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May 4, 1959

Mr. G. A. Derbyshire  
Space Science Board  
2101 Constitution Ave.  
Washington 25, D. C.

Dear Mr. Derbyshire:

Our group, which met May 2nd and 3rd, spent some time discussing the application of ionizing radiation for the sterilization of missile payloads. We had previously considered radiation technique during our previous meetings and had felt that it might be applicable although marginally in relation to the complete sterilization of a payload at doses that would leave the instrumentation intact. If the circuitry can be subject to basic redesign, as might be necessary for the application of radiation, we felt that heat might prove to be about as effective and considerably more convenient to use in practice. There is, of course, considerable objection to complete overhauling of the electronic systems to make them amenable to either thermal or radiation sterilization. However, we feel that the question should be studied as closely as possible. The presentation was, however, somewhat narrow both from the point of view of the biological aspects of sterilization and of the effect of large radiation doses on the electrical properties of material, these properties being probably more important, and in some cases more sensitive, than the mechanical ones which were tabulated. There are at least two other organizations which should be considerably better qualified to study various aspects of this problem than is General Electric. One of these is the Argonne Laboratories, operated by the University of Chicago under contract to the A. E. C.; the other is the Biological Warfare Laboratories at Fort Detrick, Frederick, Maryland. The Argonne Laboratories must have very much more extensive data on the radiation sensitivity of microorganisms and also of materials than are indicated in the G. E. Memorandum. The Fort Detrick Laboratories have unequalled experience in the disinfection area. Additionally, the Army Quartermaster Corps, Pioneer Laboratory at Natick, Massachusetts has also had considerable experience in the sterilization of bulky materials by radiation and should be consulted. We would consider that G. E. in the light of its own report and of the indicated qualifications of its staff would be an acceptable choice but with a lower standing than the agencies just indicated to make the study called for. However, the study should be made from an operational point of view and these remarks should not discourage the participation by G. E. provided every effort is first made to interest the agencies listed.

We had some concern as to the quantitative conception of 'sterilization' indicated in the memorandum. Sterilization is a zero order kinetic process so that each succeeding dose

removes a constant fraction of the previous contamination load. In view of this consideration, the term "complete sterilization" is hardly meaningful. What can be looked for is the reduction of the contamination load to some figure which presents what will be considered an acceptable risk. In view of many intangible factors, we hesitate to suggest a tolerable level of risk at the present time. In any case, this should represent a residual contamination substantially less than one microorganism per missile. If we consider payloads of the order of  $10^5$  grams and, as Hilbert does, an initial contamination load of  $10^6$  per gram, our basic problem is to reduce a load per missile from  $10^{11}$  to some number less than one. A conservative mean lethal dose for bacteria, taking into account the probable existence of species more resistant than those commonly used for calibration, would be not less than  $10^5$  r.; this gives a decimal reduction dose of 2.3 times  $10^5$  r. To reduce the contamination load from  $10^{11}$  to one organism per missile would then require local doses of the order of 2 times  $10^6$  r. These figures are comparable to the ones quoted but it should be stressed that they refer not to "complete sterilization" but to the reduction of the contamination load to the extent indicated. It should be stressed also that if the procedure is to inactivate viruses and other more radio-resistant targets these figures would have to be multiplied by 10 or 100. We agree that these studies should be conducted in close concert with the laboratories, such as JPL, which are actively concerned with the production of scientific payloads and also with consultation with the microbiologists who have been thinking about the problem.

We hope that studies will be conducted that are not confined to radiation sterilization but include other likely techniques such as chemical fumigation and thermal sterilization.

The group asked me to take the occasion again to stress the vital importance of the problem and of developing practical measures to meet it.

Yours sincerely,

Joshua Lederberg  
Professor of Genetics