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THE NECESSITY FOR AND VALUE OF CONTINENTAL TESTS

(Prepared at LASL with aid of information from Livermore.)

August 28, 1953

Introduction

The development of atomic weapons of all types involves a composite effort including four major activities, namely, primary experimental research, theoretical investigations and calculations, component development experimentation and full-scale nuclear detonations. It is essentially impossible to apportion credit for progress in weapons development among these activities, for each serves a separate function, and, if the available effort is divided judicially among them, results from all are combined for maximum progress. Progress in the development of weapons does not depend upon these four activities being related as the links in a chain at any given time. Indeed, if any one of these lines of work were to be discontinued, no large decrease in rate of progress would be noticeable immediately. However, as the interval of no work in one activity increased, it is certain that the rate of progress would fall very rapidly, not to three-quarters of the previous value, but probably to a virtually insignificant level.

Thus, where examples of progress are attributed to one of these activities (perhaps full-scale testing) the implication is that such an activity is a necessary, although probably not a sufficient condition, for such progress. In fact, often the same examples might logically be used to support continuance or expansion of two different activities.

To those immersed in the technical work on weapons development the law of supply and demand, as applied to pertinent technical information, is a very strong governing factor in the distribution of effort among the major activities. Progress in some of these fields gets ahead of that in others. The demand for information from

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those lagging behind builds up to the point where it becomes obvious that a shift of effort, with the corresponding increase or decrease in dollar expenditure, is both economically sound and technically advantageous. Thus, the activities of a laboratory such as the Los Alamos Scientific Laboratory are kept in reasonable balance by these forces, the function of management being primarily to sense small imbalances and continuously adjust effort so as to maintain a steady progress in all necessary lines simultaneously. It is most difficult for one who does not have an intimate and detailed understanding of the part each of these activities plays in weapons development and the relative efforts being expended on each, to judge whether a given one is receiving too much or too little attention at a given time. Perhaps, the best way of judging if the distribution of effort is good is to examine the over-all progress and, if it is satisfactory over an appreciable period of time, so also must have been the distribution of effort.

A new factor has recently entered the general problem of determining the amount of full-scale-testing so as to match appropriately the progress in other fronts of development. Thereon, a combination of results from basic experimental physics, theoretical calculations, and component experiments which can be performed at the Alamo can give reliable estimates of all pertinent physical conditions at the beginning of the explosion process in almost any fission weapon configuration, this is not true for devices dependent upon newer techniques for assembly and compression. Not only are the calculations much more difficult and uncertain for the assembly phases of these newer devices, but the basic data are often less reliable (if known at all) and, still worse, simple experimental checks of predicted behavior during assembly cannot be made without a nuclear detonation. Thus, where full-scale nuclear detonations for fission weapon development purposes have been made with the primary objective of obtaining information about the explosive and disassembly phases of the process, similar tests are now required for thermonuclear development to obtain information upon both assembly and disassembly phases. This uncertainty upon these two phases of function of a proposed type of device can easily lead to more than twice as much testing as might be required if only one phase were relatively uncertain.

Another factor influencing the choice of the optimum amount of testing of thermonuclear devices as compared with pure fission devices involves the great difficulty of measuring the desired quantities affecting newer techniques during their progress. This means that,

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in the new field, test experimentation has become much more complicated and costly in manpower and dollars. This factor tends to hold down the number of such tests because the diversion of effort required for a high testing rate would so handicap the other necessary activities as to impede over-all progress. Nevertheless, it is clear that relatively more tests are needed in thermonuclear weapon development than in fission weapon development, and their demand upon budget, and particularly upon technical manpower, renders it most important to carry out such tests as cheaply time-wise and dollar-wise as possible. A comparison of the cost, especially in scientific manpower, of a given test carried out at Eniwetok with that of the same test carried out within the continental limits is, in itself, an essentially complete justification for the existence of a continental test site. Moreover, the willingness of technical personnel to spend an appreciable fraction of their time at a continental site is much greater than their willingness to do so at Eniwetok. This raises the question of the physical possibility of actually running extra-continental tests at a rate appropriate to match other lines of progress because of both willingness of technical participants and the fact that the same test yielding the same information takes much longer in the Pacific. The Eniwetok site should be used only for those tests inadmissible to a continental site.

In the more distant past, testing activity was not well balanced with other activities. The need for test information at the time of Trinity was so urgent and so obvious that a large fraction of the national stockpile of fissionable material was used up during a hot war in which it might have been put to direct military use. The Cross-Roads tests were essentially valueless to weapon development and the growing demand for test-type information again became determining in 1947 leading to Sandstone. Another high surge in the demand for information arose before Ranger. The very great and sudden improvements in the national stockpile capability resulting immediately after Sandstone and after Ranger are proofs, not only of the value of full-scale testing, but also of the fact that testing activity had been at too low a level compared with the other activities. We were sufficiently far ahead in other fields so that even a little information from tests improved the over-all situation enormously. We should never again allow one of our major activities to fall so far behind progress in all other major lines for, if we do, these activities will soon reach the point of diminishing returns.

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The Los Alamos Scientific Laboratory does not yet feel that the rate of testing is as rapid as the generation of new ideas would really warrant.

An attempt is made below to define the purposes of full-scale nuclear detonations, to illustrate the progress in weapons development in the past by examples in which full-scale testing was at least a necessary factor, and to predict as well as possible the probable value of full-scale testing in the near future. Finally, some comparisons are made of predicted rates of progress with and without a continental test site.

The Purpose of Full-Scale Nuclear Detonations

To confine our attention here to the weapon development purposes of full-scale tests, the value of tests for determining effects of military and civilian significance [illegible] testing elements. The purpose [illegible] still valid, full-scale tests involving nuclear explosions will be essential to the progress of weapon development to accomplish the following main purposes, many of which shade into the others:

1. To assure the adequacy of a weapon, or warhead, before it enters the national stockpile. This "proof-testing" of a device is really an integral experiment designed to check that the engineering and practical fabrication of the components into a complete, usable device have been carried out in a manner which leaves unchanged the planned and previously-tested functions of the components. Although the chance of very poor performance compared with prediction for a warhead at the stage to be proof-tested is small, the consequences upon national security of very poor performance of a warhead which may involve an appreciable fraction of the available fissile and other strategic materials is so great that even small chances of failure are unacceptable.

2. To provide a firm basis for undertaking the extensive engineering and fabrication effort which must be expended to carry a "breadboard" model to the version satisfactory for stockpile purposes. This is "proof-testing" of a combination of principles usually embodied in an assemblage of both hand-made and factory-made components.

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3. To demonstrate the adequacy (or inadequacy and limitations) of current theoretical approaches in order that promising avenues of development may be more fully exploited or given lower priority of attention.

4. To explore phenomena which can vitally affect the efficiency and performance of an atomic weapon but which are not susceptible to prior theoretical analysis of sufficient certainty.

5. To provide a basis of choice among existing theoretical methods of weapon improvement in order to concentrate the attack along lines of the greatest practical significance.

6. To determine the validity of entirely new and untried principles proposed for application to the production of explosive atomic energy at improved efficiency.

7. To provide entirely new information pertinent and valuable to weapon development arising simply as a by-product of scientific observation of full-scale explosions, independent of the significant value of such fundamental information obtained in addition to the specifically-planned objectives.

8. To gain time in very urgent development programs by the substitution of full-scale tests for a portion of a possible but lengthy calculational and experimental program in the laboratory.

9. To provide, as a by-product, basic scientific information which becomes a part of the stockpile of such knowledge more normally obtained in the laboratory. Thus, tests contribute, to some extent, to another of the major activities in weapon development. Another application of this type of information lies in its use in the interpretation, from studies of bomb debris, of the constitution, efficiency, etc., of nuclear devices exploded by other nations.

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Weapons Development Progress Attained Through Tests.

A very brief outline of full-scale tests of weapon development interest to LASL which have been carried out since 1947 is given below. This section is essentially quoted from EDR-765 (XXVIII-1417) prepared in October 1952, except that the discussion on Operation Upshot has been changed to agree with the operation actually carried out in the spring of 1953 rather than the anticipation of the previous October.

It is not possible to do more than highlight the significant results of each full-scale nuclear test in the past. Most such programs are interdependent and interrelated. In a large majority of the cases they provide further confirmation of the adequacy of theoretical approaches and predictions; occasionally they indicate further problems to be solved in order to maximize the utilization of active material in a given set of circumstances. In retrospect, some tests now seem obvious; at the time they were striking new explorations into the frontier of nuclear weapon phenomena.

(Details are provided in TS version.)

Test-Types under Consideration for the FY0.

There were two tests sponsored by the Livermore Laboratory, [redacted] on Operation Upshot. These shots provided significant data and information for development purposes at Project Whitney. The need for a facility for making similar tests is illustrated by the outline, given below, of the types of tests the Livermore Laboratory is seriously considering for operations within the continental limits in the near future.

Class I - Less than 1 Kiloton.

These shots have to do with the development of exceptionally small complete weapons [redacted] The Laboratory would want to instrument for alpha and possibly other quantities similar to alpha. It is preferred that these shots be fired on towers, but in the event that they are less than, say 0.2 kiloton, it is possible that they could be fired underground in such a way as to retain all products and perhaps even make the material itself recoverable.

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Class II - 1 to 10 Kilotons.

This group includes again small weapons of interest per se, small weapons of interest as primaries, and possibly complete primary plus secondary system [redacted] These should definitely be tower shots, although it is possible that by making perhaps one and a half to two times as many shots on equivalent amount (but not the same kind) of information could be obtained from air drops.

Class III - Between 10 and 10 Kilotons.

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[redacted] that such shots should be tower shots, but again by making more air drops it might be possible to get an equivalent amount of information as with tower shots.

The Los Alamos Scientific Laboratory is, and always has been, under constant pressure to do more and to do it more rapidly. Generally these pressures are in known weapon fields. An equally real pressure, but internally generated, is to find new ideas for new weapon techniques. These cannot be ordered or programmed but they frequently require full-scale testing.

Specific, known fields in which further development is required include the following:

Very small weapons economical in the use of fissionable material.

Weapons capable of withstanding high accelerations such as impact.

Light-weight weapons of extremely high yield.

Weapons using the newer techniques but in conventional size and yield range.

Weapons for special purposes.

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Weapons of greater versatility, interchangeability, safety, etc.

Replacements for especially costly, complicated, or potentially unreliable weapons components.

Thermonuclear-type weapons of reduced cost in critical materials and of reduced weight and dimensions.

A perusal of the above fields requiring further investigation is very indicative of the type of continental test desired by the Los Alamos Scientific Laboratory. There are, for example, many more things to learn about the application of newer techniques to thermonuclear devices. Tests of this kind probably have to be carried out upon towers but very useful tests of this nature can be kept to reasonably small yields.

A list of examples of tests and test programs which have been considered by the Los Alamos Scientific Laboratory as possibilities for a continental site in the near future is given below. It is not actually proposed to carry out all tests listed, nor is the list exhaustive, the intent being to illustrate the types of tests under consideration. Those marked with an asterisk (*) are in the class of programs requiring more than one shot.

1.* Tests relevant to efficient, low yield (1/4 to 4 KT) bombs of small size [redacted]

2.* Tests relevant to possible improvement [redacted]

3. Further theoretical studies may lead to a belief that successful boosting [redacted] might be obtained.

4. [redacted]

5. [redacted]

Such a test holds the possibility of clearing up some unexplained effects in past tests and of supplying a real basis for deciding what effort should be placed upon developing other methods of support.

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6. Test of a small implosion model [redacted] if there is sufficient military interest.

7. A test to measure the fissle yield and, at the same time, to determine another point on the yield-vs-initiation time curve.

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11.* Proof-tests of the behavior of U^{233}, highly irradiated plutonium (so-called dirty Pu) or other new materials may be required when and if such materials become available.

12.* Tests to determine basic data for the thermonuclear program are likely.

13.* Tests for the study of the behavior of thermonuclear bomb cases.

The probable value of full-scale testing during the next few years appears to be at least as great, considering especially the present state of development of thermonuclear devices, as it has been over the past five or six years.

Expected Progress with and without a Continental Test Site.

A study of the value of the information derived from the individual tests of the past indicates clearly that, at the time of the test, each provided very significant information. The amount of testing up to the present has been the main limitation upon improved development. Thus, it is quite accurate to say that if the number of weapons development tests in the past had been reduced to say one-half, then our atomic weapon position today would have been (apart from production) essentially the same as it was when we had actually completed half of those tests. This relationship would probably not hold if the rate of testing were to be increased by

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an appreciable factor in the future above its value over the past two or three years. This is because of the balance referred to above -- accomplishments in other pertinent activities would become limiting. However, if we maintain approximately our current rate of testing we must have a continental test site because of the virtual impossibility of testing at this rate solely in the Pacific. If we do not maintain our present rate of testing, we may expect a proportionate decrease in the rate of progress.

There exists no reason to believe that the present lead of the United States in the atomic weapon field can be maintained without still further acceleration of our efforts. We are told that the effort of the USSR is known to be large; it is known from preliminary results of their tests in August, 1953 to be reasonably effective. Known considerations of strategy and tactics make the U.S. more vulnerable to Russian attack in this field than Russia is to us. In consequence, our techniques must be proportionately more skillful. Thus, the necessity of continuing continental full-scale testing to ensure an acceptable rate of advancement becomes evident.

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