation would become necessary. In this case it might still be possible to emphasize: (a) that this was not an attempt at a clandestine test, and (b) that the accident which led to this small nuclear detonation was due to experiments with other parts of the weapon system, not the
\end{itemize}
the experiment was related to a carrying vehicle or missile. Publicists and propagandists hostile to the United States might try to convince foreign and domestic audiences that an accident had occurred involving the full detonation of a nuclear weapon, and that a similar accident might just as readily have led to the detonation of nuclear weapon in the megaton range and in a populated area. The U.S. public information policy should counteract such an interpretation of the accident as much as possible.

U.S. POLICY AND PUBLIC INFORMATION: (2) IN THE EVENT THAT THE DETONATION CAUSED A LARGE DISASTER

It is recognized here that one of the primary concerns of the U.S. government would be to expedite and facilitate disaster relief. This task would be primarily the responsibility of civil defense organizations, with which this study is not concerned except in so far as relief measures have political-military implications. The traditional ways of coping with natural disasters and the plans for wartime disasters would provide the necessary administrative mechanism for the relief effort.16 Apart from this, however, the crucial tasks for nuclear weapon itself. The denial that a weapon test was involved should be implicit, otherwise it might increase suspicion of its credibility.

16 The U.S. Army has been assigned special responsibility for domestic disasters (DOD Directive 3025.1., July 14, 1951,
the U.S. government would be to minimize the risk of accidental war and to mitigate the adverse political and military consequences of the detonation. Failure in these tasks would lead to much greater calamities in the future than that caused directly by the single detonation.

The following suggestions are addressed to these latter tasks. Obviously they are not a blueprint for a complete U.S. policy. The special circumstances of the situation are far too unpredictable to permit drawing up a specific plan of action. All we can hope to do is to anticipate complications, pitfalls, and perhaps some opportunities that U.S. policy makers might encounter and which might be overlooked in the urgent crisis of the moment. Once more it must be stressed that the prevention of any unauthorized nuclear detonation has top priority in all government agencies that can make a contribution to this large and continuous safety effort. To consider measures for the event that prevention fails is not to detract in the slightest from this priority.

"Responsibilities for Civil Defense and Other Domestic Emergencies." The Continental Army Command has prepared special emergency plans for such contingencies, which were also brought to the attention of overseas commanders through the Joint Chiefs of Staff. See U.S. Continental Army Command, Basic Plan, Appendix 2, Domestic Emergency Plan. 9 April 1957 with subsequent Change Orders (Secret).
The Initial Announcements by the U.S. Government

The first phase of the military and political reaction to a single detonation would probably begin with a news flash through military and/or commercial channels, which might contain no more information than that a nuclear detonation had occurred in a specified area. In the local disaster area many people might conclude that war had started. As mentioned above, certain military alert measures would immediately become necessary unless the possibility of an enemy attack could be ruled out at once. These alert measures, in combination with similar alert measures by U.S. allies, the Soviet Union, and other Soviet bloc countries, might create a certain risk of an accidental war, i.e., a war resulting from the misunderstanding by the Soviet Union, another bloc country, or a U.S. ally that the enemy had started to attack, or was about to do so.

Speed would be of the essence in any measures for reducing the risk of accidental war, and the fastest step that could be taken would be the communication of messages. Such messages

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17 Some military alert measures actually seem desirable even if the accidental nature of the detonation is immediately established (see below, pp. 41 ff.).
should reach a number of audiences and accomplish several purposes:

<table>
<thead>
<tr>
<th>Audience</th>
<th>Objective of the Message</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. U.S. and allied military headquarters, and</td>
<td>a) Communicate that the U.S. government does not think this detonation signals an enemy</td>
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<tr>
<td>allied governments.</td>
<td>attack, but feels that certain carefully controlled alert measures should be taken for</td>
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<td></td>
<td>the event that an attack followed.</td>
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<td></td>
<td>b) Urge all those involved in these alert measures to avoid giving the Soviet Union or</td>
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<td>other bloc countries the impression that the United States or its allies are preparing to</td>
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<td></td>
<td>attack.</td>
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<td></td>
<td>c) Enjoin all headquarters and Allied governments from taking any action that would only</td>
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<td></td>
<td>be appropriate in the event of war, but encourage them to remain alerted to the possi-</td>
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<td></td>
<td>bility of an enemy attack.</td>
</tr>
<tr>
<td>2. To the Soviet bloc governments and military</td>
<td>a) Make the above message public and thereby inform the Soviet government -- to the extent</td>
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<tr>
<td>headquarters.</td>
<td>that it is willing to believe the message -- that the United States does not intend to</td>
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<td></td>
<td>attack as a result of this detonation. Regardless of Soviet belief in the above message,</td>
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<td></td>
<td>accomplish the following:</td>
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<tr>
<td></td>
<td>b) Encourage continued contact between the United States and</td>
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</table>
Soviet governments.

c) Indicate publicly that the U.S. government is not alerting its forces and population for war.

d) Offer some circumstantial evidence that the U.S. government is prepared to treat this detonation as an accidental one.

e) Make it seem likely to the Soviet government that the United States is quickly improving its alert posture so that an attack at this time would not pay. This message is particularly crucial in the event that the single detonation was a premature bomb-drop or missile-launching from a planned Soviet attack. The recommended action might induce the Soviet government to call off the attack, if feasible to do so. This objective necessitates the utmost speed in the message.

3. To the foreign country or area within the United States where the disaster occurred.

Convey that the U.S. government does not think that this disaster means war. Promise help for the immediate relief effort.

4. To neutral governments, a) Reassure them that the U.S. government is doing everything it can to maintain world peace.

b) Avoid a commitment on the exact cause of the detonation until an investigation was completed.

(The public may already have learned of the disaster through commercial news services.)

These last two messages have no particular value in the event that the detonation is part of
an enemy attack (nor will they
do any harm). They are of great
value, however, as the opening
policy move to reduce adverse
political effects in the event
the detonation was an accidental
one. 18

A public announcement might well be the best means to reach
all the audiences most quickly. Its preparation and transmission
would take less time than if separate messages were dispatched to
all these audiences individually. Moreover, as suggested above,
the public ought to be reached anyhow to correct and control
erroneous or partial information disseminated through the commer-
cial news media.

The initial public announcement by the U.S. government might
consist of two parts, a general one and a military one. The
general announcement could be issued, for example, by the White
House, and might cover the following points:

(1) A large disaster which is (probably) due to a nuclear detona-
tion has just occurred in such and such an area.

(2) (If the detonation has occurred within the United States)
A relief effort is immediately being started under the
leadership of the civil defense authorities. Further

18See below, pp. 51 ff., for a detailed discussion of the
public information problem about the cause of the detonation.
announcements on relief and advice to the population will follow at once. (If the detonation has occurred in a foreign country where the U.S. forces have nuclear weapons) The United States offers to do everything it can to bring aid and relief to the disaster area.

(3) Full clarification of the causes and circumstances of this disaster will have to await the findings of an official inquiry. A board of inquiry is being set up immediately. 19

(4) Members of the armed forces, government officials, and civilians should not take any special measures except as ordered by civil defense authorities or by the appropriate military commanders. All other people who are not involved in these measures are urged to stay at home or to continue their normal activities. (The purpose here is to discourage inappropriate evacuation or uncoordinated alert measures.)

The military part of the initial announcement might be issued separately, for example by the Department of Defense, to tone down the connection between the nuclear disaster and the military alert

19 If somewhat more detailed and confirmed information was available about the circumstances, this should be added, but not as if it were the full explanation of the cause (e.g. "the detonation seems to have occurred in connection with an aircraft accident."). However, the initial announcement should not be held up because such information is unavailable. See also below, pp. 51 ff.
measures and to soften the political implications of the
military measures. This military part of the public announce-
ment might cover the following points:

(1) In response to the announcement (from the White House)
about the disaster in .... the U.S. armed forces in the
affected region will take immediate measures to assist the
civil defense authorities in their relief effort. The
local commanders will be advised instantly how to coordi-
nate their assistance with the authorities in the disaster
area.

(2) A disaster of this character also makes it necessary for
our armed forces (and those of our allies) to take certain
limited alert measures, such as have been customarily
taken in the past during peacetime crisis situations. The
purpose of these measures is to protect the capability and
integrity of our forces so that they can ensure the main-
tenance of peace. (At this point it may be prudent to
specify those alert measures which would soon attract
public attention. For example, if NORAD were to call a
state of Air Defense Readiness this might become known in
communities where air defense units are stationed. If
this move is defined as being purely precautionary and
limited, rumors and excessive civilian reactions might
be avoided.)
(In case alert measures near border areas are necessary, the announcement might add: all our military forces will take special care to prevent incidents and to forego actions which could be misconstrued by other nations as evidence of hostile intentions.)

These public announcements would obviously be complemented by many subsequent unpublished messages to military commanders, allied headquarters, allied governments, and other parties concerned with the disaster. In addition, a rather continuous public information program will have to be maintained to further the relief activities (such as evacuation from the local fallout area) and to combat unwarranted reactions and rumors. It may even be necessary to dissuade other military authorities (state governors in relation to the National Guard, allied military commanders, etc.) from instituting excessive alert measures.

The Military Alert Measures

The military actions taken in response to a single nuclear detonation will have a significant influence on the stability and strength of the U.S. and allied position following the detonation. The military response could be either so precipitate as to be

20This section was written in co-authorship with Colonel David Gould, USAF.
mistaken by Soviet intelligence as preparations for an attack, or so slow and uncertain as to present Soviet planners with future temptations. A consistent and well-executed pattern of immediate responses among all appropriate combat forces would serve to demonstrate our preparedness to the Soviets. Furthermore, the military response should take into account the possibility that the detonation has actually signalled the start of a war, unless it is immediately apparent that it was an accident. The danger lies in the possibility that the military reactions will not be internally consistent, that some isolated actions will work at cross-purposes with the political and public information measures, and that other actions will seem so threatening as to provoke an enemy attack.

The most desirable situation would be one in which the military response measures, including those of our Allies, are pre-planned and co-ordinated so as to provide an optimal response according to the variety of contexts in which the detonation might occur. It is unlikely that we could attain this goal. However such advance planning and co-ordination as can be accomplished could prove very fruitful.

The military forces whose reaction to a detonation would have the most direct bearing on the situation include:

In the United States,

a. SAC
b. NORAD
Overseas (including both U.S. and Allied Commands),

a. SAC
b. RAF Bomber Command
c. Tactical Air and Air Defense forces
d. Certain ground and naval units

The specific form of military action taken in response to a single detonation should be influenced primarily by the degree of certainty and the speed with which the possibility of an enemy attack can be ruled out. In nearly all possible situations, the fact that a detonation had occurred would be known to central command posts before an explanation about the circumstances and likely cause became available. For a detonation in the Zone of Interior, the first report might reach the Pentagon command posts from military commanders in the field near the event, from the nuclear detonation reporting system of the Air Defense Command and NORAD (NUDET), or from 21 The NUDET system depends on visual observation by radar stations, Nike sites, weather stations, etc. and could determine the ground zero with an error of from 2 to 10 miles. The initial report from could normally indicate the rough

21 Within about a year the Bomb Alarm System will be set up to signal a detonation instantaneously if it occurs on a likely target point within the ZI. It is planned to extend this system to overseas bases later.
yield and general location. An overseas detonation would first be reported by the nearby military commands through military channels, or conceivably through commercial wire services. The latter might reach the Pentagon control rooms fastest if the military command at the spot had been destroyed and if there were no other U.S. commands in the vicinity who could observe and report the event. Large disasters are relayed very quickly by commercial news services.

Two facts are of outstanding importance for the initial reaction:

(1) In the vicinity of the detonation commanders might learn of the event five to fifteen minutes before the highest authorities had been alerted. In addition, it might take an hour or so until the highest authorities had conferred, evaluated the reports, and transmitted their instructions back to the local commanders -- unless, of course, the response had been prepared in advance.

(2) Given the many different channels for reporting such a detonation it is likely that several parallel reports would arrive at the highest command within a short time. Since most of these reports would be given over voice channels and since many would originate from visual observations under conditions of stress, it is likely that they would not fully
agree. Hence, the highest authorities would be uncertain at first as to how many detonations had taken place. This would be a particularly crucial question in an area like West Germany or England, where potential targets are close together! The report might turn out to be the best source for determining that only one detonation had occurred.

**If the Detonation Immediately Appears to be Accidental.**

In this case, relatively low alert measures are indicated. Obviously those measures would be undesirable which could easily be mistaken by the enemy as the beginning of an attack and hence cause him to strike first. "Low alert measures" might consist of such actions as, for example, SAC Cockpit Alert (but not the launching of bombers under positive control) and NORAD Increased Readiness, Condition 2 or 3. For forces overseas, there should be comparable preparatory measures, but not the launching of alert aircraft. Inherent in these "low alert" measures are all the preliminary steps necessary for moving very quickly into the highest state of alert.

However, these relatively low alert measures should evidence a very fast and consistent reaction because:

a. In any period of crisis it is generally prudent to take some alert measures; and a single nuclear detonation might well lead to a political crisis.
b. The enemy's intelligence would gather information about the U.S. and allied military reaction to this single detonation. A fast, determined, and consistent response would suggest that the U.S. decision processes and reaction times are short, and would therefore bolster deterrence. Failure to react in this manner would degrade deterrence.

For both the United States and overseas areas the activities concerned with the acquisition of warning should be placed in the highest alert state. In this connection, it would be particularly important not to stop those regular or routine flights conducted normally within range of Soviet intelligence, including ferret operations. It would be desirable to continue this type of operation at such a time not only for its intelligence value but also to avoid the interruption of routine operations, which might create unnecessary suspicions on the part of the enemy.

The problem of consistence in our response patterns is one which warrants more attention, especially for the case in which a detonation occurred overseas. A danger lies in the possibility of inappropriate actions by local military elements, which could lead to incidents (e.g., shooting
down a plane). The risk of inappropriate actions would be greatest in the vicinity of the single detonation and, of course, would extent to national forces not under U.S. or allied command.

**If the Cause of the Detonation is not Immediately Known.**

In this case high alert measures for all forces would seem appropriate for two reasons: (1) The detonation might signal an attack which is underway (a ragged attack), or an attack which has been planned for the near future (a premature detonation). If the enemy went through with his attack an alert would obviously improve the outcome of the war. A quick response, however, might cause the enemy to call off the planned attack. (2) If the detonation later turned out to have been accidental, a quick and effective response would bolster deterrence for the future. We mentioned this effect in the previous case, where the detonation immediately appeared to be an accident, but it would be even more important here.

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22 A premature detonation could be due to an inadvertent missile launch while the enemy's entire missile force was being readied for the attack, or a timing error among clandestinely planted weapons which were supposed to be part of the first strike.
High alert measures following a detonation should be designed to minimize the risk that the enemy will strike first for fear that the West may mistake the accident for his attack. "High alert measures" might include such actions, for example, as partial or total SAC positive control launching, NORAD Increased Readiness, Condition 4 or Air Defense Readiness, and, for overseas forces, all preparatory actions necessary to achieve the highest possible state of combat readiness but probably not involving the launching of aircraft. Soviet intelligence concerning the U.S. and allied forces close to the Soviet bloc is likely to be prompt and fairly accurate. This should be taken into account in planning alert measures for these forces. Commanders might be reluctant to take alert measures with adverse civilian effects (grounding of civilian planes; interruption of normal broadcasting) because of the political repercussions.

In implementing alert measures, there is always the possibility that they will have to be continued for some time, perhaps for several days. This could be due to the political crises that might ensue from a single nuclear detonation, or to continued military uncertainties. Some alert measures, if sustained over time, could seriously degrade the effectiveness of our forces. For example, a level of air alert significantly greater than that normally maintained, would soon lead to
severe aircraft attrition because of delayed or backlogged maintenance.

**Initial Measures on Weapon Safety.** In addition to alert measures, the military services would have to take some immediate steps on weapon safety, for two reasons: (1) to respond to internal and external fears of another unauthorized detonation, and (2) to cope with the increased risk of sabotage, which we discussed above. After a nuclear disaster the public and allied governments would press for immediate steps to increase nuclear safety. In addition, within the U.S. Government itself and even within the military there would be an urgent desire to eliminate any possible or surmized hazard. The grounding of a certain plane type after an unexplained crash is a common practice which illustrates this reaction. Carefully chosen safety measures could help to avoid curtailments of nuclear operations that would undermine the retaliatory capability. The pressures for maximum safety, of course, would be greatest in connection with the operation or weapon system that was involved in the detonation.

Certain temporary measures could be instituted that might relieve anxieties with regard to weapon storage and transport without impairing the retaliatory capability. Among these would be the temporary cessation of weapon transports, or of part of
these transports, and the cessation of all weapon modifications and maintenance tests. Thus, the stockpiles would be "inert," and the exposure to any possible hazard, human or mechanical, would be minimized. For the long run, these measures would have to be relaxed or replaced by more specific safety measures which would not degrade the stockpiles.

We mentioned before that a SAC airborne alert operation might be jeopardized if the detonation appeared to occur in connection with an aircraft flight, take-off, or landing. At a time when an airborne alert might be crucial for SAC's survival capability, a sudden cancellation of the Canadian overflight permission or a curtailment of operation within the United States could make the nation dangerously vulnerable to enemy attack. It is possible, however, that a temporary rerouting of the flights over oceans would save a large part of the airborne capability and at the same time satisfy the requests for added safety. The rerouting would have to be prepared in advance so that it could be instituted immediately. Should the cause of the detonation be ascertained and eliminated, the normal and more effective routes might be resumed. Similarly, in the event of a detonation involving a naval vessel, the utilization of ports by carriers or submarines might have to be changed.
Public Information About the Cause of Detonation

An official announcement of the cause of a large nuclear disaster -- or even publicized official guesses about it -- involves far-reaching policy decisions of gravest importance and hence should never be done at the field level. It is crucial that the country should not be irrevocably committed to a specific view of the cause without a thorough examination of the various alternatives. During the first hour or so all that could probably be said in public would be that the cause was being investigated. In some cases it might be known immediately under what circumstances the detonation had occurred, so that the question of the cause could be narrowed down. For example, if the detonation occurred in connection with a plane crash, it might be prudent to make this public soon, emphasizing however, that is still had to be determined how the many safeguards that should have precluded such a detonation could all have failed.

The question of the cause might be the only area in the public information field where the government could exercise some control, since it would require specialized technical knowledge and access to military data. Hence, this question would be the key to the general public information program and the political measures dependent on public attitudes, as will be discussed in the next section.
The Official Inquiry and Initial News Releases. The early public announcements regarding the cause of the detonation might best deal with the official inquiry itself, that is the news releases should focus on the arrangements that have been made for determining the cause and circumstances of the detonation. Prominent news coverage of the official inquiry could serve two purposes. First, it would help to explain why the cause of the detonation was not being announced immediately. Second, it could be used to delay undesirable political action, as will be discussed below (p. 59).

The official board of inquiry might be set up, for example, by the Chief Executive, and would have to consist of experts on military matters, security and investigations, nuclear weapons, and public information. But it might also include some prominent politicians who were aware of the fact that the risk of nuclear accidents always has to be weighed against the risk of nuclear war.23 If the detonation occurred in a foreign country it probably would be desirable to organize a joint investigation by U.S. experts and participants from the country of occurrence. If the country of occurrence did not have special access and/or know-how in the nuclear weapons field (e.g., the foreign

23 See pp. 1-3 above.
participation might be confined to a political board of inquiry working with the U.S. technical team. On the other hand, if the detonation occurred in the United Kingdom, a joint technical investigation would be indicated. In the United Kingdom, in particular, there might also be a question as to whether the detonation was due to a U.S. or to a British weapon. Hence, it would be important that the two countries co-ordinate their findings about the cause of detonation so that they would not inadvertently implicate each other.

The completion of the inquiry might take considerable time, perhaps a number of weeks, particularly if there was little or no evidence of the cause. On the one hand, such a prolonged inquiry might serve a useful purpose in postponing adverse political reactions (see below). On the other hand, the continued uncertainty about the cause would impair public relations and create anxieties about nuclear weapons safety. These drawbacks of a prolonged inquiry, however, could be mitigated by giving continued publicity to the inquiry itself, discussing its progress and difficulties, and releasing intermediate reports.

For example, within a few hours it might be stated that the inquiry had the objective to find out whether an accident, some
sort of malfunction, or some other cause had led to the detonation. A day or so later the board of inquiry might state that the explosion seemed to be due to a nuclear weapon of roughly such and such a yield, but that the board could not yet reach a final conclusion as to the cause and circumstances of this nuclear detonation. However, the second report might continue, the board wishes to discuss some of the possibilities.

The first possibility to be considered is that the detonation was caused by a combination of several unusual technical malfunctions in the safing mechanism of a nuclear weapon, perhaps coinciding with a series of human errors. In view of the fact that a great many separate steps and independent events are necessary to arm and detonate a nuclear weapon, such a chance combination of failures would be an exceedingly improbable event.

The second possibility that must be studied is that an accident, for example a fire or collision (plane crash, if appropriate) led to the detonation of a nuclear weapon. Stringent safety measures incorporated in the design of all weapons are expected to preclude a nuclear yield in the event of such an accident.

Third, it is necessary to examine any other possible causes even of the most unusual kind. It must be established
whether an act of sabotage has been involved, or whether such natural phenomena as lightning could have caused the detonation. These possible causes are being studied in spite of the fact that the safeguards in the design and handling of weapons are believed to preclude any such possibility.

Additional examination of all available evidence is evidently required to say more about these possibilities. So far the inquiry has collected the following evidence. (This would follow.)

The fact that the board of inquiry is studying the above mentioned possibilities in connection with this particular detonation, however, does not imply that the safety of nuclear weapons in general has come into question. The additional precautions which have now been instituted\(^\text{24}\) make these extremely unlikely occurrences even more improbable.

The combination of technical malfunction and human error might well serve as the dominant hypothesis. On the one hand, if the actual cause should remain unknown for some time, this hypothesis would probably have to be emphasized more strongly so that the continued uncertainty would not worsen public

\(^{24}\text{See above p. 49 for new safety measures that might be publicized.}\)
anxieties (see also below, pp. 57-58). On the other hand, if the cause finally turned out to be a specific technical accident or human act, the board of inquiry would not have to reverse itself, it could merely subsume the specific cause under this broader hypothesis. As we shall see below, it would be desirable for political reasons to gain time with the inquiry. Hence, further progress reports might eliminate the above-mentioned possibilities gradually, and the final report should be released only after a careful examination has been completed.

Cause Due to U.S. Equipment or Personnel. If the investigation should eventually arrive at this finding, a major goal of the public information policy would be to dispel fears that the accident might be repeated, that is, to show that the disaster was a unique event. It might be possible to make clear to the public how a number of extremely unlikely accidents or failures combined in the most unusual way to cause this disaster. It would be important not to create exaggerated fears that other weapon systems or other nuclear operations are subject to the same risk.

A delicate situation would arise if it should turn out that the detonation was caused by an irrational act on the part of U.S. personnel. Unless such an act were proven beyond
doubt, an official public reference to it should be avoided. In fact, even if an irrational act was clearly the cause of the detonation, it would be in the country's best interest not to publicize this but, if possible, rather to interpret the event in terms of human errors and technical malfunction. Information about an irrational act would undermine public confidence in the integrity of U.S. military personnel at home and abroad and lend credence to Soviet propaganda about "American madmen". But this would not be the worst result, for to some extent these effects would be unavoidable anyhow. A more damaging consequence from publicity about an irrational act would be that it might stimulate other individuals prone to irrational behavior to attempt similar destructive acts.  

Cause Remains Unknown. In some circumstances, the cause of a nuclear detonation might remain unknown. In that case, the public information program should make clear that all conceivable causes have been studied, but should give special

25 This point again illustrates the importance of controlling the publicity about the investigation of the cause and avoiding premature releases. In a sense, an irrational act that causes a full detonation implies that the technical safeguards against such occurrences have malfunctioned.

26 A publicized act of arson due to pyromania frequently is followed by other ones, unless special security measures are instituted to deter them.
emphasis to two possible types of cause: (1) an extremely unusual combination of several technical malfunctions and/or human errors. The purpose here would be to suggest that the cause must have been an unlikely one and its repetition extremely improbable. (2) A well concealed act of sabotage. This second hypothesis could not be entirely omitted in the public information program, since -- if the cause were unknown -- sabotage might well have been involved, and the enemy should be deterred from repeating it (see below pp. 77 ff). The United States should not accept full blame for a nuclear disaster that might have been caused through sabotage. However, any emphasis upon the possibility of an irrational act would be unwise for the before-mentioned reasons. Reference to the possibility of sabotage in this uncertain case should be made in a hypothetical fashion. If it were done too blatantly many people might feel that the United States was merely trying to evade responsibility, or was even preparing the public for retaliatory action. Furthermore, it should be made clear that all U.S. (and allied) personnel had been so carefully investigated that only outside agents could possibly be suspected.

**Indications of Sabotage.** If there should be fairly clear indications of sabotage, the United States would be faced with a major policy decision. Once the evidence was revealed, the
United States would have to take some retaliatory action to safeguard its prestige, to respond to public indignation, and to deter similar acts in the future. As far as the public information program was concerned, the important thing would be to control the release of the evidence until the U.S. policy in response to it had been formulated. The method which the U.S. government chose for releasing the information that sabotage was involved would depend on circumstances. One method might be an immediate Presidential announcement setting forth U.S. moves in response to the indications of sabotage. Another might be a more tentative release for the purpose of testing out the domestic and international reaction. Of course, evidence of sabotage would lose its credibility if it were withheld too long or established long after the event.

**Temporizing to Prevent Decisions During U.S. Weakness**

The public reaction to large disasters in the past shows that concern over destruction and casualties declines rather rapidly, more rapidly than would seem possible at the time of the initial impact with its strong emotional shock effect. Accordingly, if the question arises as to whether inadequate safety measures or lack of warning caused the disaster,
hostility against those held responsible will be most acute
at the beginning and will decline with the passage of time. 27

In the event of a nuclear disaster, national and world-wide
concern about the casualties and destruction would also decline
rather rapidly and be overshadowed within the space of a month
or so by other news. In particular, the rehabilitation effort
would soon absorb the major interest of the news media and crowd
out reports about the destructive aspects. 28 However, if there

27 For example, on July 10, 1926, lightning caused a disas-
trous explosion in the naval ammunition magazine at Lake Denmark,
New Jersey, which killed thirty people and injured several hun-
dred. In the first few days the public reaction was violent.
According to The New York Times, citizens denounced the practice
of storing dangerous explosives near populous communities and
were against the plan to rebuild the depot at the same place.
Two days after the disaster Senator Walter Edge from New Jersey
said: "We are not at war and I repeat that it is nothing short
of criminal to maintain these supplies in community centers."
However, two days later The New York Times reported that the
Governor of New Jersey was marking time in making an official
protest to the federal authorities. Still later, leading citi-
zens of the area actually expressed themselves against removal
of the arsenal, since it meant a major source of income to the
people.

The subsequent history is also of interest: the Navy
appointed a board of inquiry, and in its next session Congress
asked for a joint Army-Navy survey of ammunition storage, which
led to a number of recommendations for improved storage sites.
Congress approved most of these recommendations, and furthermore
asked that a permanent board be created. This led to the Joint
Army-Navy Ammunition Storage Board, which later became the current
Armed Services Explosives Safety Board.

28 After the tornado in Waco, Texas, in 1953, which killed
114 people, the disaster news in the local newspaper declined
should be widespread fallout, public concern over the casualties would last longer, especially in view of the delayed effects of radiation sickness. Furthermore, pressure groups opposed to nuclear weapons might succeed in keeping the issue alive for a longer time.

In general the more precipitate and emotional reactions would be confined to the initial period. In fact, within a few days a marked improvement could be expected in the attitudes of political leaders and government officials in Western countries. Many of these important people might be panicky for a short time, but they would rapidly come to realize that the reaction to the disaster should not go so far as to jeopardize the security of their countries.

U.S. policy after an unauthorized nuclear detonation in the West must be designed so as to take full advantage of this gradual improvement in the political climate after the disaster. Irreversible measures that would degrade the defense posture should be postponed until the initial world reaction has subsided and the pressures against the U.S. (or U.K.) military posture have lost some momentum. Likewise, the United States

very rapidly; in the second month five times less space was devoted to it than in the first month. But the news about casualties and physical destruction declined even more precipitously, from 15 per cent of all disaster news in the first month to less than 2 per cent in the second and third month. (H.M. Moore, Tornadoes over Texas.)
should delay conferences and meetings in which it would have to bargain with other countries about political or military changes in consequence of the nuclear disaster. The U.S. bargaining position would be weakest at the beginning.

An important device for temporizing would be the official inquiry into the cause of the detonation. Within the first day or so after the detonation, the U.S. government might set an approximate date for the board of inquiry to report on its findings. A few days later, when the situation could better be assessed, this date might be firmed up and it could then be explained that most decisions regarding the detonation would have to be held in abeyance until the specified date. It might be stressed that the United States obviously could not make major changes in its defense posture without better knowledge of the cause and circumstances of this single detonation. However, as mentioned before, the United States should announce that the safety measures in the nuclear weapons field had been further increased.

Considerable publicity should be given to the termination date of the inquiry. For example, if specific military measures came under criticism as a result of the detonation, the United States might declare that it would make all the feasible improvements in safety that the findings of the inquiry might
suggest, as soon as these findings became available at such and such a date. If the detonation caused a serious political situation in Western Europe, a NATO conference might be announced for a date shortly after the termination of the inquiry to deal with the safety of nuclear weapons. The same might be done for SEATO. Thus, some of the unfavorable political agitation might be deflected toward the future, and decisions on the Western military position would be taken at a time more favorable for constructive negotiations.

The optimal duration of the postponement would depend on the size and circumstances of the disaster. If it were too long, political decisions could not be held in abeyance; if it were too short, the political climate for these decisions would not yet have improved. Perhaps a period of one to two months would make the best out of these limitations, but the actual time would depend on the nature and intensity of the public reaction at home and abroad.

During this delaying period the public information program should provide the news media with all possible news about rehabilitation and relief. There is always a strong and continued interest in such news after a disaster. Within a relatively short time the interest in rehabilitation tends to crowd out reports about destruction and casualties. If the loss in lives were
relatively small, the public information program might compare
the nuclear detonation with other accidental explosions in the
past to deprive it of its uniqueness and place it in a more
tolerable perspective.\textsuperscript{29}

It is obvious that the government information program would
have to operate in an environment of opinion created by the
Western news media, and to some extent even by Soviet propa-
ganda. An extensive coverage of news from the disaster area would
doubtless leaven useful information with human interest stories
and even erroneous or exaggerated reports (for example, con-
cerning radiation hazards). Factual errors about the disaster
situation might be corrected by civil defense authorities, which
possesses public information capabilities for a program to cover
the local situation. In addition to local reporting, however, the Western news media would influence Western political
attitudes, both popular and parliamentary. For example, they
might give added emphasis to statements by minority parties,
church leaders, parliamentarians, and so on, as to what should
be done about atomic weapons.

\textsuperscript{29}For example, the explosion in Texas City on April 16, 1947,
killed some 570 people and injured over 3,500.
Seizing the Political Initiative

As mentioned before, it is to be expected that the Soviet Union (and Communist China) would try to exploit a single nuclear detonation in the West. The Soviets might move quickly to seize the initiative and to consolidate gains while the West was still weakened by the psychological impact of the disaster. We suggested that the United States should put off political and military decisions and avoid bargaining situations until the political climate became more favorable. However, such a strategy would have to be protected by certain initiatives to counter the Soviet moves. The West would weaken its position if it tried to maintain a purely passive attitude toward Soviet pressures for a summit meeting or some quick disarmament agreement. The temporizing strategy might look like sheer intransigence and push the anti-U.S. forces into a united front.

One possibly advantageous U.S. initiative might be to respond to Soviet moves (such as a call for a summit meeting, demands for base withdrawal, ultimatums, etc.) by bringing the issue before the United Nations. The United States would probably not want to introduce the problem of the single detonation into the United Nations prior to any Soviet moves, lest it seem tantamount to an admission that the detonation had endangered international peace. In all likelihood, it would be precisely
the Soviets who would argue that the United States was endangering world peace with unsafe nuclear weapons. Upon such an accusation, however, the United States might want to express its willingness to discuss this in the United Nations, and only there, instead of in separate conferences or summit meetings.

The United Nations would offer several advantages as a forum to counter these Soviet initiatives. (1) Unlike a summit meeting, it would avoid direct negotiations, so that the United States would be less handicapped by its weakened bargaining position. (2) It would offer possibilities for delaying tactics (and time would be on the side of the United States). (3) A United Nations debate might help friendly governments to control anti-U.S. pressures within their parliaments. These governments might argue that unilateral actions -- such as demanding the withdrawal of U.S. nuclear forces -- would be unwise while the issue was being dealt with in the United Nations. On the other hand, the United States might run the risk of being outvoted in the General Assembly, which would mean a further loss in prestige. This risk could be important during the first few days after the detonation, when U.N. delegates who usually side with the United States might receive panicky instructions from their governments for fear of war or exaggerated anxieties about radiation effects.
An effective U.S. initiative would require more than just the willingness to answer Soviet charges in the United Nations. The United States might derive political benefits from renewed insistence on linking disarmament measures with inspection procedures, and from attacking the secrecy on which the Soviet Union has always insisted in past disarmament negotiations. While the Soviet Union would probably aggressively propagandize a "ban" on nuclear weapons, abolition of foreign bases, etc., it would be on the defensive with regard to control and inspection procedures. The United States might capitalize on its past willingness to submit to control and inspection measures in the interest of genuine disarmament.

However, in addition to the pre-disaster disarmament position, the United States might introduce new proposals in order to relieve itself of political pressures and to force the issue into a broader context where it would be more difficult for the Communists to appear righteous. For example, the United States might make a general and broad proposal to "abolish secrecy as the first step toward world-wide disarmament", and it could offer to permit free travel, complete international inspection on land and in the air, and a subsequent elimination of all nuclear stockpiles. This last point would be essentially a reformulation of the Western Four Power
proposals for partial measures of disarmament of August 29, 1957. The time right after the detonation is not opportune for actual negotiations, hence these early proposals should serve mainly political purposes, not negotiatory ones. Such proposals might throw the Soviet Union off balance in the propaganda contest for world support, as happened in 1955, when the United States put forward its successful Open Skies Proposal.

Policies to Soften Opposition to Foreign Bases and Alliances

The unfavorable reaction of U.S. allies to a single detonation could vary greatly in the amount of damage it inflicted on the Western position. Essentially, there are four possible degrees of severity: (1) an official request from an allied government that all nuclear weapons be withdrawn from the country; (2) an official attempt to oblige the United States to abandon its military bases and/or evacuate its forces; (3) a cessation of the military alliance with the United States; (4) a cessation of the political alliance with the United States. It seems unlikely that any government presently allied with the United States would go the length of breaking the alliance, provided internal conflicts stemming from the nuclear disaster did not replace the allied government by one neutral or even hostile towards the United States. However, the mildest reaction
described, a request for removing or keeping out nuclear
weapons, might be likely, particularly in a country where an
accidental detonation has occurred.

In countries where the cancellation of U.S. base rights
or the banning of nuclear weapons became an imminent threat,
it might be better for the United States to offer a
temporary and partial withdrawal rather than to risk political
defeat by being forced out. The main objective would be to
deprive the elements opposed to the U.S. bases or nuclear
weapons of their principal issue, and thus to tone down the
political hostility against the United States and perhaps save
a friendly government.

The temporary withdrawal might consist, for example, in a
declaration by the U.S. base commander that all nuclear opera-
tions had already been halted pending completion of the inquiry
into the cause of the detonation. If politically feasible,
temporary withdrawal should be arranged with the host government
in such a way that the nuclear operations could be resumed
without necessitating a new agreement provided, of course, the
findings of the inquiry justified this resumption. In other
countries no changes might be necessary; it might be possible
simply to indicate that the bases in question had never con-
tained live nuclear weapons or had already been deactivated as
far as these weapons were concerned.

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No changes or public declarations, of course, should be made in countries where the opposition to U.S. bases is not critical. In particular, the United States should emphasize that there are wide differences in the utilization of its overseas bases, and that the detonation which occurred had no bearing on the safety of other military installations. Soviet propaganda would probably attempt to link all U.S. military installations with the disaster, to initiate a chain reaction against them which might expand into a movement against the whole alliance. In many countries conditions are already ripe for the withdrawal of U.S. base rights. If a wave of withdrawals occurred after the detonation (perhaps in violation of the base treaties), this might be interpreted by the world public as necessary to save each country from nuclear disaster. Hence, other host governments which would be willing to accede to the continued presence of U.S. nuclear forces might be compelled by public pressures to follow suit. Here again we see the great importance of a prudent U.S. interpretation of the cause of the detonation: the more extraordinary the cause, the more effective a differentiated policy for the overseas bases.

In certain allied countries the forces opposed to nuclear weapons might achieve a majority after a nuclear detonation, although at the same time these countries might still retain
a majority who feared communism and opposed an expansion of the Soviet bloc. In such a situation the question of complete U.S. withdrawal might actually serve to rally the anti-communist forces by arousing the fear that without the U.S. alliance and military bases they would face a risk far more serious than the possibility of another nuclear accident. In a country like Italy, for example, with a small pro-Western majority, this fear might bring just enough support behind the government so that an alliance of neutralists, socialists, and communists could not overthrow it.

The Question of Legal Liability and Compensation.

This study will not make detailed comments on the question of legal liability for an unauthorized detonation of a nuclear weapon, but will merely mention certain aspects of the question that ought to be kept in mind when U.S. policy for the aftermath of such a disaster is being formulated.

The question of the cause of the detonation may play a varying role in relation to the liability issue. If it remained uncertain whether the detonation was caused by a U.S. weapon or by that of a foreign country (deliberately or accidentally) the liability question could probably never be resolved in a legal sense. On the other hand, if the detonation was due to a U.S. weapon but the precise cause remained
unknown it might be argued that the U.S. government, as the owner and custodian of the weapon, was liable for all damages regardless of whether or not it was at fault. The concept of "strict liability" is frequently applied in discussions about nuclear reactor accidents. The question arises to what extent the courts would hold these concepts applicable to nuclear weapons. 30

In the Texas City disaster of 1947 the attorneys for the damaged persons, including the insurers, maintained that the United States government was responsible and sought remedy under the Federal Tort Claims Act. (The fertilizer which caused the explosion had been produced for the government.) The district court held that the disaster was caused by the

30 It is doubtful whether the liability limitation of the Atomic Energy Act of 1954 (as amended by the Anderson-Price Act of 1957) applies to a weapon accident or only to "nuclear incidents" in connection with the peaceful uses of atomic energy. This limitation, which sets the maximum liability per incident at 500,000,000 dollars, seems to have been added to the original act of 1954 for the purpose of clarifying the liability situation to licensees or contractors of the AEC who are engaged in industrial or other peaceful uses of atomic energy.
negligence of the United States and that the government was therefore liable. However, the U.S. Court of Appeals and the Supreme Court concluded that the case was not covered by the Federal Tort Claims Act, primarily because the "discretionary function" clause\(^{31}\) exempted the government from liability. As there was no longer any possibility for recovery in the courts, Congress decided to enact relief legislation. Two years after the final Supreme Court decision Public Law 378 was passed, stating that "the Congress recognizes and assumes the compassionate responsibility of the United States for the losses sustained by reason of [the disaster]." The Act designated the Army to investigate and settle the claims. This followed the precedent of the Port Chicago, California, explosion of 1944, when Congress designated the Navy to settle claims.

The history of the Texas City disaster illustrates the complexity of such a settlement. Owing to the delays of litigation and Congressional legislation the Army could not start to settle the claims until eight and a half years after the disaster. The administration of the claims itself stretched out over two years, cost about $200,000, and involved roughly 40 man-years.\(^{32}\) The paid claims amounted to some 16,000,000 dollars.

\(^{31}\) U.S. Code 2680 (a).
\(^{32}\) U.S. Army, Claims Division, Office of the Judge Advocate General, Texas City Disaster Claims Program, August 1957.
Such a long delay would probably not be accepted by Congress in the event of a large nuclear disaster. However, the settlement would not only require vast sums, but would pose enormous administrative and legal problems. Many angles would have to be considered: (1) the uncertainties of long-term radiation damage to man; (2) the uncertainties of radiation damage to agricultural land; (3) the solvency of life insurance companies, banks, etc. that are concentrated in the disaster area; (4) the destruction of legal and financial records in the area; (5) the maximum death, personal injury, and property claims, etc. Many of these problems have been dealt with in civil defense studies, although the context of nuclear war is, of course, different from that of a single, localized disaster.

In the event that the nuclear detonation caused damage in a foreign country, a variety of liability situations and compensation arrangements would be possible. The Foreign Claims Act (10 U.S. Code 2734) has the purpose "to promote and maintain friendly relations through the prompt settlement of meritorious claims arising in foreign countries" for losses caused by, or incident to, "noncombat activities" of the U.S. armed forces.

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33 For the Texas City disaster these maximums were set uniformly at $25,000.
This act enables the secretary of the military department concerned to settle claims, but does not, of course, establish an international obligation. However, for NATO countries, the NATO Status of Forces Agreement (Article VIII) specifies a method for settling claims by one NATO country or its citizens against NATO forces from other countries who are stationed there. According to this article, claims will be settled in accordance with the laws of the country where they arise, but that country has to pay a certain percentage itself. Similar agreements, with certain exceptions, exist for non-NATO countries where U.S. forces are stationed.

If the losses resulting from a detonation were not recoverable through a previous agreement, an ad hoc settlement could be negotiated. An example is offered by the settlement of Japanese claims for damages resulting from nuclear tests in the Marshall Islands in 1954. Through a special agreement between Japan and the United States of January 4, 1955 (nine months after the incident), the United States tendered "ex gratia, without reference to the question of legal liability" the sum of 2,000,000 dollars, whose acceptance by the Government of Japan was in full settlement of any claims.

If no agreement could be reached between the United States and a claimant nation, the latter might put its case before the
International Court of Justice. The United Nations might also become involved, and the General Assembly might use Article 96 (1) of the Charter to bring the issue before the International Court. The United States would suffer an additional loss in international prestige if it found it impossible to accept an unfavorable decision of the International Court (assuming the Court would accept jurisdiction in the case). Another complication might arise if fallout damage occurred in a third country which then sued the country that permitted the stationing of U.S. forces. For example, Yugoslavia might press claims against the Italian government if a U.S. weapon in Italy caused damage in Yugoslavia.

The complications of liability and compensation payments would assume importance only in case of a large disaster. If the amount of damage were small, the traditional ways of settling such claims would be adequate. Planning is now in progress within the Air Force to provide for quick action on claims in connection with contamination incidents arising from nuclear weapons. In case of a nuclear detonation that caused great civilian damage, however, Congressional action would be necessary after the event. Congress would not only have to provide the necessary funds if compensation were to be made, but in most cases would also have to set up special legal and administrative provisions.
Measures to Deter Future Sabotage.

As stated before, after an unauthorized detonation had occurred the risk that another weapon might be detonated through sabotage would be considerably greater, particularly if the United States (or the United Kingdom) accepted full blame for the first disaster. This increased risk of sabotage, we have seen, would be due to the fact that the enemy's gains from instigating a second detonation would be substantially greater and his risks smaller.

If a detonation occurred, therefore, the United States should broaden its existing measures against sabotage. We mentioned that the public information program ought to hint at the possibility of sabotage in the event that the cause of the detonation remained unknown. In addition, it might have a deterrent effect to state publicly that security measures against sabotage had been stepped up.

Nuclear sabotage can never be made impossible. The principal protection against it lies in the enemy's uncertainties about detection and its consequences. The United States could plant doubt in the mind of the enemy as to whether it had put a secret tracer element into its nuclear weapons for the purpose of making the radioactive debris from an enemy weapon different from that of a U.S. weapon. This might be done through
carefully arranged leaks, regardless of the technical merits of actually incorporating such a tracer element.\textsuperscript{34} This tactic could be an effective deterrent by creating uncertainties for the enemy.

One might think of other measures to improve the ability to differentiate between the detonation of an enemy weapon and that of a U.S. weapon: for example, a detector device that could indicate the center of the detonation within a few yards and thus give away smuggled weapons or enemy missiles if they were detonated at a distance from the location of U.S. weapons.\textsuperscript{35} Such a device might offer added protection for small storage sites and could possibly be incorporated in the Bomb Alarm System (whose general purpose is to detect an attack, not sabotage).

Additional measures against nuclear sabotage fall within existing weapon safety or security programs and need not be

\textsuperscript{34} The United States should not definitely state that it has incorporated a tracer element, since this element might be compromised, thus making sabotage safer for the enemy than before.

\textsuperscript{35} A detector for the "prompt gamma rays" could be focused on the location of U.S. weapons, for example in an area where weapons are being modified, repaired, or stored. This detector would have to be connected with a distant registration point so that the signal would be received before the detector was destroyed. The equipment would be quite similar to that used to study weapon tests.
detailed here. The point we wish to make is that this whole area would have to receive a much higher priority of effort after an accidental detonation than is required now. Some increase in anti-sabotage measures might be desirable even now and will be discussed below in Part III.

Long Range Measures to Restore Confidence in Weapon Safety

A number of steps would have to be taken after an accidental nuclear detonation to restore some confidence in the peacetime handling and storage of weapons. Without some improvement in confidence, the United States would be subject to a continued degradation of its military capability as a consequence of public pressures (e.g., from local communities where bases are located) upon the government and the military.

Measures to increase confidence without degrading capability might consist in new weapon safing techniques which are not yet available but may emerge from current R and D efforts. This does not mean that the present safing techniques are inadequate. But if an accidental detonation occurred it might become necessary to demonstrate that changes were being instituted to make weapon safety even more effective.

Another measure to increase confidence in weapon safety might consist in the construction of underground storage sites that could safely contain an accidental detonation, in contrast
to the present operational storage sites which would generally
not contain even the smallest yields. This measure would be
fairly costly.\footnote{36}

Furthermore, airborne and/or seaborne nuclear peacetime
operations may have to be rerouted farther away from populated
areas, a change which may entail considerable expense for the
construction of new bases.

In summary, it seems safe to say that the cost of the
national defense effort would have to increase substantially
after a single detonation in order to maintain an adequate
deterrent capability in face of the political reactions against
nuclear weapons. In addition, there might be huge outlays for
the relief and rehabilitation effort.

\footnote{36\textit{For the depths required to contain underground detonations, see Appendix II.}}}
PART II. A NUCLEAR DETONATION IN THE SINO-SOVIET BLOC

THE QUESTION OF THE CAUSE AND POSSIBLE SOVIET REACTIONS

The cause of a single detonation in the Soviet bloc might initially be unknown to the Soviet government, much as the U.S. Government might be uncertain about a detonation in the West. The Soviet government would probably be less concerned about externally instigated sabotage, owing to the greater security of weapon sites within Soviet territory as compared with U.S. overseas bases. But it might be just as concerned about the possibility of an attack. Consequently it seems likely that the Soviet bloc forces would take certain alert measures after a nuclear detonation on a Soviet base or storage site.

During this initial period of uncertainty the Soviet government would probably say little about the detonation in public. Somewhat later, when it became more likely that the detonation was due to a Soviet weapon, the Soviet government might pursue one of several different policies. If the civilian damage was small it would probably favor a policy of concealment. This might be feasible, for example, in the Arctic region, where even people in the vicinity of the detonation might be unable to determine whether it was an accident during ordinary testing.
or an accidental detonation of an operational weapon. If the detonation could not be concealed or passed off as a test, Soviet policy would face three choices: to accept blame for the disaster, to try to blame the United States, or to blame a vaguely defined group of "enemies." If the Soviet government accepted the blame it would undermine its prestige, not only at home but also abroad among uncommitted nations and foreign communist sympathizers. The present Soviet propaganda about nuclear accidents would backfire with such an admission. However, it is conceivable that the Soviet government would admit that the accident was caused by some technical malfunction and attempt to generalize this occurrence as being applicable to U.S. weapons as well, so as to undermine confidence in weapons safety in Western countries. The Soviet government might even try to argue that the accident would not have occurred but for the nuclear armaments race "imposed on the world by the West."

The Soviet Union might blame the United States government outright for having instigated the detonation, through sabotage or through a missile fired at the Soviet Union. But this would be to risk provoking the United States to attack pre-emptively. If the Soviet Union confined its accusation to a U.S. ally (e.g. "Turkish agents"), it would lose prestige unless it followed through with some action. If the Soviet leaders
should have planned an aggressive move for about this time they might use this accusation as a pretext. However, since the United States government would clearly know that the charge was untrue, it would have to react strongly against any aggressive moves that were initiated under this pretext, perhaps more strongly than if the aggressive moves had consisted of a less open challenge (such as sending "volunteers" to support some indigenous communist rebellion). Hence, it seems more likely that the Soviet Union would shy away from an aggressive act following an accidental detonation, so that the Soviet leaders would have correspondingly less motivation to blame the United States government for the accident.

With these considerations in mind the Soviet leadership might prefer to blame a vaguely defined group of "enemies," "sabateurs," or "agents," and link the cause of the disaster with the Western "refusal" to abolish nuclear weapons. Soviet propaganda might emphasize the past Soviet proposals for nuclear disarmament and the renunciation of nuclear war, to create the impression that the disaster ultimately sprang from the "aggressive" policies and atomic stockpiling of the West, rather than from the specific shortcomings of Soviet personnel or equipment.
U.S. POLICY MOVES AFTER AN INTERNALLY CAUSED DETONATION IN THE SINO-SOVIET BLOC

The United States would probably first learn about the detonation through its test detection system (AFOAT-1). An unusual location may suggest immediately that the detonation was not due to an ordinary test, but full confirmation about its accidental character might have to await additional intelligence information. If the civilian damage was large, say the destruction of a major city, the character of the disaster might be confirmed through the monitoring of local Soviet broadcasts.

In the realm of military reactions, the United States and its allies could choose between two alternatives: (1) to take limited alert measures as soon as they detected that the detonation was not a test; or (2) to take alert measures only if and when Soviet alert measures had been detected. It is also possible that the United States might detect Soviet alert measures before it detected that the detonation was not a test. The alert problem for the United States would generally be less critical than in case of a detonation of unknown cause in the West. Much of the foregoing discussion of the latter case, however, also applies here. An unauthorized detonation in the Soviet bloc would certainly create a period of tension so
that low alert measures would be needed for the U.S. forces, much as in any other political crisis. This alert status would have to last until it became definitely clear that the Soviet response to the detonation did not endanger the West. Indeed, the alertness of the West might help to discourage the Soviet government from formulating an aggressive response to the disaster, such as accusing the United States of having instigated it.

We will now discuss very briefly some elements of the U.S. political response to an unauthorized detonation in the Soviet bloc. In accordance with our three possible Soviet policies we can consider three different U.S. responses.

First, if the Soviet government concealed a seemingly accidental detonation within its territory which had caused some civilian damage, it might be advantageous for the United States to announce this. The more information the United States obtained about civilian damage, the better could it exploit such a detonation in its information programs. The United States would probably never learn the true cause of the detonation, but its information services, nevertheless, could speculate that this disaster seemed to be due to careless handling of nuclear weapons in a military exercise or test.
Second, if the Soviet Union falsely blamed a U.S. weapon for the detonation, what the U.S. reaction should be is rather obvious. The denial would probably be kept in a relatively low key, lest the United States appeared to be on the defensive. But more important would be some military alert measures, because the Soviet Union might follow up its accusations with an aggressive move. In addition, the United States ought to demand an international investigation of the detonation.

Third, if the Soviet Union should accuse undefined "enemies" and the Western defense posture in general, the United States might try to expose this accusation as a smokescreen to cover up irresponsible Soviet practices with nuclear weapons. The United States ought to insist on an international investigation and even offer aid teams. These steps should be widely publicized since they would have political value, although the Soviet Union would almost certainly reject them. More indirect approaches would be open toward some of the Soviet satellites and neutralist nations. Selected government leaders and military officers in such countries might be receptive to rumors that the Soviet military could not be trusted to prevent nuclear disasters, as demonstrated in this case. Technical rumors about the "unreliability" of Soviet nuclear weapons might be fed to satellite officers, who might readily absorb such information in the
absence of Soviet data about the accident. This would be a situation where the internal secrecy in the Soviet bloc might favor the West.

THE SPECIAL CASE OF AN EXTERNALLY CAUSED DETONATION IN THE SINO-SOVIE T BLOC

Hypothetically a nuclear detonation within Soviet territory could be caused by the accidental launching of an armed U.S. or British missile, or an unauthorized attack by a fighter plane with a nuclear weapon. It goes without saying that the most extensive precautions have been taken in U.S. weapon systems to prevent such a disaster. It is assumed that similar precautions are being taken in British weapon systems and would be instituted by other allied nations if they should acquire nuclear weapon systems. For the sake of completeness, however, it may be worth while to consider the case of an accidental delivery from West to East.

In the reverse case, in which a Soviet missile is accidentally fired against a Western target, the Soviet authorities might well be able to deny what happened and blame the detonation on the West. A Western investigation might later reveal the true cause, but the Soviet government could still maintain its original position. This policy of denial does not seem to be available to the West, should one of its missiles cause an
unauthorized detonation on a Soviet target. The truth would probably come out eventually through rumors, probings by newsmen, and inter-governmental discussions; quite apart from the fact that Western nations generally would not want to use such a policy.

The United States, however, should avoid public self-implication and delay the release of any details about the accident until it has completed an internal investigation. This would give an opportunity to start secret diplomatic negotiations without explicitly assuming responsibility (perhaps simply for the purpose of discussing "urgent problems arising in connection with an accident that has just occurred.") The objective of diplomatic communications would be to discourage the Soviet government from committing itself publicly to excessive demands which could not be accepted by the West and hence might lead to all-out war.

In later public statements it might be possible for the United States (and other Western nations involved) to point at considerable ambiguities in the circumstances of the detonation, such as the possibility that a third power might have been involved or that individuals other than United States (or Allied) nationals seemed to be responsible. Such ambiguities could help soften the impact on Western public opinion and combat the
attitude in the West that only the most immediate and far-reaching concessions to the Soviet Union could avoid total war and atone for the disaster.

The hypothesis cannot be totally rejected that Soviet agents might simulate an "accidental" launching of a Western missile against a Soviet military target. It is at least conceivable that Soviet agents might arrange the unauthorized take-off of an armed U.S. fighter plane and have it drop its nuclear weapon on satellite or sparsely inhabited Soviet territory. The objective would be to create feelings of dismay and guilt among Western statesmen and the Western public, so that some Western nations or political elements would become willing to grant the Soviet Union substantial concessions.\(^{37}\)

Admittedly, a Soviet stratagem of this kind seems highly unlikely. Nevertheless, Western statesmen could not reject this possibility prior to a thorough investigation of any such detonation.

\(^{37}\) If the West should refuse to grant these concessions the Soviet Union (or Communist China) might then embark on a pre-planned local aggression to take advantage of the dissen-sion in the West. For example, if a weapon were "accidentally" (i.e. by communist agents) launched against Communist China, U.S. aid for the defense of Formosa might lose all political support among Western allies and even within the United States.
Western nations implicated in a genuine accident might offer to discuss the question of liability but should refuse to negotiate about political or military Soviet demands (e.g. for the withdrawal of nuclear weapons). The purpose of the Western stand would be to transfer the basis of discussion from the area of military and political threats to that of legal liability. The Western nations would have to emphasize that the question of liability ought to be settled in accordance with international law. They ought to stress that the unauthorized detonation obviously did not constitute a political act on their part and that a peaceful international settlement of the issue would have to be confined to the aspects of legal liability and possible financial compensation and could not in any way involve political questions.

The military alert measures of the West would have a short-term and a long-term aspect. Immediately after the detonation, the Soviet Union might mistake Western alert measures as confirmation of their fear that the detonation was the forerunner of an attack. In spite of this, however, certain defensive alert measures by the United States and its allies would seem indicated, along the lines discussed above (pp. 41 ff.). The before-mentioned secret diplomatic communications might be utilized to facilitate an understanding mutually to refrain
from certain alert measures which could be readily observed by
either side. Such an understanding, of course, would have no
value against alert measures that might go undetected.

The danger of all-out war as a result of a misunderstanding
about the purpose and cause of a single detonation and of
the subsequent alert measures would probably be overcome within
a very short time, perhaps a day or so. At this point the
dominant military threat would be that the Soviet Union (or
another bloc country) might start a previously planned local
aggression to exploit temporary dissension and self-incrimina-
tion in the West. Hence, the West would have to maintain a
state of readiness higher than normal, especially in critical
local areas, until the negotiations with the Soviet Union became
stabilized.
PART III. PREVENTIVE MEASURES AND CONTINGENCY PLANNING

We have discussed policies and measures that might mitigate the military and political consequences of a single nuclear detonation. We have assumed that the relief and rehabilitation effort would be taken care of by the existing agencies for disaster relief, and that this effort would receive adequate support from the nation to the extent that these agencies were unable to cope with their task. All the measures discussed so far would be instituted only after a detonation had occurred. Now we shall consider whether certain preparations should be made in advance.

PREVENTION OF AN UNAUTHORIZED DETONATION

As we have said before, the policy regarding the risk of an unauthorized detonation must be to give absolute priority to the prevention of such a disastrous event. As far as the risk from U.S. weapons is concerned, the services and the AEC maintain a large and continuous effort to attain the highest degree of safety that is compatible with the military mission. This effort includes careful and ingenious design of safety features in the construction of weapons, an extensive testing and reviewing program for the finished weapon systems, and far-reaching operational precautions and controls for the storage,
transport, and handling of weapons. There exists a considerable
literature on weapon safety, so that it is unnecessary to cover
this extensive field here. We wish to discuss only two special
areas where additional safety measures might be desirable.

Safety against Sabotage

The first area to be considered is that of sabotage. The
Atomic Weapons Reward Act of 1955 offers a reward up to $500,000
to anyone furnishing information about illegal entry of nuclear
materials or weapons into the United States. This act can only
serve its purpose if it is generally known. It might be possible
to give it some renewed publicity, without, however, implying
that the United States had suddenly become more vulnerable to
this threat. Moreover, it might be desirable to extend the
scope of this act to include nuclear sabotage against U.S. mili-
tary installations outside of the United States. This would
have to be done in rather general terms to avoid creating anxie-
ties among the Allies.

A more important deterrent against nuclear sabotage con-
sists in the current technical effort to detect the clandestine
entry of nuclear weapons into the United States. Devices to
detect fissionable materials are being used by customs personnel
at various ports of entry and by the Coast Guard. These devices
have a limited range and might fail to detect fissionable
material that is strongly shielded. However, we must remember that even a slight risk of detection may suffice to deter the enemy, since the consequences of detection could be very grave. Hence, it may seem worth while to extend this detection effort somewhat, both for United States and overseas installations. Occasional spot checks of traffic near overseas storage areas and at East-West border crossings might yield a high deterrent value at small cost.

A third safety measure against sabotage that deserves to be considered is the incorporation of tracer elements into U.S. weapons. We mentioned above that this should be done after an unauthorized detonation occurred. But a small effort in this direction may be desirable even now, for example for weapons that will be used in certain exposed overseas areas. Again, the objective would be to make sabotage more risky for the enemy rather than to guarantee that detonation of an enemy weapon would always be distinguishable from that of a U.S. weapon.

Prevention of Extremely Large Numbers of Casualties

The other area where additional safety measures ought to be evaluated is the location of high-yield weapons relative to the largest population concentrations. Let us assume that there is a very small, but not negligible, probability of an
accidental nuclear detonation. Given such a risk, some of the worst possible outcomes could be precluded if it were possible to keep high yield nuclear weapons always at a sufficient distance from the largest cities. However, such a policy would only be warranted if it did not create other more serious risks. Air defense weapons, for example, are of a relatively low yield, so that an accidental detonation in a city would not cause more than 100,000 casualties even under the worst circumstances. These weapons, on the other hand, might prevent enemy bombs from reaching their target and thus save several million lives.

A specific and detailed policy to restrict nuclear weapons in the largest population centers would obviously have to be based on a detailed knowledge of the storage, transport, and operational uses of nuclear weapons and would involve many subjective judgments. However, one can suggest certain basic guidelines that would reduce or eliminate the risk of the most catastrophic accidents without seriously increasing other risks. A minimal guideline might be based on the following rule:

A nuclear weapon should never be allowed so near to a population center that the blast effect

from a full-scale

The blast effect is the dominant lethal agent for an urban population, provided that fallout protection or quick evacuation measures are available so that a 24-hour integrated dose below 1000 roentgens would not produce casualties. It is the task of civil defense and not part of the weapons safety effort to provide such protection, since it would be the very minimum required in time of war.
nuclear detonation would lead to casualties in excess of a

certain number (say 100,000 or half a million), (a) unless the
weapon makes a contribution to the defense effort by virtue of
being in or near the population center, and (b) provided that
this restriction would not lead to greater risks elsewhere or
substantially increase the costs of the defense effort.

Even a minimal guideline like this involves many subjective
evaluations, of which the most difficult relates to the restric-
tion on the number of casualties. One is faced with such
questions as: why is it all right to expose, say, 490,000
people to this remote risk, but not 500,000? 39 However, a certain
risk must be accepted anyhow to maintain urban air defense, which
requires that low-yield nuclear weapons be kept within metro-
opolitan areas. Hence it would seem unjustified to go to great
lengths to guarantee fewer casualties from other weapons, even
if they do not make a contribution to the defense effort by
virtue of being in the cities (e.g. if they are merely being
in the cities for transport).

The crux of the matter is that conditions (a) and (b) of
the above safety rule would rarely, if ever, be unequivocally

39. The policy of locating nuclear power reactors far from
densely populated areas sets a precedent for such calculations,
though a reactor accident, if more likely, would be less destruc-
tive than a nuclear detonation. For nuclear-powered submarines,
for example, the Advisory Committee on Reactor Safeguards of the
AEC emphasized the importance of limiting the utilization of
parts. (Joint Committee on Atomic Energy, 86th Congress, 1st
Session, AEC Report on Indemnity Act and Advisory Committee on
Reactor Safeguards, Washington 1959, p. 58.)
fulfilled. For example, our tentative safety rule would create
great problems for the carrier operations of the Navy.

Hence, provision (a) would be fulfilled. But to
build substitute ports away from population centers, of course,
would enormously increase the defense budget, and in some regions
all ports large enough for carriers are at a big city. There-
fore condition (b) might not be fulfilled in this case.

A more stringent version of our safety rule would be the
following:

A nuclear weapon should never be allowed so near to a
population center that the blast effect from a full-scale
detonation would lead to casualties in excess of a certain
number, even if the weapon makes a contribution to the defense
effort by virtue of being near the population center, provided
that this contribution can be obtained by keeping the weapon
elsewhere without creating greater risks and without substantially
increasing defense costs.

In this form, the rule might create problems for some SAC
and TAC bases and, to a lesser extent, SAC flight routes. How-
ever, most SAC bases where bombers use war-reserve weapons, both
within the United States and overseas, are not near large population centers. On none of these SAC bases could the detonation of the largest weapons used cause more than half a million casualties from the blast effects, and on only about four to six SAC bases (Catfoss) could such a detonation cause more than 300,000 blast casualties. In addition, the currently used flight routes for bombers carrying nuclear weapons generally avoid densely populated areas.

As a further refinement of our safety rule, it might be desirable to consider the circumstances under which nuclear weapons would be taken near population centers. Some circumstances constitute a greater exposure to the risk of accidental detonation than others. Obviously, the risk is nil for individual parts of a disassembled weapon. (If all parts were transported together there might be a remote risk of unauthorized assembly.) The exposure is greater during weapon modifications and tests than in completely inert storage. Perhaps we should also add here that regulations already exist regarding the transport and storage of nuclear weapons in populated areas. But to our knowledge these regulations are mainly concerned with the risk of HE detonation or local plutonium contamination, whereas our tentative safety rule would apply to the risk of a full nuclear yield.
CONTINGENCY PLANNING

It is not feasible for the government to prepare plans for all possible contingencies and crises that the nation might encounter in the future. In many cases the actual situation would differ so drastically from what has been anticipated that the contingency plans would be of little use. We submit, however, that a single detonation of a nuclear weapon is an event for which certain preparations should be made, for several reasons: first, the probability of a single detonation does not seem negligible given the large number of weapons in the world and given the possible enemy interest in sabotage; second, the event is relatively well defined and hence more amenable to advance planning than other types of crisis; third, speed of reaction would be essential to mitigate the adverse consequences of the disaster and especially to minimize the risk of an accidental war; fourth, a single detonation involves certain intricacies which might not be apparent at the moment of the crisis.

Judging from the plans for coping with contamination incidents and similar accidents with nuclear weapons, the services and the Department of Defense seem to recognize the
need for planning in this general area. However, the plans in this area that came to our attention are not intended to meet the contingency of a substantial nuclear yield, especially one causing a large disaster.

Specific preparations ought to be considered in three areas:

The Planning of Military Alert Measures. Above in Part I we discussed certain objectives that the military alert measures in response to a single detonation should meet and mentioned some possibly dangerous effects that should be avoided. The problem is not that of designing new alert measures, but of

Examples of such plans are: Joint Department of the Army, Navy, Air Force and ACE Agreement of General Areas of Responsibility and Procedures Applicable to the Prompt, Effective and Coordinated Response to Accidents Involving Nuclear Weapons, 27 February 1958 (Unclassified); Hq. Field Command, Armed Forces Special Weapons Project, Directive 55-2, Special Weapons Accident Alerting System (Confidential); Hq. U.S. Army Europe, Guidance on the Handling of Radiological Incidents, AEAGD-PL 250/17, 6 February 1959 (Confidential); Continental Army Command, Basic Plan, Appendix 2, 9 April 1957, (Secret); Department of the Air Force, Information Plan No. 58-A-14, Peacetime Nuclear Accidents, October, 1958 (For Official Use Only); and a Department of Defense information plan based on these plans by the military departments, currently in process of coordination.
choosing the most appropriate form of alert among the various prepared measures available to the commanders. This choice is a matter of delicate military judgment and, given the crisis we have in mind, would involve decisions at the highest level. It may not seem desirable to commit the various major commands to a specific reaction beforehand. But it may be advantageous to prepare broad guidelines to avert inappropriate reactions between the time the detonation became known to various commands and the time specific instructions had been formulated at the highest level and transmitted to all these commands. Furthermore, preparation of these guidelines -- to the extent that they are not already contained in the current war and alert plans -- would serve to expedite and facilitate the decision-making process at the time of the crisis itself.

The overall response would not only involve Air Force commands but also joint commands, such as NORAD and allied commands, for example SHAPE. Hence, part of the planning could not be carried out by the Air Force alone.

Preparations for Public Information. It is a common practice of the information services to prepare news releases for a variety of contingencies that are not fully predictable.
Releases have been prepared in advance for nuclear weapon incidents not involving a nuclear yield, and on several occasions have been used to good effect. In a few places some preparations have also been made for the event of a nuclear yield accident. However, for the event of a large nuclear disaster it seems particularly difficult to prepare specific releases in advance that would meet the many possible situations. Moreover, in this very sensitive area there is a greater risk of leaks or inappropriate releases (for example upon the occasion of some other type of accident). Therefore we have refrained from suggesting specific news releases and emphasized instead certain important objectives and guidelines for information policy. It goes without saying that the information program in response to a large nuclear detonation would not be finished with a few news releases. This program would be one of the greatest tasks ever faced by the information services, and it would continue for several months.

In spite of the fact that ready-made news releases are not the full answer to the problem, some preparations for the information policy can and should be made in advance. At the lower levels the preparations would merely require instructions that no information be released in the field, except guidance necessary for public safety (e.g., fallout warnings for very
specific areas). This injunction against releasing information in the field applies particularly and most emphatically to the (surmised) cause of the detonation. The injunction is necessary because the information program would constitute one of the most critical parts of national policy. Actually, current Department of Defense instructions for incidents with nuclear weapons already require that no news releases about nuclear accidents be made locally except those that have been authorized in advance.

It seems likely that the information policy for a large nuclear disaster would have to be co-ordinated and controlled at the highest government level. Some of the most important messages, such as the initial non-military announcement by the U.S. government that we suggested, would most appropriately come from the White House. The crucial reports from the board of inquiry might be released by the board itself after consultation with the White House or the Defense Department.

In the event of a large domestic disaster, civil defense information and other instructions for public safety would require the highest priority for access to the information media. This requirement would have to be balanced with other urgent objectives of the information program. A crucial role would also have to be played by the U.S. Information Agency,
particularly if the detonation occurred in a foreign country. The number of demands might create conflicting objectives in formulating a program, so that a central authority would have to provide co-ordination. This does not preclude, of course, that the Department of the Air Force or the other departments could generate preparations and suggest guidelines for this information program.

Major Policy Planning. We have emphasized that the reaction of the United States to a large nuclear disaster would involve more than public information, relief, and military alert measures. It would involve major national security policies, both in the domestic and in the foreign field. For example, the initial government announcement that we have suggested as a device to control the risk of accidental war and to mitigate certain political consequences would involve the kind of decisions and authority that are normally exercised only by the President and the National Security Council.

It is conceivable that the board of inquiry into the cause of the detonation would be set up by the Department of Defense or by the military department concerned. If the disaster was large, however, it is more likely that both Congress and the White House would take a direct interest and exercise authority in this inquiry. It is also clear that the negotiations and
communications with Allied governments and with Soviet bloc countries would involve the Department of State.

A detonation which led to a large number of casualties and widespread contamination would cause a strong psychological shock among the domestic and foreign public as well as among government leaders. Decision makers would be under an enormous strain and might be influenced by feelings of guilt and fear of total war. This emotional impact might distort the evaluation of the crisis among those who have not seriously considered the possibility of such a disaster beforehand.

The psychological situation could be improved by the previously discussed contingency planning within the government. This planning, apart from its primary purpose of providing a mechanism and guidelines for a quick reaction, might have useful psychological effects, such as the following:

(1) The planning process would automatically communicate to command posts and other selected government offices the idea
that a single detonation could happen, thus forcing them to consider this risk seriously.

(2) The broader responsibilities in this area would become more widely understood. If, in the event of a nuclear accident, Allied governments or other political groups reacted in a way that would jeopardize the security of the West, U.S. officials who might have to cope with such reactions would be more fully aware of the fact that the West must balance the risk of nuclear accidents against the risk of nuclear war.

(3) The advance evaluation of anticipated losses and compensating strengths could help to counteract excessive pessimism or unwarranted optimism. Even if the advance estimates proved wrong in many respects, they would still encourage a calculated reaction which would seek to optimize the outcome through every available and acceptable measure.

(4) The fact that the cause of the detonation might be totally unknown and that the apparent cause might well be deceptive is an especially important one in all contingency planning. If this fact is understood, premature reactions would be less likely, since technical knowledge and studies would be required to evaluate the cause.

(5) The knowledge that a plan existed for this kind of crisis would in itself give some strength, because it would
imply that such a crisis could be coped with, even if the specifics of the plan must await the actual event.

To some extent these psychological benefits from contingency planning might even be extended to allied headquarters. The risk of an accidental detonation of a U.S. weapon, however, should be de-emphasized, and the uncertainties of Soviet weapons and Soviet attack (which might be signalled by a single detonation) instead be used to justify the planning. In such a context the planning would not imply a lack of confidence in the safety of U.S. (or U.K.) weapons.

For the special case of the United Kingdom, however, a more specific arrangement would be feasible, because a considerable exchange of data on weapon safety has already been authorized. A joint safety board could be established, to which questions regarding the safety of U.S. weapons in the United Kingdom could be referred. This would have to be evolved gradually, for example, from the present Joint Atomic Information Exchange Group and the joint arrangements for high explosive safety. It might be preferable to leave the initiative to the British representatives, to avoid creating anxieties. Furthermore, the joint safety information would probably be confined to operational safeguards and fusing and firing systems, since the exchange of certain nuclear data is not
authorized. The joint safety board could be helpful in the event of minor weapon incidents in the United Kingdom. But the principal objective of such an arrangement would be to create a tradition of mutual confidence and shared responsibility. Should there ever be a nuclear disaster, this tradition would help to reduce friction between the United States and the United Kingdom. In addition, a joint safety program might be of some value for the safety of British weapons in which the United States is obviously so vitally interested.

The question has been raised to what extent the public, and perhaps allied governments should be informed about the risks and problems of a single detonation. Over the past years, a considerable amount of information has been released about the problems of weapon safety, reaction times, nuclear sabotage, clandestine entry of weapons, etc. In view of these releases and the additional discussions which occur frequently in Western news media, it would seem unjustified to argue that the basic issue was being withheld from the public. A more detailed public information program at the present time might endanger classified information about weapon design and alert measures. This could increase the danger of sabotage and degrade the Western defense posture.
Appendix I

LONG TERM Fallout Contamination FROM SURFACE BURST NUCLEAR WEAPONS

Jerald E. Hill

Introduction

In the event of an accidental surface detonation of a nuclear weapon, fallout could result in loss of life and radiation injury for large numbers of people. In fact, if such a detonation were to occur, it appears quite likely that ground zero would be sufficiently remote from heavily populated areas so that the majority of casualties would be caused by fallout radiation rather than by prompt effects such as blast, thermal and prompt nuclear radiation. Since the fallout radiation decays rapidly with time, the danger of death or serious injury from fallout would be greatest during the period from arrival of the fallout to the first few hours or days depending on the contamination levels encountered. Efforts to minimize the number of radiation casualties would therefore depend primarily on the efficiency of civil defense and other disaster agencies in evacuating the population or getting them into appropriately shielded shelters as promptly as possible before the accumulation of dangerous levels of fallout. Clearly, the prompt prediction of the probable areas of dangerous fallout and warning of the populations in these areas would be of paramount importance in keeping casualties to a minimum.

In addition to these early hazards, there are long term fallout effects which would have an important bearing on the magnitude of total damages for which the government might be expected to accept responsibility. Because of the total body radiation hazards there would be areas of heavy fallout which would be unsafe for continuous occupancy for many years unless very thorough decontamination procedures were carried out. Other areas with lower levels
of contamination could be reoccupied after allowing sufficient time to
eclipse for radiation to decay to acceptable levels. The magnitude of these
delays would depend on the levels of contamination, on the radiation levels
specified as acceptable, and such factors as weathering, feasibility of
decontamination efforts, etc.

Also because of the incorporation of certain long-lived fission pro-
ducts, such as strontium-90 with a half-life of about 28 years, in food
grown on contaminated soil, large agricultural areas might have to be with-
drawn from production to prevent contaminated food from reaching the popula-
tion. The total areas involved would depend on the fission product yield
of the detonation, the portion of the area in the fallout pattern utilized
for agriculture, the nature of the soil and the concentrations of the danger-
ous isotopes which are specified as acceptable.

In certain areas contaminated water supplies might also present problems
but the high efficiency of normal filtration processes for removing radio-
active impurities and the tendency for such materials to be retained in the
soil rather than in water which filters through it would probably make this
a relatively minor hazard.

It is the purpose of this paper to consider the possible magnitude of
these long term hazards, to suggest possible criteria for controlling the
hazards and to estimate the potential damages which the government might
have to assume. While no specific recommendations will be made, it is hoped
that the results may be useful if it is decided that advanced plans for such
an emergency situation are necessary.

External Total Body Radiation

It is customary to estimate dose rates and accumulated dose from fallout
gamma radiation by the following procedure:

1. 1 KT (kiloton TNT equivalent) of fission energy release gives 300 MC (megacuries) of gamma rays with an average energy per quantum of 0.7 mev (million electron volts) at one hour after detonation.

2. The dose rate at 3 feet above an infinite smooth plane contaminated to a level of 1 MC/mi<sup>2</sup> is about 4 h/ hr (roentgens per hour). Consequently a contamination level of 1 KT/mi<sup>2</sup> corresponds to 1200 r/hr 1 hour after the nuclear detonation.

3. Dose rates at subsequent times are calculated by the relation

\[ R = R_1 t^{-0.2} \]

(1)

Where \( R \) is the dose rate at time \( t \), in hours and \( R_1 \) is the dose rate at 1 hour after detonation.

4. Accumulated dose, \( D \), from \( t_1 \) hours to \( t_2 \) hours after detonation is computed by integrating equation (1) above to give:

\[ D = 5 R_1 (t_1^{-0.2} - t_2^{-0.2}) \]

(2)

When using equations (1) or (2) it is necessary to be certain that all of the fallout has been deposited before the equations are valid. Since the fallout may not arrive at locations far from the point of detonation until 24 hours or more have elapsed and may continue for some time, failure to observe this restriction may considerably overestimate dose rates or accumulated dose at such locations. Despite this difficulty it is frequently convenient to present fallout patterns in terms of "equivalent" 1 hour dose rate contours that would have obtained if the whole fallout field had been deposited at one hour after detonation, since these are indicative of the total fraction of fission products deposited within the enclosed areas at times sufficiently long for the complete fallout pattern to have been deposited.
However, even when the above restrictions are observed the use of the
above procedure overestimates dose rates and accumulated dose, particularly
for times greater than a week or two. This is true for the following reasons:

(1) For a given contamination level in terms of MC/mi\(^2\) or KT/mi\(^2\) the
use of the infinite plane dose rate is too high because roughness of real
terrain results in absorption and scattering of gamma radiation that would
otherwise reach the subject. Also, the small fallout particles may fall
into cracks, etc. Such effects may reduce the effective dose by from 22%
to 42% depending on the degree of departure of the actual terrain from the
ideal infinite smooth plane.\(^2\)

(2) The actual decay rate of fission product gamma rays is more rapid
than the t\(^{-1.2}\) relation predicts particularly for times greater than two
weeks.\(^1\)

(3) Weathering causes the radioactive fission products to penetrate
into the soil. The magnitude of this effect depends on the amount of rain-
fall, its time and frequency of occurrence, and the physical and chemical
properties of the soil. The result, however, is to increase the observed
decay rate relative to that computed by the t\(^{-1.2}\) relation.

An example of the combined effects of deviations 2 and 3 was provided
by observations of the decay rate on the island of Rongelap following the
Castle Bravo test.\(^3\) At 90 days post detonation the observed dose rate was
41% of that predicted by the t\(^{-1.2}\) relation. At 455 days or 1 year later
the observed dose rate was less than 18% of the t\(^{-1.2}\) value and at 730 days,
less than 11%.

The accumulated dose from 90 days to 455 days was 29% of that predicted
by the t\(^{-1.2}\) relation and for the period from 90 to 730 days was 26% of the
Since responsible agencies such as the National Committee on Radiation Protection (NCRP) and the Department of Public Health (DPH) have not specified total body radiation criteria which would apply in such a fallout incident, all that can be done is to use the criteria that have been established for other situations as a guide.

The NCRP has established maximum permissible levels (MPL) of gamma or X radiation for industrial workers. This MPL is 0.3 rem/wk with the stipulation that the accumulated dose should not exceed \((N-18) \times 5\) rem where \(N\) is the worker's age in years. However, in a single emergency a worker may be allowed as much as 25 rem. However, where the emergency dose is planned and consciously taken it should be limited to 12.5 rem. Also, such planned emergency dose should not be taken by women of reproductive age. It should be emphasized that all of the above specifications apply only to areas where radiation levels are "controlled."

For the general population outside of controlled areas the MPL is 0.5 rem per year. However, the population of the U.S. as a whole should not exceed \(1.1 \times 10^6\) rem per million for the first 30 years of life (starting at conception) and one third of that amount in each decade thereafter, from all sources of radiation including medical and other man-made sources and background. Since background is about 1 rem in 30 years this means that exposures to the whole population from all "man-made" sources should not exceed \(10^7\) rem per million for each 30-year period.

Since the number of people at risk in a single nuclear accident would be a relatively small fraction of the total U.S. population and for the long term situation (i.e., for times greater than 90 days after detonation) a
degree of radiation control is certainly feasible, the industrial maximum permissible levels specified by NCRP would appear to be a reasonable guide for establishing criteria for continuous occupancy of contaminated areas.

A conservative procedure would be to specify that during the first year after reentering a contaminated area the accumulated dose for continuous occupancy should not exceed 5 r. Because of the decay characteristics of the fission products this would insure that the accumulated dose during each year after the first would be much less than 5 r.

Another less conservative procedure would be to allow reentry into an area where the accumulated dose for continuous occupancy during the first year would not exceed 25 r but with the stipulation that decontamination measures and shielding of buildings should be carried out as promptly as possible to reduce the radiation exposure rate by at least a factor of 5, as indicated by radiation monitoring. Since relatively simple decontamination procedures alone can reduce radiation levels by a factor of five, this second procedure should be nearly equivalent to the more conservative one above, except for the additional exposure received during the decontamination operations which should be kept as small as practicable.

The philosophy of the second procedure could make continuous occupancy of areas with even higher contamination levels possible by more extensive decontamination and shielding operations, since reduction factors of 100 or more can be obtained by more thorough decontamination and shielding efforts. However, the larger reduction factors imply greater exposures during the decontamination and shielding operations since more man hours are needed and the radiation levels at the time of entry will be higher unless reentry is delayed for longer times. Consequently, careful radiation monitoring of
personnel during such operations is necessary to prevent the accumulation of more than 25 r during the first year after reentry.

While the above total body radiation criteria appear reasonable for adults (age greater than 18 years) where only a small fraction of the population of the U.S. is at risk, they would probably not be acceptable guides for young children and adolescents.

A reasonable procedure for establishing criteria for the continuous occupancy of an area by children would be to apply the NCRP restrictions for people outside of a controlled area but subject to sources of radiation from within the controlled area. The NCRP statement for this situation is "the dose to any such individual shall not exceed 0.5 rem in any one year from external radiation."

While this restriction is more conservative by a factor of ten than the first of the two procedures outlined for adults it should be possible to meet it by an appropriate combination of delayed reentry and additional decontamination and shielding.

To indicate how delayed reentry and decontamination and shielding influence the contamination levels at which continuous occupancy becomes possible under the above restrictions, Table I is presented on page 116. The first column gives the reentry time at which the one hour post detonation contamination levels listed in columns two and four would produce accumulated doses of 5 and 25 r respectively during the first year after reentry. Columns three and five give the corresponding dose rates at the time of reentry and give some indication of the times which could be utilized for decontamination and shielding operations.

It should be emphasized that all of the data in Table I are based on...
<table>
<thead>
<tr>
<th>Reentry Time</th>
<th>Contamination Level in r/hr at 1 hour post detonation to give a dose of 5r during first year after reentry</th>
<th>Dose Rate in mr/hr at time of reentry</th>
<th>Contamination Level in r/hr at 1 hour post detonation to give a dose of 25r during first year after reentry</th>
<th>Dose Rate in mr/hr at time of reentry</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 day</td>
<td>2.72</td>
<td>60.1</td>
<td>13.6</td>
<td>301.</td>
</tr>
<tr>
<td>7 days</td>
<td>5.08</td>
<td>18.6</td>
<td>25.4</td>
<td>92.8</td>
</tr>
<tr>
<td>30 days</td>
<td>9.25</td>
<td>3.45</td>
<td>46.3</td>
<td>17.2</td>
</tr>
<tr>
<td>90 days</td>
<td>16.8</td>
<td>1.67</td>
<td>83.9</td>
<td>8.36</td>
</tr>
<tr>
<td>0.5 year</td>
<td>27.1</td>
<td>1.16</td>
<td>136</td>
<td>5.78</td>
</tr>
<tr>
<td>1 year</td>
<td>48.1</td>
<td>0.892</td>
<td>240</td>
<td>4.46</td>
</tr>
<tr>
<td>2 years</td>
<td>90.6</td>
<td>0.741</td>
<td>453</td>
<td>3.71</td>
</tr>
<tr>
<td>3 years</td>
<td>137</td>
<td>0.680</td>
<td>685</td>
<td>3.40</td>
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<tr>
<td>4 years</td>
<td>186</td>
<td>0.654</td>
<td>929</td>
<td>3.27</td>
</tr>
<tr>
<td>5 years</td>
<td>236</td>
<td>0.636</td>
<td>1182</td>
<td>3.18</td>
</tr>
<tr>
<td>6 years</td>
<td>290</td>
<td>0.627</td>
<td>1449</td>
<td>3.13</td>
</tr>
</tbody>
</table>

*Note these are "equivalent" dose rates at 1 hour post detonation if all the fallout were down at that time. To convert to contamination levels in KT/mi² divide by 1200.*
the $t^{-1.2}$ decay relation and consequently overestimate the delay in reentry time required to satisfy the dose restrictions at the indicated contamination levels.

The effect of the deviations from the $t^{-1.2}$ relation and departures from the ideal infinite smooth plane source is to increase the contamination levels in Table I at which reentry is possible without violating the NCRP total body radiation restrictions.

Since there can be large variations in surface roughness and also in the effects weathering on the effective decay rates, it is difficult to make quantitative estimates of these effects.

However, if we use the 22% reduction figure (page 112) for the smaller degree of surface roughness and the departure from the $t^{-1.2}$ relation observed in the Rongelap fallout, it is possible to get an indication of how important these effects might be. However, it is important to remember that different rainfall histories and soil conditions might alter these estimates considerably.

Table II (page 118) shows how Table I can be altered by these effects. Since the Rongelap observations only cover a period of two years, reentry times greater than one year are omitted from Table II. Also, since the observed decay during the first ten days did not deviate significantly from the $t^{-1.2}$ relation, the one and seven day reentry figures are changed only by the surface roughness factor.

Comparison of Table II with Table I indicates that the effects of surface roughness and deviations from $t^{-1.2}$ decay can make areas with significantly higher initial contamination levels acceptable for reentry at any given time after detonation. For example, under the conditions assumed
Table II

COMBINATIONS OF REENTRY TIME AND FALLOUT CONTAMINATION LEVELS WHICH RESTRICT ACCUMULATED DOSES DURING FIRST YEAR OF CONTINUOUS OCCUPANCY TO 5 AND 25r

(Modified by the Effects of Surface Roughness and Deviations from the t^-1.2 Relation.)

<table>
<thead>
<tr>
<th>Reentry Time</th>
<th>Contamination Level in r/hr at 1 hour post detonation to give a dose of 5r during first year after reentry*</th>
<th>Dose Rate in mr/hr at Time of Reentry</th>
<th>Contamination Level in r/hr at 1 hour post detonation to give a dose of 25r during first year after reentry*</th>
<th>Dose Rate in mr/hr at Time of Reentry</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 day</td>
<td>3.49</td>
<td>60.1</td>
<td>17.5</td>
<td>301</td>
</tr>
<tr>
<td>7 days</td>
<td>6.52</td>
<td>13.6</td>
<td>32.6</td>
<td>92.8</td>
</tr>
<tr>
<td>30 days</td>
<td>26.8</td>
<td>1.54</td>
<td>13.5</td>
<td>22.7</td>
</tr>
<tr>
<td>90 days</td>
<td>74.1</td>
<td>2.55</td>
<td>370</td>
<td>12.8</td>
</tr>
<tr>
<td>0.5 year</td>
<td>162</td>
<td>1.55</td>
<td>810</td>
<td>7.77</td>
</tr>
<tr>
<td>1 year</td>
<td>361</td>
<td>0.95</td>
<td>1805</td>
<td>4.75</td>
</tr>
</tbody>
</table>

*Note these are "equivalent" dose rates at 1 hour post detonation, if all the fallout were down at that time. To convert to contamination levels in KT/m^2, divide by 1200.
in Table II, areas with 1.4 times the contamination levels indicated in 
Table I could be entered safely at 90 days post detonation and at one year 
the ratio is 7.5.

It is also apparent that the use of delayed reentry to increase the 
contamination level at which continuous occupancy is "permissible" is most 
effective during the early post detonation period. For example, using $t^{-1.2}$ 
decay the contamination level which permits continuous occupancy increases 
by almost a factor of 10 by delaying reentry from 1 day to 6 months. To 
gain an increase of another factor of 10, reentry would have to be delayed 
almost six years. Under the conditions of Table II, delay of reentry from 
1 day to 41 days gives an increase of 10 and to gain an additional factor 
of 10 requires waiting almost a year.

If columns two and four of Tables I and II are regarded as essentially 
equivalent as far as accumulated dose during the first year after reentry 
concerned, except that a factor of five for decontamination and shielding 
has been applied to column four in each case, it becomes clear that rather 
modest radiation countermeasures are equivalent to comparatively long wait-
ing periods in increasing the contamination levels at which continuous 
occupancy is permissible. The only restriction to this procedure is that a 
sufficient waiting period should be allowed in each case so that the 
doses accumulated during the decontamination and shielding operations are 
small compared with the dose accumulated during the remainder of the first 
year.

For example, in Table I, if a contamination level of 136 r/hr at one 
hour is reentered at 6 months post detonation and one week is devoted to 
radiation countermeasures to reduce dose rates by a factor of five, the
result is equivalent to delaying reentry for three years. If it is assumed
that the average dose rate during this period is the average of the initial
rate at reentry and the rate after the countermeasures are completed, the
accumulated dose during the week would be less than 0.6r.

Similarly, in Table II, reentering a one-hour level of 370 r/hr 90
days post detonation and reducing radiation levels by a factor of five would
be equivalent to a delay of more than a year for an accumulation of less
than 1.3r during the operations.

To get some idea of the possible government liabilities from an acci-
dental detonation of a nuclear weapon, because the long term total body
radiation hazards might prevent use of the more heavily contaminated areas
in the fallout pattern, an estimate of the areas inside various contamination
level contours is helpful. The area inside a given contamination level
contour depends on the total energy release of the weapon, the fraction of
the energy release which results from fission, the height of burst of the
explosion, the nature of the soil at the explosion site and to a lesser
extent on the meteorological conditions which exist in the area of the
fallout pattern during the first 24 to 48 hours post detonation.

Such estimates have been made based on observed fallout patterns from
weapons tests in combination with various models used for predicting fall-
out patterns. Uncertainties in the observed fallout patterns and differences
in the assumptions and approximations used in various fallout models have
resulted in a number of estimates of such areas which differ considerably.6,7,8.

The areas with contamination levels greater than certain specified
levels for a range of weapon yields from [redacted] are given in con-
venient form in reference 6. The weapons are considered to be surface burst
over land areas and to derive 100% of their energy release from fission.

Variations in the areas due to changes in meteorological conditions such as wind velocities, rainfall, etc. are considered negligible in comparison to other uncertainties. By graphical interpolation of these data, it is possible to get estimates of areas to associate with the contamination levels of Tables I and II. It should be emphasized that these areas could be in error by at least a factor of two. However, they do give a rough indication of relative consequences of the different criteria for "maximum permissible exposures" and for various assumptions about reentry times, deviations from $t^{-1.2}$ decay and radiation countermeasures.

Table III on the following page, gives the areas inside the contamination contours of Table I, for five reentry times from 1 week to 1 year, for the two maximum "permissible" exposure criteria mentioned above, and for weapon yields of 1, 10, 100, 1000 and 10,000 ET respectively, assuming $t^{-1.2}$ decay. Table IV (page 123) is the same except that the contamination levels correspond to Table II, i.e., to the observed decay rates on Rongelap with a 22% correction for surface roughness.

As indicated in their footnotes, Tables III and IV refer to weapons with 100 per cent of their energy release from fission. For such cases the areas for given contamination levels and reentry times would be correspondingly reduced. If the fraction, $f$, of the total yield which is derived from fission is known, the area inside a contour where the contamination level is $R$ r/hr at 1 hr. equivalent will be the same as the area inside the $R/f$ r/hr contour for a 100% fission
Table III

<table>
<thead>
<tr>
<th>Reentry Time Yield (KT)</th>
<th>1 week</th>
<th>30 days</th>
<th>90 days</th>
<th>0.5 year</th>
<th>1 year</th>
<th>1 week</th>
<th>30 days</th>
<th>90 days</th>
<th>0.5 year</th>
<th>1 year</th>
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<tr>
<td>1</td>
<td>15</td>
<td>7.7</td>
<td>3.8</td>
<td>2.1</td>
<td>1.1</td>
<td>2.4</td>
<td>1.2</td>
<td>0.58</td>
<td>0.31</td>
<td>0.17</td>
</tr>
<tr>
<td>10</td>
<td>170</td>
<td>90</td>
<td>14</td>
<td>26</td>
<td>14</td>
<td>28</td>
<td>14</td>
<td>7.4</td>
<td>4.3</td>
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<tr>
<td>100</td>
<td>1,200</td>
<td>750</td>
<td>1,70</td>
<td>310</td>
<td>180</td>
<td>330</td>
<td>185</td>
<td>100</td>
<td>60</td>
<td>32</td>
</tr>
<tr>
<td>1,000</td>
<td>16,000</td>
<td>9,100</td>
<td>5,800</td>
<td>3,800</td>
<td>2,200</td>
<td>4,100</td>
<td>2,300</td>
<td>1,300</td>
<td>820</td>
<td>470</td>
</tr>
<tr>
<td>10,000</td>
<td>160,000</td>
<td>105,000</td>
<td>67,000</td>
<td>16,000</td>
<td>28,000</td>
<td>18,000</td>
<td>29,000</td>
<td>17,000</td>
<td>11,500</td>
<td>6,800</td>
</tr>
</tbody>
</table>

*These areas are for weapons with 100% of the energy release from fission.
### Table IV

<table>
<thead>
<tr>
<th>Reentry Time</th>
<th>Yield (KT)</th>
<th>1 week</th>
<th>30 days</th>
<th>90 days</th>
<th>0.5 year</th>
<th>1 year</th>
<th>1 week</th>
<th>30 days</th>
<th>90 days</th>
<th>0.5 year</th>
<th>1 year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>12</td>
<td>2.2</td>
<td>0.66</td>
<td>0.27</td>
<td>0.10</td>
<td>1.8</td>
<td>0.33</td>
<td>0.10</td>
<td>0.040</td>
<td>0.016</td>
<td></td>
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<tr>
<td>10</td>
<td>14.0</td>
<td>27</td>
<td>8.5</td>
<td>3.6</td>
<td>1.5</td>
<td>20</td>
<td>4.4</td>
<td>1.4</td>
<td>0.53</td>
<td>0.165</td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>1,100</td>
<td>310</td>
<td>115</td>
<td>4.9</td>
<td>20</td>
<td>210</td>
<td>61</td>
<td>19.5</td>
<td>8.2</td>
<td>3.0</td>
<td></td>
</tr>
<tr>
<td>1,000</td>
<td>13,000</td>
<td>3,900</td>
<td>1,500</td>
<td>690</td>
<td>310</td>
<td>3,000</td>
<td>830</td>
<td>310</td>
<td>135</td>
<td>56</td>
<td></td>
</tr>
<tr>
<td>10,000</td>
<td>140,000</td>
<td>1,600</td>
<td>20,000</td>
<td>9,800</td>
<td>4,700</td>
<td>37,000</td>
<td>11,500</td>
<td>4,600</td>
<td>2,150</td>
<td>920</td>
<td></td>
</tr>
</tbody>
</table>

*These areas are for weapons with 100% of their energy release from fission.*
weapon of the same total energy release.

For example, a 10 MT weapon with 50% of its energy release from fission would have the same area inside the 20 r/hr at one hour contour as that inside the 480 r/hr contour for a 10 MT, 100% fission weapon. From Tables I and III (pages 116 and 122) the area inside the 20 r/hr contour for the 10 MT, 100% fission weapon is 6800 mi². For the 10 MT, 50% fission weapon this area would be reduced to 3600 mi².

From the standpoint of denial of areas for continuous occupancy it is clear that the use of ideal infinite plane dose rates and \( t^{-1.2} \) decay (Table III) would provide a rather pessimistic guide for estimating possible government liabilities. Table IV (page 123), on the other hand, indicates that actual liabilities might be less by factors of from 1/2 to 1/7 of those indicated in Table III, for reentry times from 30 days to 1 year. Unfortunately, it is not possible to say with assurance whether Table IV represents a near average or an optimistic expectation, since the deviations from \( t^{-1.2} \) decay due to weathering and soil conditions have not been observed for a sufficient range of these variables. However, Rongelap is in the northern or drier part of the Marshall Islands, where the average annual rainfall is in the neighborhood of 25 inches. This is less than the world average for latitudes between \( 20^\circ \) and \( 60^\circ \). On the other hand, Rongelap soil is porous, so that the fallout might penetrate to greater depths for the same rainfall than in less permeable soils. It appears likely, therefore, that the observed deviations from the \( t^{-1.2} \) relation on Rongelap may represent a fairly average expectation for areas in the U.S. and Europe.

**Long Term Fallout Effects on Agriculture**

The purpose of this section is to estimate the potential loss of agricultural land because of contamination with long-lived fission products,
particularly Sr-90 and Cs-137. These isotopes have half-lives of about 28 and 30 years,\textsuperscript{11} respectively. Their fission yields are about 100 and 180 curies per MT of fission energy release for average nuclear weapons. The chemical behavior of strontium is very similar to calcium and cesium is similar to potassium so that both can enter into the metabolism of plant and animal foods and eventually become incorporated in the human body.

The major portion of the Sr-90 that is retained in the body becomes fixed in the skeleton, where at sufficient concentrations it may cause bone cancer or other bone damage. Sr-90 that becomes fixed in the bone is eliminated very slowly, its biological half-life in the skeleton being about 11 years.\textsuperscript{12}

Cs-137 is more generally distributed throughout the body, the critical tissue being muscle. Also, Cs-137 emits 0.66 mev gamma rays in addition to beta particles for about 92\% of the disintegrations.\textsuperscript{11} Since these gamma rays are much more penetrating than the beta rays the biological effects apply to the whole body so that the potential risks involved are essentially the same as for total body external gamma radiation, i.e., life shortening, leukemia, cancer and genetic damage.

However, Cs-137 is eliminated from the body much more rapidly than Sr-90. The biological half-life of Cs-137 is about 10\% days.\textsuperscript{13} Consequently, from the standpoint of internal deposition in the human body the contamination levels of Sr-90 would be a more restrictive limitation on the use of agricultural land than will Cs-137, even though the latter has the higher fission yield.

Consequently, the limitations on the use of agricultural land for food production which might result from a single surface burst nuclear weapon
will be estimated in terms of the potential Sr-90 internal deposition hazard.

Again a reasonable guide is to consider the NCRP recommendations on the maximum "permissible" concentration (MFC) for internally deposited Sr-90 for industrial workers and large populations. The industrial MFC given in reference 12 is 1 microcurie (μc) of Sr-90 fixed in the whole body. Since the average adult contains about 1000 grams of calcium, the MFC would correspond to 1000 micro-microcuries (μμc) of Sr-90 per gram of calcium.

For large populations the recommended MFC is one-tenth of the above value. Recently it has been announced\(^{11}\) that the NCRP will increase the above Sr-90 MFC values by a factor of two and also make recommendations for MFC's in various foods, etc. in a revised version of reference 12.

While it is impossible to predict the restrictions that might be established to prevent the marketing of foods with unacceptable concentrations of Sr-90, in the event of a nuclear accident, two different approaches suggest themselves. The first would be to establish the Sr-90 concentration in the soil which would cause young children receiving their entire food intake from such soil, to deposit one MFC of Sr-90 in their skeletons at maturity. Then all farm land with greater than this concentration could be withdrawn from production. With this approach either the industrial MFC or the large population MFC could be used to establish criteria for condemning agricultural land.

The second approach might be to monitor the food products from contaminated farms and prevent foods with Sr-90 to Ca. ratios greater than that implied by the MFC from being marketed for human consumption.

The first type of control would be easy to administer but might allow some food with higher than "acceptable" concentrations of Sr-90 to reach
the market because of small-scale variations in the Sr-90 content of the soil, varying uptake of Sr-90 by different crops and the possibility that different soils with the same Sr-90 levels might lead to different concentrations in the food products.

The second approach might require a considerable Sr-90 monitoring program at the individual farm level. Also, much good might have to be condemned with consequent economic loss.

Perhaps a combination of the two procedures could be applied so that only marginal areas would require Sr-90 monitoring of the farm products.

To get some idea of the areas which might have to be withdrawn from food production because of Sr-90 contamination, the first approach will be used in combination with the areas having greater than certain specified fallout contamination levels which were used in the previous section on total body radiation.

The concentration of Sr-90 in the soil which would deposit one MPC in people living from conception to maturity on food from the contaminated land is not known precisely. However, a number of methods can be used to estimate this quantity. Measurements on the Sr-90 levels in soils and in the bones of children in the age range from 0 to 4 years are available for the New York area for the period from 1953 through 1956. The average soil levels for the four years were 5, 9, 18 and 28 millicuries of Sr-90 per square mile (mc/mi²) respectively. The corresponding bone concentrations for the 0 to 4 year age group were 0.28, 0.57, 0.61 and 0.69 micro-microcuries per gram of calcium. If the ratios of these quantities are used to estimate the Sr-90 soil levels which would result in bone concentrations of 2000 mc per gram of calcium the results are 36, 32, 59 and 81 mc/mi².
The simple average is 52 c/m². Such a simple use of these measurements is open to a number of objections. Clearly the average soil levels for each year are not representative of the average Sr-90 environment for the children greater than one year of age, since the soil levels were increasing during their lifetime. Also, because of the increasing soil levels equilibrium in the soil to bone chain was not established. Finally, the total number of bone samples for the four years was only 36 and 25 of these were in the 1956 group so that the statistical confidence level in the averages is low.

Another treatment of the data which compensates to some extent for the changing Sr-90 levels in the diet is to regard the 1956 bone levels as a result of the average soil levels over the four years and consider all 25 of the 1956 bone samples as four years of age. On this basis the average soil level for the four years would be 15 mc/m² and the corresponding soil concentration to give 2000 μc per gram of calcium in the bone would be 1/6 c/m². Since the younger children in the 1956 group would be expected to have higher bone concentrations of Sr-90 than the four year age group this last estimate is probably conservative.

The effect of non-equilibrium conditions on the above estimates is difficult to assess. Since the fallout was being continuously deposited during the whole period, a part of the Sr-90 entering the diet was not involved in the soil to plant link of the soil to bone chain. Since a considerable portion of the calcium and hence of the Sr-90 comes from dairy products the Sr-90 intake of cattle is an important factor in the ultimate human bone levels. Sr-90 which adhered to the grass and fodder and dissolved in the water would be consumed by cattle and increase the Sr-90 content.
of milk. Furthermore, Sr-90 is known to be foliarily absorbed by plants. This Sr-90 would be ingested both by the cattle and directly in the human diet. Also, since most of the fallout is deposited in the form of very fine particles, some of which stay suspended in the air near the earth's surface, a small amount of Sr-90 can enter the body by inhalation.

In the case of an accidental detonation, most of the fallout in heavily contaminated areas would be deposited in larger particles during the first 24 to 48 hours post detonation, so that the above jumping of the soil to plant link would probably represent a smaller portion of the total human intake than in the case of the long term fallout considered above. Hence, this would tend to make the above estimate of Sr-90 soil level corresponding to the MPC conservative.

Other factors in establishing equilibrium between the Sr-90 in the soil and that entering bone are the chemical and physical reactions of the fallout with the soil.

If the chemical and physical characteristics of the fallout particles were such that the Sr-90 would be relatively unavailable to the plants initially, the processes of weathering and cultivation could increase their availability with the passage of time. If on the other hand the Sr-90 were highly available initially, the reverse might be true. Since most of the long-term fallout is deposited dissolved in rain water, the Sr-90 in the observations used above was probably highly available initially and might be expected to become less available with the passage of time. If so, this would also give a degree of conservatism to the above as an estimate of the "equilibrium" soil level of Sr-90 corresponding to the MPC in bone.

Another possible element of conservatism will result from the application of this estimate to the accidental detonation situation. There is
some evidence\textsuperscript{16} that Sr-90 and Cs-137 are present in the "local" fallout in a smaller proportion than their fission yields would indicate. This is the so-called phenomenon of "fractionation." Both of these isotopes arise in fission primarily from the decay of shorter lived gaseous precursors which are also chemically inert. It appears reasonable, therefore, that, during the period during condensation of the materials in the fireball into fallout particles, these inert gasses would not be incorporated as readily as isotopes with higher condensation temperatures. As a consequence, a portion may stay suspended in the atmosphere essentially as single molecules and become much more widely dispersed than other fission products. Since the Sr-90 will be related to fallout pattern contours by means of its fission yield, the result is to overestimate the Sr-90 levels in the local fallout areas. However, since there are insufficient data to make a quantitative estimate of this effect, it will be ignored.

Reference 15 also indicates that the average Sr-90 bone levels in adults in the New York area was only about 1/12 that of the 0 - 4 year age group.

For the purpose of this study, it will be assumed that 40 c/mi\textsuperscript{2} of Sr-90 in the soil is equivalent to one industrial MPC or 2000 \textmu c per gram of Ca in young bone. The corresponding figure for the large population MPC would be 1 c/mi\textsuperscript{2}. These Sr-90 levels would correspond to the 4.80 and 4.8 r/hr at 1 hour "equivalent" dose rate contours respectively or 0.4 and 0.04 \textmu KT/mi\textsuperscript{2}.

The areas having greater Sr-90 levels than the two MPC equivalents are given as a function of surface burst weapon yield in Table V on the following page.

For weapons in the megaton range where a significant fraction of the energy release can be from fusion, the areas with greater than the indicated
### Table V

**AREAS WITH GREATER THAN 0.001 AND 1.0 c/mi² OF Sr-90**

<table>
<thead>
<tr>
<th>Weapon Yield (KT)</th>
<th>Area with Sr-90 Contamination Greater Than 0.001 c/mi² (mi²)</th>
<th>Area with Sr-90 Contamination Greater Than 1.0 c/mi² (mi²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.07h</td>
<td>1.1</td>
</tr>
<tr>
<td>10</td>
<td>1.0</td>
<td>1h</td>
</tr>
<tr>
<td>100</td>
<td>15.</td>
<td>180</td>
</tr>
<tr>
<td>1,000</td>
<td>2h0.</td>
<td>2,250</td>
</tr>
<tr>
<td>10,000</td>
<td>3,600</td>
<td>28,500</td>
</tr>
</tbody>
</table>

*100% Fission Yield Surface Burst.*
Sr-90 levels would be less than those in Table V as in the case of total body gamma ray restrictions. For example, the two areas for a 10 MT, 50% fission device would be 1800 and 15,500 m² for the 40 c/m² levels respectively.

Comparison of Total-Body Radiation and Sr-90 Restrictions on Land Use

It is of interest to compare the Sr-90 restrictions for the use of agricultural land with the total body radiation restrictions on continuous occupancy discussed in the first section of this report.

Consider first, the 0.01 KT/m² or 10 r/hr at 1 hour post detonation Sr-90 restriction. From Table I (t^{-1.2} decay) it is evident that the more conservative total body radiation restriction (column 2) would be the limiting factor for the first year post detonation and that Sr-90 would be the limiting factor thereafter. On the other hand, the less conservative total body radiation restriction (column 4) would be the limiting factor for only about 35 days.

For the case where allowance is made for the observed deviations from the t^{-1.2} decay and infinite smooth plane source (Table II, page 118), the 10 r/hr Sr-90 criterion would be the limiting restriction after 57 days (column 2). Under the conditions of column 4, the Sr-90 restriction would be the controlling one after 10.5 days.

For the less conservative Sr-90 restriction (0.1 KT/m² or 480 r/hr at 1 hour post detonation), Table I (column 2) indicates that total body radiation would be the limiting restriction for 9.5 years, whereas by column 4, total body radiation would be the limiting restriction for 2.1 years.

Finally, comparing with Table II, the 0.1 KT/m² Sr-90 criterion would be the limiting restriction after 1.3 years under the conditions of column
2 and after 111 days under the conditions of column h.

It should be emphasized that there are many uncertainties in the above estimates, so that any individual item could be in error by as much as a factor of two. They do, however, present a fairly reliable indication of the increase in potential liabilities to the government which could result by combining reasonable radiation exposure criteria with decontamination, shielding, and radiation monitoring programs.

Summary

The most pessimistic estimate of the area that could be denied for more than 90 days by total body radiation from the accidental detonation of a device of 10 KT or less would be 1.4 ml². Denial for more than 1 year would be restricted to 1.4 ml². However, if reasonable allowances are made for observed deviations from the infinite smooth plane dose rates computed by the $t^{-1.2}$ relation and for the utilization of decontamination, shielding and radiation monitoring, the corresponding areas would be only 1.4 and 0.17 ml², respectively.

For a 100 KT device the pessimistic estimates would be 470 ml² denied for more than 90 days and 180 ml² for more than 1 year. These areas would be reduced to 20 and 3 ml², however, if the more reasonable assumptions concerning decay rates, etc., are considered.

For a 1 MT, 100% fission device the pessimistic estimates are 5800 ml² denied for 90 days or more and 2200 ml² for greater than 1 year. The corresponding areas with the more reasonable assumptions would be 310 and 56 ml².

For a 10 MT, 100% fission device the two pairs of areas are: pessimistic, 67,000 and 28,000 ml²; more reasonable, 4,600 and 920 ml².

Denial of areas for growing food crops because of Sr-90 contamination could vary from 1.1 ml² for a 1 KT weapon to 28,500 ml² for 10 MT, if the
large population MPC of 0.2 μc of Sr-90 per 1000 grams of calcium in the bones of young children is used as the criterion. These areas would be reduced to 0.074 mi² to 3600 mi² if the industrial MPC or 2 μc of Sr-90 per 1000 grams of calcium were specified as permissible.

The Sr-90 restriction on the use of land for growing food crops is more severe than reasonable total body radiation restrictions for reentry times greater than one year, regardless of whether the industrial or large population Sr-90 MPC is used as a criterion.
REFERENCES


Appendix II

CONTAINMENT OF THE EFFECTS OF AN ACCIDENTAL DETONATION IN UNDERGROUND STORAGE

The risk of an accidental explosion of a nuclear weapon while in storage, and of consequent damage from blast, heat, and subsequent fallout, makes it worthwhile to consider the possibility of containing the dangerous weapon effects by underground storage. The RAINIER test of September 1957 and the TAMALPAIS, NEPTUNE, LOGAN, and BLANCA tests of October 1958\(^1\) provided information which can be used to estimate the depths of burial necessary to contain the effects of nuclear explosions of specified yields. In these five tests nuclear devices of various yields were exploded in tunnels at various depths inside a mountain at the Nevada Proving Grounds. Since the tunnels were driven into the sloping side of the mountain, the shortest distance from the center of the explosion to the nearest free surface was somewhat less than the vertical depth of burial. Three of the tests were at such great depths that the explosions were completely contained, while two were sufficiently shallow to break through the surface to varying degrees. The conditions of these tests and the observations relevant to the present problem are summarized in Table I on the following page.

From the data in the sixth and seventh columns it is clear that, given the geological structure of these tests, beyond some scaled depth of burial between 290 \(\mathrm{W}^{1/3}\) feet and 500 \(\mathrm{W}^{1/3}\) feet, complete containment of radioactivity would be assured. Johnson and Violet (see ref. 1) estimate that a scaled depth of 150 \(\mathrm{W}^{1/3}\) feet would assure complete containment. The results for the BLANCA shot also show that even for scaled depths of 290 \(\mathrm{W}^{1/3}\) feet only 0.1% of the radioactivity escaped the surface. This happened about fifteen seconds after the explosion, when the initial cavity formed by the
explosion collapsed and a plume of dust rose about 1000 feet into the air, carrying a small amount of radioactivity with it. If the site of such an explosion were a few miles from inhabited areas, it was clear that the damage from any of its effects would be negligible. Hence, burying weapons in storage to such a scaled depth would provide a larger factor of safety than storage above the surface.

It should be remarked that the above observations apply to burial in the specific geological structure found at the test site; somewhat different results might be obtained under different geological conditions. The burial sites for these tests were in a bedded tuff structure extending about 2000 feet down to bedrock and capped with about 250 feet of welded tuff. The bulk density of the material within about 100 feet of the RAINIER shot was 1.9 to 2 g/cm³ with a water content of 15 to 35% in different samples and the compressive strength varied from 3.5 to 7 x 10⁸ dynes/cm². More detailed data on the test environment are available in the Johnson and Violet report.

Using the above scaling relations, the depths of burial necessary for complete containment (150 w⁻¹/³ feet) and for allowing 0.1% of the radioactivity to escape (290 w⁻¹/³ feet) were computed for a series of nominal weapon yields and are shown in Table 2 on the following page.

The costs of underground storage sites would depend mainly on the amount of space required for storage and working areas, on the width of the access tunnel or shaft, and on the terrain and soil. Construction would probably be cheaper on a hillside than on a plain. The width of the tunnel and access road would have an important effect on the speed with which the weapons could be taken out of the storage site. As a very rough order-of-magnitude estimate, the cost of a storage site with a small working area
<table>
<thead>
<tr>
<th>Nominal Yield (kT)</th>
<th>Depth of Containment (feet)</th>
<th>Depth of Burial for 0.1% Escape of Radioactivity (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>210</td>
<td>130</td>
</tr>
<tr>
<td>1.0</td>
<td>150</td>
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<td>1350</td>
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<tr>
<td>100.0</td>
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<td>2900</td>
</tr>
<tr>
<td>1000.0</td>
<td>1350</td>
<td>2900</td>
</tr>
</tbody>
</table>
to contain a hundred 2 KT weapons, assuming low construction costs, might be 300,000 dollars; for a storage site with more ample working areas to contain a hundred 100 KT weapons, allowing for higher construction costs, the cost might be 3½ million dollars. Both examples allow for 1 to 2 per cent fallout escape. The size of the yield to be contained affects the costs less than the amount of underground space desired and the basic construction costs in the area.
REFERENCE