[redacted] This seems to be true even for so-called "clean" devices - capture in the fuel is quite high. (Calculated neutron numbers and energies for six typical weapons are contained in LA-2246, Goad and Allen.) For detonations in air the neutrons are captured in nitrogen of the a ir; [redacted] (Can. J. Physics, 1, 29, 1951.) The cross section is approximately 1/v and contained in BNL 325. The effect of the shock wave upon these neutrons is not well known; Monte Carlo calculations by Biggers of LASL indicate the bulk of the neutrons stay ahead of the shock wave. This would put the source of gamma rays ahead of the shock but probably quite close to it. (Some calculations are outlined in LA-1620 using the interior of the shock wave as the source.) For the high pressure ranges the shell source character may be quite pronounced as is indicated by the data. Following the explosion gamma ray peaks but preceding that gamma radiation which is clearly due to capture in nitrogen, there is a region of gamma radiation [redacted] whose origin is yet unknown. Radiation from isomeric states of fission products has been postulated and, though refuted by Bethe, has recently been observed at ORNL and LASL, though whether of the right magnitude remains to be seen. Another postulate is that it is due to neutron capture in nitrogen contained in the shock wave [redacted]. For larger yield explosions its contribution will be smaller compared to the total because of the shock wave enhancement of the latter gamma radiation.

The remaining radiation, appearing after the nitrogen capture component, is that due to fission product activity. The fission product gamma radiation time dependence is given by $3 \times 10^8 e^{-0.106 \ln^2 10.5}$ r/sec at 1 m per kiloton by Starner of LASL in a re-evaluation of some data of Fermi's group during the war. Its spectrum is also assumed to be the Motz spectrum. The fission fragments remain behind the shock wave and remain with the fireball. As the shock wave has the effect of piling the air within the shock radius in the region just behind the shock the $\int_0^{Rs} \rho dr$ shows a marked decrease even before arrival of the shock wave and a greater decrease following passage of the shock. The effect is greatest for high yield detonations and high overpressure regions. The enhancement for the few megaton region the overpressure range of interest can be three or four orders of magnitude. (An upper limit may be obtained by assuming all air is removed between source and point of interest.) The rise of the fireball containing the fission products makes the radiation fall off much faster than the $t^{-1.2}$ which Starner's relation becomes at times longer than 20 seconds.

To calculate the gamma radiation versus time for the fission product component particularly, it is necessary to determine $\int \rho dr$ versus time and the cloud height versus time. $\int \rho dr$ at LASL has been obtained from Fuchs M Problem and the cloud rise from EG+G data of which there is a large amount taken since 1953.

There are also available more recent data on fission product gamma radiation, e.g., Oak Ridge data, and on nitrogen capture data from Chalk River. These might be better than those quoted above.

I also suspect that the curves in TM-23-200 are derived through Liedke's (NDC), AFSWP 1100, calculations done under contract to AFSWP and has the above as a starting point. It would be worth exploring this possibility and if so try to determine the quality of the work and save some labor. These calculations appear to me to be well done but may lead to high predictions since cloud rise apparently was neglected.

In looking over the overpressure versus distance number you quoted to me I find they are very conservative relative to the M Problem which we here consider to give answers agreeing with experimental data and are accepted by Porzel of Armour Research Foundation. Liedtke, I believe, used results of Courant's (NYU) work.

As I mentioned before, I believe the data obtained by Evans Signal Laboratory ought to be used to delineate the calculations. The work involved in the computations outlined above is not large and can be done by a number of groups as I indicated before.

May I also ask that if you wish me to review any work that the assumptions, model, and source of the material used in the computations be quoted. Unfortunately in AFSWP-1100 and particularly TM-23-200 this has not been done adequately and hence it is difficult to assess the quality of the predictions.

jc

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LOS ALAMOS SCIENTIFIC LABORATORY
UNIVERSITY OF CALIFORNIA
LOS ALAMOS. NEW MEXICO

OFFICE MEMORANDUM

TO : Distribution

DATE: May 27, 1958

FROM : George Bell

SUBJECT: COMPARISON OF WORLDWIDE HAZARDS DUE TO C^{14}, AND FISSION PRODUCTS.

SYMBOL : T-1026

THIS DOCUMENT CONSISTS OF 7 PAGE(S)
NO 1 OF 12 COPIES, SERIES A

In T-1009 (rough draft), estimates were made of the amounts of C^{14} produced by detonations of clean weapons. It was indicated that C^{14} may represent the most hazardous radioactivity produced by detonation of a clean weapon and some comparisons were made with Sr^{90} hazard. Attention has recently been focused on such a comparison by Soviet claims that C^{14} production rendered the concept of a clean bomb meaningless (paper by Liapunsky) and by similar statements of Linus Pauling and others.

It is the purpose of this memo to present a more detailed comparison[1] of C^{14} with the fission products and other induced activities, and to note in what sense C^{14} may be taken to be a worldwide hazard comparable to fission products -- even for a standard weapon. Effects of tritium production will also be discussed.

In attempting to compare C^{14} with fission products, one must first note the impossibility of making any simple comparison. Of the longlived fission products, Sr^{90} and Cs^{137} are conventionally regarded as most hazardous. Sr^{90} is believed dangerous, largely in that it may induce leukemia and bone cancer. Cs^{137} and C^{14} appear to be most hazardous in that they can produce genetic damage and lead to the premature death of individuals in subsequent generations. Genetic death seems a very intangible and theoretical thing compared to leukemia but it is presumably just as real. For a second difficulty, C^{14} has a lifetime which is nearly 200 times that of Sr^{90} or Cs^{137}. Thus damage due to C^{14} will extend over several hundreds of generations whereas that due to Sr^{90} and Cs^{137} will be completed within a few generations (although the Cs caused genetic damage will not become completely manifest for much longer). In addition, genetic damage has a unique property in that heavily irradiated survivors of local fallout may, through intermarriage, transmit a hazard in the form of radiation induced mutations to the entire world. Thus to some extent the effect of C^{14} must be compared with the sum total of all genetic damage produced by fission products or by other local fallout.

[1] In this undertaking I am indebted to E. C. Anderson for pointing out the relatively short residence time of CO^2 in the atmosphere, and to the article by Liapunsky for indicating that one should integrate C^{14} radiation over a very long time to obtain its full effect.

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leukemia such that per r delivered by Sr^{90} to the bones of an individual there is one chance in 10^6 per year that that individual will subsequently develop leukemia because of that r of radiation. This number was suggested by Lewis (Science <u>125</u>, 965 (1957)) from an analysis of experimental data. It is in general agreement with the casualty calculation of Langham and Anderson which took about 10% of present leukemia cases caused by radiation. It is exactly a factor two less than the number used by Liapunsky. (Liapunsky took 2×10^{-6} which Lewis suggests as the probability for irradiation of both bones and lymphatic system rather than 10^{-6} which Lewis suggested for bones alone.) Assuming that an average individual will live 30 years after receiving an r, we find the probability of death by radiation induced leukemia to be 3×10^{-5}/r.

Genetic hazard due to radiation has been discussed by Muller (How Radiation Changes the Genetic Constitution -- Bull. Atomic Scientists 11:329) and in the 1956 report by the Committee on Genetic Effects of Atomic Radiation of the National Academy of Sciences and National Research Council. The geneticists point out at great length their lack of definite knowledge as to the effect of radiation on human genetics. However they do make estimates of genetic damage per r delivered to the gonads. As applied to a long term increase in radiation such as for C^{14}, and for a constant population the geneticists estimate that per r delivered to reproductive organs of an average individual (including those above reproductive age) there will be produced: (1) with probability about 2.5×10^{-5} a tangible genetic defect (such as mental defect, epilepsy, etc.) which will show up in first generation children (2) with probability about 2.5×10^{-4} a tangible genetic defect which will show up clearly sometime (3) with probability about 2.5×10^{-3} a mutation which will, statistically speaking, be eventually eliminated from the race by premature death of an individual. It appears at this time impossible to understand the significance of mutations of this sort (3) in terms of human suffering or burden to society. The geneticists state that their estimates (of (3) above in particular) may be in error by a factor 10 either way. Muller appeared rather confident that the probability of a mutation (3) was very likely larger than above.

Suppose now that we take as a genetic death either a mutation producing a tangible genetic defect ((2) above) or a mutation which will eventually be eliminated ((3) above). Comparing these probabilities of genetic death per r with probabilities of leukemia per r, we find that <u>reproductive organs are 8 or 80 times as sensitive to radiation as are bones</u>. It is to be noted that Liapunsky took criterion (2) above.

We are now in a position to compare the genetic casualties produced by C^{14} with the leukemia casualties produced by Sr^{90}. For example if we assume that C^{14} damage includes that produced over the entire C^{14} lifetime and if we assume that each mutation is a legitimate casualty then we find 125 airburst megatons are required to produce the same number of casualties as are produced by Sr^{90} from 2×10^5 megatons of fission products. This low number is arrived at by dividing the C^{14} long term genetic background doubling yield (2×10^6 megatons) by the ratio of C^{14} to Sr^{90} half life (200) times the ratio of genetic to bone sensitivity (80 counting each mutation as a casualty).

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It can be argued that it is unrealistic to integrate the C^{14} damage over all time as we have done. Certainly there are some isotopes which have such long half lives (eg., Cl^{36} with half life of 3×10^5 years) that it would seem nonsense to integrate over all time for these. We have assumed a constant population over $\sim 10^4$ years in computing C^{14} casualties. We have further assumed that it will not become possible to prevent or decrease the effect of radiation induced mutations. Because of these uncertainties as to the long term effect of C^{14} we have also estimated the number of mutations which would be produced in the first generation or two. For this purpose we dilute the C^{14} in the small C reservoir and give it a half life of 5 years. The integrated damage for a given yield and such a short-term calculation is less than the above estimated long term damage by a factor 21 (effective half life is less by factor 5600/5, but concentration higher by factor 8/.15; 5600/5 x .15/8 = 21). The results of these calculations are summarized in Table I.

For orientation, we note that each entry of Table I, with our assumptions, corresponds to of the order of 5×10^5 casualties. For example in the case of Sr^{90} the 2×10^3 megatons of fission products would irradiate the world's population (2.5×10^9) with about 6 r apiece (.15 r/year for assumed 40 years). Multiplying the 1.5×10^{10} man r by probability of leukemia per r (3×10^{-5}) leads to about 5×10^5 casualties, or .25 casualties per kiloton. Note that 5×10^5 C^{14} casualties spaced over 200 generations would imply only 2500 casualties per generation or only one induced casualty per $\sim 10^6$ ordinary deaths.

The question should now be raised whether there are other fission products or induced activities which could lead to comparable damage. From the data of T-1009 we see that Co^{60} produced in very poorly chosen weapon components could be a hazard approaching that due to short term C^{14}. It remains to discuss H^3 and Cs^{137} which were noted by Liapunsky.

As regards tritium, analysis of swordtail calculations reveals that for burning of conventional clean devices, one must expect at least 10^{26} tritons left over per megaton, and in some instances two to three times this number. Taking 10^{26}, we produce 5 Mc tritium per megaton. Libby (P.R. 93, 1337 (1954)) estimated that an available world tritium inventory of 1800 grams, produced mostly by Cosmic Rays, leads to a tritium to hydrogen ratio of $\sim 10^{-17}$ in the biosphere. This implies that tritium in the biosphere is on the average in equilibrium with a reservoir of about 10 gm/cm^2 of hydrogen. By this is meant that if one takes 1800 gm of tritium and mixes it with a hydrogen reservoir of ~ 10 gm/cm^2 of earth surface, he finds $H^3/H \sim 10^{-17}$ as observed in animals. This same reservoir should be effective in diluting bomb made tritium. If we assume that gonads have average body composition, then from NBS Handbook 52 we see that about 20 μc of tritium per kg of hydrogen would double the genetic background radiation level. This would be produced by about 2×10^5 megatons. It follows that the tritium genetic damage would be closely comparable to short term C^{14} genetic damage. With our above numbers we actually obtain 5×10^3 megatons for tritium damage equivalent to C^{14} damage from 2.6×10^3 Mt. However these numbers are uncertain enough to be equal for all practical purposes.

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TABLE I

Comparison of C^{14} and Sr^{90}

Number of megatons airburst (clean or standard) producing a number of C^{14} genetic casualties equal to the number of leukemia casualties produced by Sr^{90} from 2×10^3 megatons fission. (For comparison, yields are also given for equivalent genetic damage by tritium and Cs^{137}).

	Integrating C^{14} radiation over all time with stable population.	Integrating C^{14} radiation only over first generations.
Counting each inherited mutation which must be eliminated from genetic strain as a genetic casualty.	125 Megatons	2600 Megatons (Cs^{137} 500 Mt fission) (T 5000 Mt fusion)
Counting as genetic casualties only those mutations which will lead to "tangible genetic defects."	1250 Megatons	26,000 Megatons (Cs^{137} 5,000 Mt fission) (T 50,000 Mt fusion)

DOE b(3)

[redacted]

Length - 40" - 50"

TYPE II:

DOE b(3)

[redacted]

DOE b(3)

[redacted]

Length - 40" - 50"

TYPE III:

DOE b(3)

[redacted] This type can probably be made with the following very approximate characteristics assuming that the basic design is feasible.

DOE b(3)

[redacted]

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Total Yield: Weight:

[redacted]

DOE b(3)

Length - 50" - 60"

II. Possible Time Scales for the Various Types

This section gives a possible set of self consistent time scales for developing the three types of devices listed in Section I. In order to make up this schedule, we have made the following assumptions.

1. [redacted] DOE b(3)

2. The "breaks" will be with us at virtually every step of the development.

3. There will be no net increase in weapons R & D effort, but the program will be given a high priority within the effort available. Some other programs now tentatively scheduled for Phase III will have to be dropped.

4. Each design problem can be solved in regular sequence by continuous extrapolation as the development proceeds, i.e., no new R & D "break-throughs" are required.

The following table gives a possible weapons test program for the development of the clean tactical weapons:

	Device Test	Weapon Prototype Test
Hardtack (Pacific, 1958)	Type I Type II	
Nevada, 1959	Type II [redacted] Type III	Type I Type II (?)
1960	Type III	Type III (?)

DOE b(3)

The following table gives a possible joint UCRL-Sandia Weaponization Program. Other weapons are also included to indicate what other programs can be carried on at the same time as a serious program of tactical clean weapons development. The dates given are the fiscal years in which the indicated weaponization program would begin. These dates are, of course,

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very tentative and are intended primarily as examples of what might be done, since they depend on all of the speculations and estimates above, as well as on DMA-DOD estimates of relative importance and determination of priorities.

FY 1958 [redacted]

FY 1959 [redacted]

DOE - b(3)

FY 1960 Nike Zeus, Polaris

FY 1961 Clean Type III, ?

DOE b(3)

Assuming that all of the above time schedules can and will be met, the following is then a list of the dates at which the various types might enter the stockpile:

Type I	-	CY 1960
Type II	-	CY 1961
Type III	-	CY 1963

III. The Meaning and Importance of Cleanliness in Tactical Atomic Bombs

The reason for developing and producing clean tactical bombs is to provide the armed forces with nuclear weapons of low and intermediate yield which can be used in situations where, because of radioactive contamination, a tactical atomic weapon of the present 100% fission type cannot be used. Perhaps the most important and easily described situation of this type is that in which it is desired to remove or destroy, by means of a ground burst, a hard target, such as a deeply dug in enemy or an airstrip, in friendly territory or in close proximity to our troops. As indicated by an overall analysis of the recent Army "Sagebrush" exercise, (which involved, among others, ground bursts on airfields), such applications are very dangerous, or, more probably, generally impossible using the present day atomic weapons. In the case of high air bursts, in which the fireball is well off the ground, the situation is less bad in the present case of pure fission bombs, since the radioactivity is generally spread out over a very large area and a very large number of tactical size bombs can be used without approaching the world wide "Sunshine Limit." However, even in this case, there is still the problem of possible serious localized "rain out" which problem would, of course, be greatly alleviated or completely removed by the use of clean bombs.

DOE b(3)

None of the bombs listed in Section I are, of course, absolutely clean but all of them represent very large improvements in this respect over the present stockpile. [redacted] DOE b(3)

[redacted] It may be noted from the tables that, for most of the cases considered, the area of lethal radiation is less than the area of other lethal effects. [redacted] DOE b(3)

All distances given in the tables are for unprotected personnel in the open. The ranges and areas of the various effects are either taken from "Capabilities of Atomic Weapons," AFSWP, Rev. 1 June 1955, or have been calculated from basic data given there. All of the numbers, of course, are very rough estimates, both because they are for one particular set of field conditions (i.e., an average wind of 15 knots) and because some of the necessary important input data are not accurately known. [redacted] DOE b(3) The detailed distribution of such intense radiation fields have not been measured and there is in fact some doubt as to their existence). The various assumptions made in preparing the table, and the uncertainties and limitations inherent in such an oversimplified treatment of the problem are given immediately following the tables.

TABLE I - Area in Square Miles for Various Effects

Fission Yield & Effect		Total Yield [redacted] DOE b(3)
100%	400 R 50 R	[redacted]
[redacted] DOE b(3)	400 R 50 R	[redacted]
[redacted]	400 R 50 R	[redacted]
[redacted]	400 R 50 R	[redacted] DOE b(3)
Direct Casulties Produced by Blast		[redacted]

For friendly troops, I would think distance is the important parameter not area. — N.

The assumptions and limitations of the table are given below:

1. Winds - The handbook gives the fallout range parameters for wind pattern having an average velocity of 15 knots. The range given is the distance downwind (as determined by the winds at around 10,000') at which a given dosage would be found. The crosswind range is about $\frac{1}{4}$ of the downwind range for large dosages, and the upwind range is, of course, smaller still. For winds differing from those assumed here, the fallout situation will differ also. In this brief analysis it has not been possible to include these cases.

2. Determination of Intensity - It was assumed that if a pure fission bomb gives a dose of R at a point P, then a clean bomb of the same yield fired under the same conditions having a ratio f of fission to total yield will give fR at point P. This assumption should be precise except for the added effects of induced activity which is discussed below.

   [redacted] DOE b(3) In fact, there is some doubt that such very high dosages exist at all, except perhaps in very localized hot spots, in which case the "range" and "area" of lethal fallout may be much smaller than indicated.

3. Time Spent in Radiation Field - All radiation doses have been calculated for the case where an unprotected person is at the indicated range from the time at which fallout begins until five hours after shot time. For other time intervals and for the higher dosages, the dosage rate may be very roughly estimated as follows:

   If the time spent in the fallout zone is from time-of-fallout to time-of-fallout plus one half hour, then multiply dose by about $\frac{1}{2}$.

   If the time spent in the fallout zone is from one hour after shot to ten hours after shot, then multiply dose by about 1/3.

   If time spent in fallout zone is from time of fallout to one month or more, then multiply dose by about $1\frac{1}{2}$.

4. Radiation Protection Possibilities - According to the handbook quoted above (pg. 188), very simple precautions can greatly reduce the fallout radiation dosage received. [redacted] DOE b(3) It would

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6. Weight Penalty -

DOE b(3)

We believe that the above rough discussion of the meaning and evaluation of cleanliness is sufficient for use as a guide to the development of clean tactical bombs. However, we must point out that much better experimental data is needed for input to further calculations, and that many more cases (other wind conditions, burst conditions, etc.) must be calculated in order to get a really good picture of the value and increased usefulness of clean tactical bombs.

DOE b(3)

Very truly yours,

Original signed by
Herbert F. York

HERBERT F. YORK
Director
UCRL - Livermore

HFY:jbr

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INTER-OFFICE MEMORANDUM

ADWD-169

Unique Document #SAB200085530000

DATE July 28, 1950

TO: Norris Bradbury

FROM: Edward Teller

SUBJECT:

VERIFIED UNCLASSIFIED

1452

The meeting of the Tech Board yesterday greatly increased my feeling of uncertainty concerning the future Laboratory program. I am particularly worried about two points.

First, that decisions may be reached in Washington concerning the test sites and the timing of the tests without full knowledge of what disastrous effects such decisions may have on the work of this Laboratory and in particular on the development of thermonuclear weapons.

Second, that in the absence of a definite date at which thermonuclear tests may be performed, the work on the thermonuclear weapons may lapse into an insignificant role. If this should happen, I should feel that it would be inappropriate to cut back our thermonuclear program in this way without a full understanding of what we are doing and without informing the proper authorities in Washington that the program is running on a low priority.

In view of the above uncertainties and worries, I do not see in a clear way what course the work of the Family Committee should take.

I should request urgently that I have in the near future an opportunity to talk with you about these questions.

Edward Teller

Distribution:
1A Norris Bradbury
2A Darol Froman
3A Edward Teller

No date = Maybe lapse = cut back w/o telling

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N. E. Bradbury

[redacted]

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M E M O R A N D U M

UNCLASSIFIED

March 6, 1951

PUBLICLY RELEASABLE
OS-6 [signature] 1/26/94

TO: Division Leaders and Assistant Directors

FROM: N. E. Bradbury

1. Attached herewith is a draft memorandum covering a somewhat revised definition of the duties of the Technical Associate Director.

2. This matter and others will be discussed at a meeting of Division Leaders and Assistant Directors on Monday afternoon, March 12, at 1:30 PM in my office.

[signature]
N. E. Bradbury
Director

✓ Darol Froman
✓ John Bolton
✓ Edward Teller
✓ M. F. Roy
✓ W. H. Crew
✓ E. R. Jette
✓ M. G. Holloway
✓ Carson Mark
✓ J. M. B. Kellogg
✓ A. C. Graves
✓ J. L. Shipman
✓ D. P. MacDougall
✓ R. C. Smith
✓ H. R. Hoyt

3/17/51
All copies destroyed except this one.
RB

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Per E. M. Sandoval
(Person authorizing change in classification) (Date) MAR 3 1990
By [signature] MAR 3 1990
(Signature of person making the change, and date)

[redacted]

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~~M. L. KOLBAY~~, A.D.C. DATE:
[signature]

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ENC 2

95SA20B060244

March 20, 1951

A SEPARATE THERMONUCLEAR DIVISION

Advantages over present organization.

1. The personnel of the division have a major single objective, namely accomplishment of the thermonuclear program. Thus, a great part of their effort is expended on the program and much time spent on anything else becomes apparent and needs explanation.

2. The direction of the program becomes administratively simple and straightforward. There is a well-defined group of people available. Their potentialities can be estimated and progress predicted. Conflicts about what an individual or unit should work on are less likely than if they have additional responsibilities and conflicts are easily resolved within a single division.

3. In recruiting new personnel for such a division it is clear to them that they are to work in the thermonuclear field and will not be expected to dissipate their efforts on other pursuits.

4. Correlation by the Director's office of effort in several divisions, each of which has additional responsibilities, is difficult compared with similar correlation by a single division leader within a division having a single major responsibility.

5. Some very influential and important members of the Laboratory staff believe strongly that a separate division is greatly advantageous. Therefore, formation of such a division will help their morale and thereby increase their effectiveness.

Disadvantages and methods of overcoming difficulties with present organization.

1. The rather marked benefits now accruing to both the thermonuclear work and fission weapon development from the thought and ideas contributed by men working mainly in the other field would certainly be reduced and probably lost to a major extent by formation of a separate division.

2. It would be extremely time consuming, wasteful, costly, geo-grahpically inappropriate or otherwise difficult to duplicate many functions of the Laboratory which may be needed for both major fields of weapon development. The writer does not know just to what extent the advocates of a separate division wish to carry the separation. It can be imagined almost anywhere varying from the present organization to a separate laboratory structure including personnel, property and shop departments. It is assumed here that the intent would be to include in a thermonuclear division those activities which are now carried in that field by the technical divisions, viz.: T,P,CMR, GMX, and J. Although certainly not comprehensive, the following illustrate some of the difficulties of a separate division:

(a) Testing of nuclear explosive devices. The duplication of personnel and activities in J Division in logistics, military assistance, etc., is absurd. Site duplication or difficulty with two bosses is patently inappropriate. It seems J Division should continue testing of both fission and fusion devices.

(b) Separate staffs to design and measure safety etc., of the fission bomb parts of fusion devices (work of W-1 and W-2) are not very feasible to obtain personnel-wise and facility-wise (build a new Pajarito?). Nor would it be efficient because there would be long periods of inactivity with sudden bursts of work which would require a big crew.

many minor organizational changes I think advantageous and there are undoubtedly activities going on which take man-hours but do not contribute sensibly to any of our major programs. Possibly these things can be improved. In any case, it must be clear that it will take quite a lot to convince me it would be advantageous to form a system under which it would be quite difficult, or taboo, to call upon any talent or facility we may have to meet any special problem arising in either of our important programmatic fields.

Darol Froman

March 20, 1951

DF:b

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[redacted]

UNIVERSITY OF CALIFORNIA
LOS ALAMOS SCIENTIFIC LABORATORY
(CONTRACT W-7405-ENG-36)
P. O. Box 1663
Los Alamos, New Mexico

Unique Document # SAB2000855900000

IN REPLY REFER TO: ADWD-260

April 20, 1951

This letter is Unclassified
(not enclosure, which is questionable)

Chairman Gordon E. Dean
U. S. Atomic Energy Commission
1901 Constitution Avenue
Washington, D. C.

Dear Mr. Dean:

Following our conversation, I have given thought to the alternatives which present themselves concerning the future of the thermonuclear program.

PUBLICLY RELEASABLE OS-6 B. Fiflaka 1/26/94

Classification changed to UNCLASSIFIED by authority of TSM OS-6 1/26/94 (Sig. of person authorizing change, title, org., date)
TSM OS-6 1/28/94 (Sig of second reviewer, title, organization, date)

A detailed plan for a new site would enable one to judge more realistically the advantages and disadvantages of a new location. The past two weeks have been too short to formulate such a plan but I have tried to arrive at an outline of manpower and space requirements as well as some estimates of the cost of principal equipment. I am attaching this outline for your use but would like to emphasize that it is submitted only in order to put discussions on a more concrete basis and not as a definite proposal to the Commission. A wide choice for the location of a site presents itself. I have singled out Boulder but have briefly discussed some other places to show relative merits.

While I am sending you this outline in order to complete the picture, I am fully aware that in order to avoid delay and duplication it might be of considerable advantage to keep the thermonuclear program at Los Alamos. If anyone hopes to achieve practical results within an extremely short time span--such as a year--then a delay would be particularly serious. Recent theoretical considerations offer some prospect of a fairly simple thermonuclear system. On the other hand, Los Alamos carries a heavy burden in the fission development program and it is not evident whether a more prolonged and ambitious program could be carried out at Los Alamos.

Los Alamos is in my opinion the best scientific laboratory of any government department. I believe nevertheless that the following changes would have to be introduced in order to pursue the thermonuclear program in an effective way:

(a) Concentrate responsibility for the scientific administration of the thermonuclear work in a single individual who actively heads the program and participates in its exploration as a full-time job.

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(b) Induce a considerable number of scientists, including some now outside the AEC to spend full time on thermonuclear questions at Los Alamos.

These changes would be effective only if they bore the fullest support of the Laboratory administration.

A new site would automatically meet conditions (a) and (b) above. In addition, considerable impetus would be given to the recruiting program. The drive and enthusiasm in a project with a single but large goal was shown in the early days of Los Alamos. A new site should operate in such a spirit and I believe that it is important that the project be kept relatively small. The top scientific staff might amount to not more than 50 people. Frequent discussions and daily contact on the single subject of thermonuclear work would distinguish such a site from the compartmentalization of ideas (not dictated by security) now so prevalent.

As you have heard from the Laboratory, I complied with your wishes not to come to any personal decision before June. As a matter of fact, I am now planning to return from Eniwetok by plane at the earliest possible date. I shall be at Eniwetok until about 10 days after the shot and plan to attend a Reactor Safeguard Committee meeting in Schenectady on May 28th.

I sincerely hope that a vigorous program will be planned and that I may contribute to defense work by participation in the field of Atomic Energy rather than by helping in other branches of defense.

Yours very truly,

Edward Teller

Encl.- ADWD-261 copy 2A Rec. 65770
1A - Chairman Dean – seen prior to recording
2A - N. E. Bradbury
3A - E. Teller

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A. Experimental Physics

Fundamental measurements such as cross sections, etc. will be farmed out whenever possible. This can be done the more readily because the relevant data are mostly in an unclassified area or are declassifiable. In some exceptional cases, such measurements might be carried out with advantage at the site by an experimental physics division.

The main function of such a division would, however, be a different one. It will frequently be necessary to carry out physical measurements on a model which is a mockup of a test object or else a mockup of a part of a test object. Most of these would be neutron experiments.

Another function of the physics division is to make specific measurements which will aid in design and construction of measuring apparatus for intermediate and final tests.

The over-all staff for the experimental physics division would be 7 senior scientists, 7 junior scientists and 5 technical assistants.

B. Electronics

Delicate electronics equipment is needed in connection with the work of the experimental physics division, radiochemistry and tests. Therefore a strong electronics group is needed. The staff may consist of 3 senior scientists, 10 junior scientists and 10 technical assistants. No particularly expensive apparatus is needed.

C. Chemistry

To carry out the necessary tests, unusual structural materials will be needed and these materials will be subject to unusual requirements. It is therefore necessary to have a group of chemists who are fully familiar with the thermonuclear program. Inorganic chemists, because of their knowledge of unusual materials, are needed to help in the selection of the right materials. An analytical group will be needed, mostly for the purpose of checking materials used in design.

Another important role of chemists in the project will be to participate in the test observations by analyzing the radioactive substances produced in the tests.

The chemistry division will therefore have to consist of an analytical, an inorganic group and a radiochemical group. Each of these three groups will have approximately 3 senior scientists, 5 junior scientists and 5 laboratory assistants. Equipment will be of the usual laboratory type for chemistry, including facilities for handling radioactive materials on a small scale.

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I. Engineering

The engineering group would have to be one of the first to be established. Its job is to plan in detail and assemble intermediate and final test objects. As has been noted earlier, the components of these objects will be fabricated as far as possible outside the new site. Such objects as detonators which are being fabricated within the AEC establishments will not need to be duplicated. The group might consist of 3 senior scientists, 4 junior scientists and about 20 technical assistants. Many of the scientists will be engineers and many of the assistants, draftsmen. The equipment of this group should include a one-million electron volt x-ray machine, which will be used to inspect the test objects.

J. Field Tests

This group will eventually be one of the larger groups in the laboratory. It is, however, impossible to plan tests at an extremely early date and it therefore seems reasonable to start this group with only 3 senior scientists and 3 junior scientists. An early function of this group would be to plan test operations and to establish the much bigger group which will be necessary to execute these operations. The eventual size of this group may well consist of 100 scientists and technical assistants.

Existing help from other laboratories such as NOL will have to be utilized on a contractual basis. One of these groups which is now established at the Radiation Laboratory of the University of California has been doing very useful work on the cylinder test. A further thermonuclear test program might utilize this group effectively and avoid dispersal of able personnel which might ensue if further thermonuclear tests are delayed too long.

K. Photography

A small photographic group including 1 senior scientist, 1 junior scientist and 4 assistants would be highly desirable. Particular emphasis should be placed on high speed photography to be used in observations on high explosives work and on the tests.

L. Shops

The major job to be performed at the thermonuclear site will be preparation for tests. This will require good shop facilities. The size of the shop might be indicated by an estimate that approximately 100 men would be required in the shops. These will have to include 1 senior scientist and 3 junior scientists. An effort should be made to obtain the services of these scientists at the earliest possible time. It would seem possible, however, to operate the shop for the first few months with less than 100 men.

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4. Location

As indicated in section 3, Boulder, Colorado has been chosen as an illustration because of its many advantages. There is enough land near Boulder (between Boulder and Denver) to permit the establishment of a site with explosive facilities and to provide for future expansion. The area is flat and does not represent the topographical difficulties of a place like Los Alamos. The principal advantage of Boulder is that the Bureau of Standards cryogenic facility is to be located there. Since this cryogenic facility has been planned in cooperation with the AEC it should meet fully the requirements of the cryogeny section described under G. above. In terms of manpower and cost of equipment this would be a sizable reduction in the over-all requirements of the new site.

We have noted in section 3-H. that the explosive facilities can be kept relatively small if Los Alamos can supply the basic HE parts. It is therefore desirable that the new site be in the western section of the country so that trucking of HE parts between Los Alamos and the new site can avoid congested traffic. The distance between Boulder and the Nevada test site is not too great. This is advantageous since one would hope that early tests could be performed in Nevada.

It is recognized that it would be desirable not to have to build a new "AEC town". At Boulder, this would seem to be unnecessary since a regularly established town with all facilities already exists. The vicinity of the large metropolitan area of Denver is also an advantage with respect to workmen's housing, etc. The fact that a university exists at Boulder and that the University of Denver is close by should be considered advantages, although neither of these universities is of the quality to provide real scientific assistance. Communications to Boulder are very good, both by air and land, because it is so close to Denver.

From the point of view of defense, Boulder seems to be excellently located.

In the course of time it is probable that additional housing in or near Boulder will be required. The good climate of Boulder will make it somewhat easier to provide such additional housing.

A few other possible localities will be discussed below.

Princeton.- The great advantage of Princeton is the expected presence of a strong theoretical group. Also an electronic computer will be available at an early date. There would be minor savings in the availability of physics equipment as well as in the availability of liquid hydrogen and nitrogen in the neighborhood. All these will amount, however, only to a total saving of the order of about half a million dollars. A high explosives firing site would have to be at a distance of some 30 miles from Princeton--a distance greater than desirable. The great distances from Los Alamos and Nevada are disadvantages. The location does not seem favorable from the point of view of national defense.

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Brookhaven.- A location in Brookhaven would have the advantage of an established AEC site as well as the availability of a nuclear reactor and a Van derGraaff machine. The savings on account of these installations and of the probable availability of liquid nitrogen and hydrogen will be about one million dollars. Near Brookhaven it might be difficult to find an appropriate site for explosive experiments. With respect to distances from Los Alamos and Nevada and with respect to national defense, the same remarks hold as for Princeton.

Chicago.- In Chicago, a Van derGraaff, a D-D source, a nuclear reactor, low temperature facilities and high speed electronic computers are expected to be available. In addition, considerable help could be expected from the local scientific personnel. The disadvantages of the distances from Los Alamos and Nevada, as well as the location with respect to national defense apply to a somewhat lesser extent than in the case of Princeton and Brookhaven. The project could be integrated administratively with the Argonne National Laboratory.

The greatest difficulty of the Chicago location would probably be to find an appropriate explosives site within reasonable commuting distance.

From the point of view of the AEC, the housing situation in the cases of Princeton, Brookhaven and Chicago offers the advantage that in these locations probably no new housing projects would be undertaken.

A Site near Tonopah.- This site would have no advantage with respect to existing facilities and might have the disadvantage that a new AEC town would have to be built. It would have the considerable advantage of proximity to the continental test site and probably be well located from the point of view of national defense. Isolation might be considered an advantage from the point of view of security.

5. Summary

A site at Boulder, Colorado has been considered. Total requirements for the immediate future for scientific manpower are: 50 senior scientists, 82 junior scientists, and 228 technical assistants. Table 1 gives a breakdown by fields of these numbers.

Table 1

	Senior Scientists	Junior Scientists	Assistants
Experimental Physics	7	7	5
Electronics	3	10	10
Chemistry	9	15	15
Metallurgy	2	5	20
Theoretical Physics	12	15	15
Computing	3	6	15
Cryogeny (if in Boulder)	0	0	0
Explosives	6	13	24
Engineering	3	4	20
Field Tests	3	3	0
Photography	1	1	4
Shops	1	3	100
TOTAL	50	82	228

[redacted]

[redacted]

APPENDIX I

Details on Field of Experimental Physics

The measurements to be performed in the experimental physics division will not extend to checks of mechanical construction. They will be confined to investigation of phenomena like behavior of neutrons, of fissions and activated substances in the test objects. For such measurements the following apparatus is needed:

D-D Source

The D-D Source is a low energy (250 kev) accelerator. It is needed for D-D and D-T reaction studies. It will cost approximately $30,000 and requires a floor space of about 1000 sq. ft. It is commercially available.

Water Boiler

This small nuclear reactor requires 1 kg of U^{235} and operates at an approximate power of 10 kw. It is a cheap and flexible tool for large neutron fluxes. One of its uses will be the production of radioactive substances which have to be studied in connection with the planned tests. It will cost approximately $100,000 plus 1 kg of U^{235} and will require a floor space of about 5000 sq. ft. The laboratory will have to build it, but it is not a major undertaking.

Van der Graaff

A small 2.5 mev Van der Graaff will be useful as a source of neutrons covering a wide energy range. It can be bought commercially and will cost approximately $500,000. A floor space of about 10,000 sq. ft. is required.

With high priority, these pieces of apparatus can be partly bought, partly assembled within 6 months.

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APPENDIX II

Details on Field of Chemistry

The chemistry laboratory will not make unusual floor space requirements. The general expense of the equipment of the laboratory and of the specific instruments is estimated to cost a little less than one million dollars.

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APPENDIX III

Details on Field of Machine Computation

The cost of a fast electronic computer is likely to be between $100,000 and $200,000. Duplication of the MANIAC is likely to be most successful if carried out at one of the places which by that time will have built a first machine, i.e. Princeton, the University of Illinois, or Los Alamos. It would then have to be rented. The rental is approximately $1500 per machine per month. The total floor space required for the machines will be in the neighborhood of 3000 sq. ft.

[redacted]

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APPENDIX IV

Details on Field of Cryogeny

Low temperature facilities will start operating at Boulder on January 1, 1952. This date meshes well with the date when other experimental facilities could begin to be available at a new site.

If the project is set up at a place different from Boulder, approximately $500,000 will be needed for cryogenic equipment, excluding liquefaction facilities. Another $200,000 will be needed for a small hydrogen liquefier and an additional $100,000 for a nitrogen liquefier. These two last items can probably be saved if the project is established in the east near a place where liquid hydrogen and nitrogen are available commercially. The establishment of a cryogenic laboratory at a place other than Boulder will probably take a time somewhat in excess of 6 months.

[redacted]

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APPENDIX V

Details on Fields of Explosives

In establishing the new site, high priority must be given to the building of high explosive facilities, which might easily become the bottleneck. Even with high priority it is likely to take 9 months or more to establish the machining facilities and the assembly building. The floor space required will probably be less than 8000 sq. ft. A 50,000 lb. capacity storage magazine will have to be set up in a reasonably isolated location. According to regulations, it must be 2800 ft. away from buildings and 800 ft. from any public highway. Similar time scales (approx. 9 months) will be needed to establish the facilities for the firing group. The total high explosive facilities will cost approximately $1,500,000.

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