[redacted] DOE b(3)

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] DOE b(3) (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] DOE b(3) 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] DOE b(3). 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 $\int_0^{R_s} \rho \, dr$ 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
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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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Let us first compare casualties which might be produced by C^{14} and Sr^{90}. In the paper by Langham and Anderson, summarizing Sr^{90} data, it was shown that release of 2000 Megatons of fission products would lead to Sr^{90} in human bones which would on the average produce radiation levels in the bones equal to the natural background. (This radiation doubling yield of 2000 Mt was actually arrived at for the area between 10° N and 60° N latitude -- but this area includes most of the worlds population.)

Let us next estimate the yields which would produce sufficient C^{14} to double the background radiation in human reproductive cells. We shall then compare the effects of doubling background in bones and reproductive cells.

We assume that most of the C^{14} which is produced starts out as carbon dioxide in the atmosphere. Anderson and others (Tellus IX (1957), 1) have shown that the residence time of carbon dioxide in the atmosphere, prior to absorption in the oceans, is of the order of 10 years. For the sake of definiteness we shall assume that the C^{14} has a half life in the troposphere of 5 years before absorption in the ocean. We also assume that this short time corresponds to mixing the C^{14} with a carbon reservoir of .15 gm per cm² of earth surface. This carbon is mostly CO_2 in the atmosphere. The long term carbon reservoir (ocean) with which the C^{14} is eventually mixed is about 8.0 gm/cm².

From data in NBS Handbook 52 and assuming that reproductive organs are effectively 1/6 by wt carbon (which is about the average for the whole body) we find that a C^{14} level of <u>1 μc per kg carbon</u> doubles the background for genetic purposes. For the short term reservoir (.15 gm/cm²) this corresponds to a total C^{14} production of 750 megacuries whereas for the long time reservoir, it is 4×10^4 megacuries.

In T-1009 it was stated that about .02 megacuries of C^{14} per megaton will be produced in a typical air burst. It is worth nothing that C^{14} production per megaton is essentially the same for existing U.S. clean and standard weapons. When Pauling and others speak of clean devices as "dirtier" than standard ones, it is presumably because they have the mistaken impression that clean devices release appreciably more neutrons per megaton to the atmosphere than do standard ones. For our devices this is certainly not so.

From the above we see that detonation of about 3.7×10^4 megatons would produce sufficient C^{14} to approximately double the radiation level in gonads for short times. The C^{14} concentration would be expected to decay with a half life like 5 years and as it came into equilibrium with the oceans to approach a long term level which is a factor 53 (8.0/.15) lower. It would decay from this lower level with the half life of C^{14} (5600 years). 2×10^6 megatons would double the radiation level in gonads over the long term.

Let us next compare casualties per r delivered to bones with casualties per r delivered to gonads. The only way in which one can arrive at a definite comparison here is by picking some definite numbers which have been suggested by experts in the field of radiation biology. I shall assume that Sr^{90} will produce

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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 125, 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^{3} 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/cm² of hydrogen. By this is meant that if one takes 1800 gm of tritium and mixes it with a hydrogen reservoir of ~ 10 gm/cm² 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)

For Cs^{137} we use the data of Anderson, et al. (Science 125, 1273 (1957)) where Cs^{137} was reported to be present in people and producing about 1% of background radiation (as gamma rays). A biological half life of 140 days was suggested. If we assume that this 1% level was caused from 5 megatons of fission products[2], the background would be doubled at about 500 megatons. If we assume a half life in the body of 140 days, it is found that this 500 megatons of fission products would produce the same number of genetic casualties as our previous 2600 megatons of short term C^{14}. Thus in this analysis Cs^{137} appears intermediate between long term and short term C^{14}. Evidently genetic casualties due to Cs^{137} may exceed leukemia casualties from Sr^{90}. This Cs^{137} estimate is rather uncertain (chiefly because of doubt as to the validity of the 5 Mt and 140 day half life for the above) but it should not be off by as much as an order of magnitude.

Most of the genetic casualties which we have been discussing would be expected to occur (in the sense that the mutant genes are finally eliminated from the population) only many generations after the damaging radiation is received. Thus, it is to be observed that any highly irradiated survivors of local fallout will in themselves constitute a long range genetic hazard. By intermarriage this hazard is also rather world-wide. To see whether this is an important effect compared to the long term C^{14}, let us compare the radiation (r) which might be received by survivors of local fallout with radiation delivered world-wide by the C^{14}. Suppose for example that there is a thermonuclear war in which 2×10^3 megatons are detonated, half as surface and half as air bursts. One might expect like 10^8 survivors of local fallout each one of which has received an average of 100 r. Thus like 10^{10} man r of genetic damage would be done by more or less local fallout. For a war which deposited a different amount of radiation (i.e., different size war, more or less air bursts, or clean vs. standard weapons) one would expect a slower than linear variation of damage with radiation. This is because there is a non-linear effect in that people who are close to a detonation or too highly irradiated die and cannot become genetic hazards.

The C^{14} produced by such a conflict would amount to 1.5×10^3 Mt airburst and would deliver only 2.3×10^9 man r to a stable population of 2.5×10^9 people and integrated over all time. Thus it appears that for a war of such a magnitude, a larger amount of genetic damage (which is more or less unavoidably world-wide) would be done by local fallout rather than by C^{14}. For a war of the order of 10^4 megatons (or for a smaller war in which most detonations are air bursts), the C^{14} damage might be comparable with genetic damage due to local fallout. For weapons tests, in which irradiation of people by local fallout is minimized it appears likely that long range damage by C^{14} and Cs^{137} produce most of the genetic casualties.

[2] Note that most Cs^{137} in people appears to come from fallout directly ingested by animals (or people) and not via soil and plants.

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Let us now discuss what conclusions can be drawn if one accepts genetic casualties as a real world-wide hazard. First of all, for an <u>air</u> burst (or test) there will be no significant local fallout and C^{14} will constitute a major source of genetic casualties which in turn may be a large fraction of all radiation caused casualties. Devices which are clean, in the sense of deriving a small fraction of their yield from fission, currently produce essentially the same C^{14} per megaton as standard devices. Hence air bursts of such clean devices may lead to genetic and radiation induced casualties which are comparable to those from a standard weapon.

On the other hand, for a wartime thermonuclear <u>surface</u> burst, it would be expected that local fallout would produce most of the genetic casualties, and thus the most severe world-wide hazard. It follows from the discussions of T-963 that the local fallout from a conventional clean weapon detonated over typical ground would produce fewer genetic casualties than fallout from a similar detonation of a standard weapon and that the gain would be by about a factor two to four. It now appears that differences in local fallout may be the only important distinction between the effects of current clean and standard weapons.

These considerations point to the conclusion that a truly clean bomb should not only derive a very small fraction of its yield from fission but it should also release relatively few neutrons to its enviornment. In addition it should release relatively few harmful radioactive products like Co^{60} or H^3. It is certainly possible to design devices which release fewer neutrons per megaton than current weapons. [redacted] By such an artifice one could, with addition of considerable mass and loss of yield, prevent escape of most of the fast neutrons, and some of the thermalized neutrons. One could perhaps achieve a reduction of neutrons out per megaton by up to a factor 10 in some cases. However it is difficult to see how to avoid leftover tritium or escape of many thermal neutrons. The tritium appears to impose limits on the cleanliness of any weapon which is allowed to discharge to the atmosphere.

Doe
b(3)

Finally one may inquire as to whether it is possible that C^{14} produced in a thermonuclear war may threaten the genetic annihilation of mankind. Geneticists appear to worry about this possibility if one doubles mutation rates. This corresponds to an increase in background radiation by about a factor 10 and thus to 2×10^7 Mt. Thus there appears to be no immediate danger of such a disaster.

George Bell

George Bell

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RADIATION LABORATORY
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July 11, 1957

Brig. General A. D. Starbird
Director of Military Application
U. S. Atomic Energy Commission
1901 Constitution Avenue
Washington 25, D. C.

Dear General Starbird:

The purpose of this letter is to make some preliminary estimates concerning clean tactical bombs. Such estimates could be made with much greater certainty and precision later this year after Plumbbob results are available and analyzed. However, because of the great interest engendered by the recent recognition of the possibility of producing clean tactical weapons, it seems worthwhile to make such estimates at this time even though they are of necessity very rough and tentative.

DOE b(3)

[redacted] Section II gives a possible set of self consistent time scales based on assuming "good luck" in solving some of the basic design problems inherent in the types given in Section I, and Section III discusses the importance of cleanliness in tactical bombs, and attempts to describe in a very rough but fairly concise way the meaning of various degrees of cleanliness as applied to a specific tactical application, namely, the use of a ground burst against a hard target in friendly territory or near our own troops.

I. Possible Types of Clean Tactical Bombs

The following is a list of three possible types of clean tactical bombs, including estimated dimensions, weights, total yields, fission yields, and special materials costs.

DOE b(3)

[redacted] They are listed in increasing order of difficulty. It should be emphasized that no experimental shots have ever been made of any of the types listed below, either in device or prototype form; the characteristics given are extrapolations based on application of the theoretical methods which have proved successful in the past in the design of other types of weapons. These extrapolations do not at present indicate that such characteristics can certainly be achieved, but rather, that with continued R & D work, characteristics in this general range can quite probably be achieved.

TYPE I: A [miniaturized] standard type two stage clean bomb. This type of bomb could probably be made with the following approximate characteristics:

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DOE b(3)

[redacted]

Length - 40" - 50"

TYPE II:

DOE b(3)

[redacted]

DOE b(3)

Length - 40" - 50"

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

DOE b(3)

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 [redacted]	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, 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] DOE - b(3)

FY 1959 [redacted]

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] DOE b(3)
[redacted]	400 R 50 R	[redacted]
[redacted]	400 R 50 R	[redacted]
Direct Casulties Produced by Blast		[redacted]

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

TOP SECRET SECRET

TABLE I - Area in Square Miles for Various Effect - Continued

Fission Yield & Effect	Total Yield
	[redacted]
Frame Structures Destroyed by Blast	[redacted]
Thermal Radiation (10 cal/cm^2)	[redacted]

DOE b(3)

DOE b(3)

TABLE II - Range in Miles for Various Effects

Fission Yield & Effect		Total Yield
		[redacted]
100%	400 R 50 R	[redacted] iles
	400 R 50 R	[redacted]
	400 R 50 R	[redacted]
	400 R 50 R	[redacted] of range available a
Direct Casulties Produced by Blast		[redacted]
Frame Structures Destroyed by Blast		[redacted]
Thermal Radiation (10 cal/cm^2)		[redacted]

DOE b(3)

DOE b(3)

DOE b(3)

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SECRET

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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)

[redacted] it would

seem that if one affords himself of the reductions afforded by any of this type of protection (except perhaps the last) for the first few hours after the shot, and then leaves the fallout zone rapidly (even on foot) that then there may well be no place where it is possible to survive other weapons effects and yet receive a lethal dose of fallout radiation in the case of a clean tactical bomb surface burst.

5. The Effects of Neutron Induced Activities in the Soil - The relative importance of neutron induced activities depends on the type of bomb (cleanliness and neutron leakage) the type of soil (particularly the sodium content) and the time at which the comparison between fission fragments and induced activities is made (because the time dependences are very different). It is, therefore, impossible to give a comparison between the two types of activity which is at the same time concise and accurate. However, calculations made using the following typical example will give an idea of the relative importance of induced activities. [redacted] We have then calculated the dosage to be expected at various times, compared with the fission fragment activity, and then determined what fission yield to total yield ratio (i.e., the cleanliness) a bomb would have to have in order that the fission fragment dosage and the induced activity dosage be equal. This equivalent fission yield to total yield ratio is given below for various time intervals.

DOE b(3)

TABLE III - Added Effect of Induced Activity

Time Interval (burst time = zero)	Equivalent Fission Yield to Total Yield Ratio
15 min. to 5 hrs.	[redacted]
15 min. to 1000 hrs.	[redacted]
5 hrs. to 1000 hrs.	[redacted]
1 min. to 6 min.	[redacted]

DOE b(3)

The relatively high value of the last case is due to the aluminum, and, of course, does not apply to any point more than one to two miles from ground zero, since the fallout will not reach there until after this short time interval. For the 400 R dosage cases of tables 1 and 2, only the first two cases apply, since most of the dosage comes in the first few hours. [redacted] In fact, by coincidence, the added effective fission fraction is approximately equal to the fraction of sodium in the soil.

DOE b(3)

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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

Distribution:
Brig. General Starbird, 1-2A
Commissioner Lewis Strauss, 3A
Commissioner Willard Libby, 4A
Commissioner Harold Vance, 5A
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ADWD-169

INTER-OFFICE MEMORANDUM

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 testing

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DD 51190

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PER DOC REVIEW JAN. 1973

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PER DOC REVIEW JAN. 1973

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~~M. KOLBAY~~, A.D.C. DATE: 110995

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95SA20B000244

N. E. Bradbury R. B. [illegible]

[redacted]

Unique Document # SAB200085540000

29

M E M O R A N D U M

UNCLASSIFIED

March 6, 1951

E.7.c)
10-4-00

TO: Division Leaders and Assistant Directors

FROM: N. E. Bradbury

PUBLICLY RELEASABLE
OS-6 B Palat[illegible] 1/26/94

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.

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

RESTRICTED [redacted]
[redacted]

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by authority of the U. S. D. O. E.,
E. M. Sandoval
Per ____________ MAR 3 1990
(Person authorizing change in classification) (Date)
By ____________ MAR 3 1990
(Signature of person making the change, and date)

[redacted]

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DOE/OFFICE OF DECLASSIFICATION
~~M. L. KOLBAY~~, A.D.C. DATE:

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95SA20B060244

DRAFT

DRAFT

March 6, 1951

[redacted]

TO: Assistant and Associate Directors, Division Leaders, Department Heads, Business Manager, and C. L. Tyler

FROM: N. E. Bradbury, Director

SUBJECT: Technical Associate Director's Responsibiliti[redacted]

SYMBOL: DIR

The duties and responsibilities of the Technical Associate Director have apparently lacked clarity in the past, and now require extension and revision as well in view of Mr. Manley's departure. This memorandum is issued to redefine the status, duties, and responsibilities of the Technical Associate Director in the light of the current needs of the Laboratory. Incidental to this, some additional statements are made with respect to the Laboratory's organization and administration.

I. Organization. The group, divisional and departmental structure of the Laboratory remains unchanged. Certain members of the Director's Office have duties in addition to their staff functions, completely analogous to those of a division leader. Specifically, the Assistant Director for Administration is responsible for the Supply and Property, Personnel, and Accounting Departments, the Business Office, the Budget Office, Mail and Records, and Graphic Arts. The Assistant Director for Engineering is responsible for the Engineering Department. The Assistant Director for Production is responsible for the Shop Department and the SF Control Group. The Assistant Director for Classification and Security is the Documentary Division Leader.

II. Director's Office. The staff functions of the Assistant Directors for Administration, Classification and Security, Engineering, Production, Scientific Personnel, and Weapon Development, and of the Technical Associate Director are to advise the Director with respect to Laboratory program and operations in their respective fields and to represent him in specified respects.

[redacted] UNCLASSIFIED

The detailed staff duties of these individuals may be defined in later memoranda where there appears to be a need.

III. Standing Committees Appointed by the Director. The success of the Laboratory's technical program is very strongly dependent upon the accomplishments of these committees. Although they are formally advisory to the Director, the recommendations of these committees are to be considered approved and equivalent to directives to the various divisions unless and until specifically disapproved by the Director, and divisions and departments are authorized to implement immediately such recommendations. Cases of conflict resulting from such recommendations should be brought to the Director's attention promptly.

IV. Duties and Responsibilities of the Technical Associate Director.

A. Those of the Technical Associate Director are as follows:

1. To assume the direction of the Laboratory in the absence of the Director.

2. To be a member of the Laboratory Construction Planning Board.

3. To be responsible for the preparation of Laboratory technical correspondence, including replies to technical inquiries from Washington or elsewhere, excluding, however, those matters normally handled by the Assistant Director for Production, those matters handled by the Chairmen of the joint Los Alamos-Sandia committees, and routine technical matters normally handled at the division level.

4. To act as alternate for the Director with respect to technical research and development contracts or arrangements with agencies outside the Laboratory except those directed toward J Division activities, which are normally negotiated and supervised directly by J Division. In particular, whenever action by the Director's Office is required concerning such arrange-

[redacted]

ments in the fields of thermonuclear research, cryogenics, initiators, and nuclear measurements, such action will normally be taken by the Technical Associate Director.

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5. With the aid and advice of the Assistant Director for Weapon Development and other appropriate Laboratory personnel, to study and recommend to the Director, from time to time, the desirable over-all Laboratory and individual division effort to be assigned to its major fields of research and development. In particular, to recommend in the near future the proportionate efforts to be expended upon fundamental research, fission weapon research and development and thermonuclear research and development. Following a determination of these proportionate efforts by the Director it shall be the duty of the Technical Associate Director to follow the work of each division to insure that each major field is receiving approximately its allotted share of the effort. These arrangements will make superfluous a formal Committee for Weapon Development.

6. With the aid and advice of the Assistant Director for Weapon Development, the Family Committee and such others as are deemed appropriate, to determine, recommend and modify as necessary with time a detailed program for the entire thermonuclear effort. Following approval of such a program, the Technical Associate Director will represent the Director in dealing with divisions and outside agencies to implement it. The directive to the Family Committee will require revision under the circumstances.

7. With the aid and advice of the Fission Weapon Committee and the Initiator Committee, to determine and recommend a detailed program for the Laboratory effort upon both internal and external initiator development. Following approval of such a program, the Technical Associate Director will represent the Director in dealing with divisions and outside agencies to implement it.

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[redacted]

8. With the [redacted]vice of appropriate Laboratory personnel to study and recommend, from time to time, upon any organizational changes which will increase the efficiency of accomplishment of the technical program.

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[redacted]

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No. 11 of 11 copies. Series A

ADMD, Leaders of CMR, GMX, H, J, P, T and W Divisions — March 22, 1951

Chairman, Fission Weapon Development Committee

Darol Froman

Request for Data on Effort and Program Information

TAD- 218

General McCormack has asked the Laboratory to supply information for the Commission upon the fractional effort the Laboratory has expended in the recent past, and plans to expend in the coming months, upon the thermonuclear program. This request ties in, to some extent, with the proposal recently discussed to arrive at a planned distribution of effort among research, thermonuclear and fission-weapon work. One way to estimate the relative efforts in the past is to note the average number of SM's and RA's working each field in the technical divisions, and to assume that, on the average, all supporting work and services in the Laboratory are in proportion. This method may result in somewhat better accuracy than pure guessing and, with practically no additional work, can give some idea of the distribution of our other effort. It is therefore requested that the leaders of CMR, GMX, H, J, P, T and W divisions fill in the two top rows of the attached table with their best, round figure estimates for their divisions and return one copy to the undersigned. It is suggested that each division leader use his own definition and interpretation of the terms heading the columns.

It is very difficult to arrive at a most desirable distribution of effort for the coming year from the point of view of national well-being and defense. This is especially true because we have no very coherent overall Laboratory programs in any of the major fields which describe concrete and definite objectives in a time sequence. However, it would be appreciated if those division leaders who have opinions upon what distribution of effort in their divisions is desirable and appropriate would so indicate in the third row of the table.

In order to determine, in part, a desirable distribution of effort, a committee with representatives from each of the technical divisions has been appointed to look into what we have been doing, and what we should do, in those matters referred to in the current Laboratory Technical Program under the heading, "Fundamental Research". An attempt is being made to arrive at a concrete and somewhat detailed thermonuclear program. It is requested that the Fission Weapon Committee also set up a program in its field with definite objectives, desirable time relationships and estimated effort required for accomplishment of each. It is hoped that the information available from these three sources will enable us to make some reasonable distribution of our efforts and to estimate when the major objectives in each field may be accomplished.

The red tape work in connection with this memo is regretted, but it is felt that if we can get a clearer understanding of what we are trying

~~CONFIDENTIAL~~

DAR-

March 22, 1951

to do and wish to accomplish in the Laboratory, the effort will be well repaid. Although the time scale on the above is not "Rush-Urgent" we can hardly wait until after Greenhouse. The Greenhouse observations, or other new information, may, of course, result in changes in our programs.

Original signed by
DAROL FROMAN

Darol Froman
Technical Associate Director

DF/rb

1A - Edward Teller w/encl
2A - E. R. Jette w/encl
3A - D. P. MacDougall w/encl
4A - D. P. MacDougall w/encl
5A - T. L. Shipman w/encl
6A - A. C. Graves w/encl
7A - J. M. B. Kellogg w/encl
8A - Carson Mark w/encl
9A - M. G. Holloway w/encl
10A - Darol Froman w/encl
11A - Mail and Records w/encl

DISPATCHED MAR 23 1951

CLASSIFICATION CANCELLED
PER DOC REVIEW JAN. 1973

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~~CONFIDENTIAL~~

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.

(c) Remarks similar to those in (b) apply to equation-of-state experiments, implosions, H. E. production, metallurgy, development of fabrication methods,etc, in GMX and CMR divisions at present.

(d) From the above, it appears that a separate thermonuclear division would be made up essentially from personnel and units now in T and P Divisions with, perhaps, some additions. In these divisions there are many groups and facilities useful to both major fields. Do we give the cyclotron and its crew to thermonucleonics, the Van de Graaff and crew to fission? Surely we sometimes want both in each. Do we divide the crew on each into two groups working alternate periods on the two kinds of problem? Surely it is more effective to have the whole crew, which has learned to work as a unit, tackle the different problems successively. How can we divide an operating group - say that on the Van de Graaff or that operating the IBM machines - equitably and in a way to keep good morale? Groups resist being split up. Who gets Taschek, Hemmendinger, Hammer, Carlson, Coon, etc.? How do we assign responsibility, division-wise, for property control, maintenance etc., on facilities owned by two divisions? What do we do with people who insist on having ideas, and working on them, in both fields - e. g., Ulam? It seems to the writer feasible to select some personnel and units (perhaps groups) in T Division and assign them to one or the other field, if there is no major equipment involved. It also seems feasible to program the work of other groups to include work in both fields - and surely we shall want to use the Maniac in both, for example.

The biggest reorganization which seems useful in this respect is only a minor shifting about in the group structure of T Division.

3. Some very influential and important members of the Laboratory staff believe strongly that a separate division is greatly disadvantageous. Their morale and therefore their effectiveness would be decreased by the formation of such a division.

4. The Laboratory has been gradually built up to do a very diversified set of jobs in connection with atomic weapons. Many of the talents and facilities cannot be split because they exist in units (one person or one machine).

5. If a separate division is formed, its personnel policies, pay scales, etc., must be identical with those of the rest of the Laboratory or the Laboratory will simply fall apart. Thus, with a little care, recruting to do thermonuclear work should be equally easy under either organizational system.

6. A strong stand in the Director's office can assure equitable distribution of effort in a given division about as easily as the personnel in one division can be kept untouchable by another.

From considerations such as those illustrated above, it is my opinion that LASL can be very much more effective in each of its major fields of work by retaining its present type organization than by forming a separate thermonuclear division. This does not mean that I think each person must necessarily try to contribute in more than one field, nor do I believe our present organization is anything like perfect. There are 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

Copies: five

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No. 2 of 3 copies. Series A

4' [redacted]

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

Unique Document # SAB2000855900000
4716

IN REPLY REFER TO: ADWD-260

April 20, 1951

This letter is Unclassified
22578
(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. Palatine 1/26/94

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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by authority of TSM OS-6 1/26/94
Per B. Palatine (Sig of person authorizing change, title, org., date)
M. Sandoval TSM, OS-6, 1/28/94 (Sig of second reviewer, title, organization, date)

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DOE/OFFICE OF DECLASSIFICATION
M. E. KOLBAY, A.D.C. DATE: 11/1/93

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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
1A - Chairman Dean - Rec. 65770
2A - N. E. Bradbury - sent prior to recording
3A - E. Teller

[redacted]

ADWD-261

April 20, 1951

A NEW SITE FOR THERMONUCLEAR DEVELOPMENT

1. Introduction

The following is an outline of a proposed thermonuclear laboratory. It is not intended to argue that a new laboratory is desirable. It is impossible under the present circumstances to give even an approximately correct and complete plan for such a laboratory. The purpose of this outline is to summarize--in answer to questions that have been raised--the kind and size of operations as they might be imagined at present. Specific figures given below are intended mostly as illustrations. It is firmly believed, however, that the final size of the laboratory should not greatly surpass the estimates we shall present.

V

2. Over-all Scope of Work

To investigate theoretically all avenues of thermonuclear work; to prepare for early intermediate tests (about 9 to 24 months); to design and execute a full-scale demonstration of a thermonuclear explosion; to design (but probably not to build) thermonuclear weapons.

As much experimental work as possible is to be farmed out to existing AEC installations or to outside organizations. This policy will help to keep the place small, utilize existing AEC laboratories to the fullest extent, and allow the new site to concentrate on essentials.

3. Scientific Manpower and Equipment

In order to present a proposal in the most concrete terms, the following sections have been written with a specific site in mind, Boulder, Colorado. In section 4, the relative advantages of this location and other locations are compared.

Each field of work is discussed separately below. Administratively, several such fields might be under one and the same division.

For the purposes of this rough outline, manpower is broken down according to senior scientists, junior scientists and technical assistants. The staff indicated below is that which one would attempt to hire in the shortest possible time. On the whole, expansion in most divisions would be relatively small. For the test division, this is not so. There follows a summary concerning each field with pertinent details left (where appropriate) to individual appendices.

[redacted]

[redacted]

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.

[redacted]

[redacted]

D. Metallurgy

The maximum amount of fabrication for test purposes will be farmed out to other establishments. Where peculiar materials are needed, the chemistry division can take over. There remains, however, the necessity of uranium metallurgy, and in particular of U^{235} operations (casting, machining, etc.). This job will need a separate group, both because of the hazards involved and because of problems of accountability. This group may consist of 2 senior men, 5 junior men and 20 assistants.

The expense of particular equipment is comparable to that needed by the chemistry group. The fabrication of plutonium is a particularly delicate and therefore expensive operation. It is planned to avoid the duplication of any plutonium facilities. Plutonium parts are not likely to be needed very frequently and on the exceptional occasions when such parts are needed they probably can be provided by Los Alamos.

E. Theoretical Physics

This must be a strong group. Requirements would be 12 senior scientists, 15 junior scientists and about 15 technical assistants, who would include both trained and untrained computers. In case a strong theoretical group is established at Princeton, these requirements may be slightly lower.

The establishment of such a theoretical group will be of the highest importance. The duties of the group will be to make calculations in connection with the varying needs of the laboratory and to keep all parts of the laboratory thoroughly informed of the significance of each part of the work and the requirements which have to be met. The success of the early phases of work at Los Alamos was due to a great extent to the fact that the theoretical division fulfilled precisely these functions. It will be quite difficult to get the right people for the theoretical group. On the other hand, a relatively big theoretical group will not be costly because no extra equipment and only nominal floor space will be required.

F. Machine Computations

It will be necessary to build a fast electronic computer (Maniac) as soon as possible. Present Maniac schedules indicate that it might be feasible to have a duplicate Maniac working at the new site early in 1952. While this estimate includes a small safety factor, it must be remembered that the ambitious plans for the fast electronic computing machines have met with some delays. Prior to the delivery of the Maniac, it will be necessary to have complete IBM facilities, probably consisting of three of the most advanced machines (CPEC). The staff would have to include 3 senior men (2 mathematical physicists and 1 electronic engineer), 6 junior scientists, and 15 technical assistants.

Location of the project at Princeton would make the fast electronic computer available at an earlier date. Duplication of this machine, however, will remain a necessity since the Princeton electronic computer will not be available for full-time service.

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G. Cryogeny

Liquid hydrogen facilities are essential for the oldest type of thermonuclear, or Super, work and in all probability will be required for other types. Complete cryogenic facilities are being planned at Boulder, which include a personnel of 50 scientists and an expenditure of $3,000,000. The greatest advantage in moving the new project to Boulder would be the advantage of utilizing these facilities to the fullest extent. Actually no additional cryogenic facilities would be needed if the project would move to Boulder.

If the project is established elsewhere, it will probably be necessary to establish a cryogeny group consisting of 3 senior men, 7 junior men and 12 technical assistants.

H. Explosives

The greatest delays in establishing a new site are likely to be encountered in establishing a new explosives division. Some duplication of the facilities available at the excellently functioning explosives division at Los Alamos can not be avoided. Such duplication, however, can be held to a minimum by not requiring any high explosives casting facilities. The high explosives lenses which thermonuclear work would need could, in all probability, be delivered by Los Alamos. This might require some expansion of the Los Alamos facilities. Such expansion, however, would be much less expensive and much more prompt than the establishment of new facilities. The high explosives parts fabricated at Los Alamos would have to be transported to the new site. It is therefore of advantage if the new site is not too far from Los Alamos.

The thermonuclear laboratory will have to have facilities to modify, in a slight way, the high explosives lenses delivered from Los Alamos. This will require high explosives machining facilities. In addition, facilities will be needed to assemble the high explosives systems. All these operations will require approximately 3 senior men (engineers), 4 junior men (2 engineers and 2 high-caliber machinists), and 12 technical assistants (mostly machinists and some draftsmen).

In addition, a firing group is needed in the explosives division. The purpose of this group is to investigate in detail the results of implosion shots. This group will have to include 3 senior scientists (1 physicist, 1 electronics man and 1 mechanical engineer), 9 junior scientists (5 physicists, 3 electronics men and 1 mechanical engineer) and 12 technical assistants.

A high explosives magazine of approximately 50,000 lb. capacity will have to be available.

[redacted]

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.

[redacted]

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]

In each of these fields secretarial personnel will work closely with the above groups. Technically untrained personnel such as operators for certain physics equipment will also work together with the technical people enumerated in Table 1. These two groups should represent an extra 90 people.

Specific physical equipment is likely to take about 30,000 sq. ft. The laboratory facilities for the 360 technical people plus the 90 non-technical people working with them are likely to take another 140,000 sq. ft. (based on an estimate of 300 sq. ft. per person).

As for cost, it is recognized that dollar value is a poor measure of the real cost to the nation, which is that involving scientific manpower and equipment. In particular it is believed that wherever purchase of equipment will in any way accelerate the time schedule of the laboratory this is a good bargain.

The cost of major experimental equipment would seem to amount to about 4 to 5 million dollars. This cost does not cover any expense for buildings. It should be emphasized that dollar cost estimates cover only specific technical installations considered above. Standard equipment for specific groups such as experimental physics, electronics and engineering are not included and no consideration has been given to the very expensive installations which field tests will necessitate. Eventual requirements for equipment are likely to exceed the quoted figures considerably.

In addition to the manpower and facilities directly connected with technical work, there are requirements for considerable manpower and floor space to maintain such a laboratory. Among these one notes administration, document and library facilities, business and purchasing staffs, security services, maintenance services, etc. The exact nature and location of the new site would dictate these auxiliary considerations and they are mentioned here only to recall that manpower, cost and floor space estimates concern the strictly technical work only.

The time schedule for a new site could be such that a planning and theoretical group spends the summer of 1951 at Los Alamos. Meanwhile ground could be broken at the new site and by fall 1951 rudimentary facilities might be available to permit the first group, which would include the theoretical people, to move in. Christmas 1951 might see some experimental equipment in operation and fairly routine operation might be expected by the spring or summer of 1952.

<u>Distribution</u>

1A - Chairman Dean — Rec. 65770
2A - N. E. Bradbury
3A - E. Teller

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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:

<u>D-D Source</u>

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.

<u>Water Boiler</u>

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.

<u>Van der Graaff</u>

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.

[redacted]

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.

[redacted]

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]

[redacted]

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]

[redacted]

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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Partial statement made by Hans Bethe at Princeton meeting June 16-17, 1951:

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"The main problem, at present, is to find out how the proposed thermonuclear devices will work. What we have at present, both the estimates of compression by radiation implosionand those of the functioning of the equilibrium super, are more than preliminary. Much solid theoretical work will have to be done to make the estimates firm, and even to decide feasibility. I agree very much with Wheeler that preparation of a test, even the simplest one, will interfere with this fundamental theoretical work.

"When theoretical understanding has progressed sufficiently, a test will undoubtedly become desirable. I believe the decisive point about designing a test is that it be significant. I don't think it is necessary that the avenue from the test object to a military weapon be entirely clear at the time of test, but I agree with Oppenheimer that it was a great progress when the Nevada tests were designed to find out how certain devices worked, regardless of their direct relation to weapons.

"To be significant, the test has to decide questions which cannot easily be decided theoretically or by small-scale experiments. We have never tested a gun because we have felt confident that we could predict its yield theoretically. The Tonopah tests were designed to test central compressions in the implosion on which the pin shots and RaLa experiments had given conflicting evidence. Similarly, the thermonuclear tests should be designed such as to decide . . "

(that's all there was to copy.)

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FOR DEAN FROM BRADBURY PD I UNDERSTAND THAT EDWARD TELLER HAS AN APPOINTMENT WITH YOU TO DISCUSS HIS STATUS AT LOS ALAMOS PD FOR YOUR INFORMATION WE HAVE ASKED TELLER TO BE RESPONSIBLE FOR INITIAL THEORETICAL DESIGN OF SAUSAGE CMA AND FOR THE APPROVAL FROM THE THEORETICAL POINT OF VIEW OF ALL THERMONUCLEAR ELEMENTS OF DESIGN INCLUDING FINAL DRAWINGS PD AFTER EXTENSIVE CONSIDERATION OF INDIVIDUALS BOTH INTERNAL AND EXTERNAL TO THE LOS ALAMOS SCIENTIFIC LABORATORY WE HAVE ASKED DOCTOR MARSHALL HOLLOWAY OF OUR STAFF HERE TO ESTABLISH COORDINATION BETWEEN THE THEORETICAL WORK CMA THE ENGINEERING DESIGN CMA AND THE FABRICATION OF THE VARIOUS ELEMENTS PD REPRESENTATIVES OF AMERICAN CAR AND FOUNDRY ARE COMING TO LOS ALAMOS NEXT TUESDAY TO EXPLORE POSSIBILITY OF THEIR TAKING THE RESPONSIBILITY FOR DESIGN ENGINEERING AND POSSIBLY SOME FABRICATION AND PROCUREMENT PD ARTHUR D LITTLE WILL PROBABLY BE EITHER SUBCONTRACTOR OR

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(Sig of second reviewer title, organization, date)

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penalties under applicable Federal law.

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OR CONSULTANT ON CRYOGENIC PHASES PD UNFORTUNATELY HOLLOWAY IS NOT PARTICULARLY PERSONA GRATA TO TELLER BUT IS CONSIDERED HERE TO BE BEST MAN AVAILABLE LOCALLY FOR THIS RESPONSIBILITY AND WE BELIEVE FIRMLY THAT MOST RAPID PROGRESS WILL BE MADE UNDER THESE CIRCUMSTANCES RATHER THAN BY ATTEMPTING TO BRING IN AN OUTSIDE INDIVIDUAL UNFAMILIAR WITH THE PROBLEMS AND WITH THE STATUS OF THE DEVELOPMENT PD PARA IF TELLER FEELS THAT HE CANNOT ACCEPT THE RESPONSIBILITY DEFINED ABOVE CMA I WILL ASK DOCTOR CARSON MARK TO ASSUME IT AND WE WILL MAKE MAXIMUM POSSIBLE USE OF TELLER AS A CONSULTANT PD TELLER HAS INDICATED THAT HE WOULD BE WILLING TO HELP IN THIS WAY PD IT SHOULD ALSO BE NOTED THAT DOCTOR HANS BETHE WILL BE AT LOS ALAMOS BEGINNING EARLY NEXT YEAR UNTIL FALL PD WE ARE PLANNING TO INVOLVE HIM IN THIS DEVELOPMENT IMMEDIATELY AND CMA IF TELLER LEAVES CMA WILL VERY LIKELY BE ABLE TO PERSUADE HIM TO BEGIN TO DEVOTE TIME TO THEORETICAL DESIGN

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