ESTIMATING THE NUMBER OF TERRESTRIAL ORGANISMS ON THE MOON*

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(Received 1 February, 1972)

Abstract. NASA policy requires that the number and spatial distribution of terrestrial organisms deposited on the Moon be estimated. This paper describes the way in which such an 'inventory' is being maintained, and some of the conclusions that may be drawn from it.

1. Introduction

NASA policy requires that an inventory of biological contamination placed on the lunar surface by manned and unmanned flights be maintained by location (NASA, 1969). This policy reflects the concern of many people in the scientific community that experiments conducted on the lunar surface may be biased by the presence of life carried from Earth on previous missions. Biological contamination on a lunar flight is "limited to the extent that it does not interfere with the scientific objectives that have been approved for that particular mission" (NASA, 1969). Since lunar spacecraft are not sterile, it is appropriate to consider the probability that a lunar soil sample taken on a given mission is 'contaminated' with microorganisms deposited on the moon by previous flights. This should be based on the inventory maintained by NASA.

The NASA Planetary Quarantine Officer, through his Lunar Information System (Roark and Wyer, 1968), assembles biological data collected from outbound lunar spacecraft by the U.S. Public Health Service. On the basis of these data, the Lunar Inventory subsection of the information system, through the use of mathematical models, predicts the quantitative biological load on each spacecraft when it reaches the lunar surface. Additional models then predict the manner in which this bioburden is dispersed on the lunar surface, and, for any location on the lunar surface, the probability that a lunar surface sample taken at a given date will be contaminated by life from unmanned flights and from non-astronaut sources on manned flights to the lunar surface prior to that date. Precisely how this lunar inventory is maintained, and conclusions that may be drawn from it are the subjects of this paper.

To look briefly ahead, Section 2 will discuss the methods used to obtain estimates for the biological loadings on lunar bound spacecraft prior to launch. Section 3 will provide a discussion of the mathematical models used to calculate the microorganism density on the lunar surface and the probability that a sample will be contaminated.

* This work was conducted under Contract W-12,853, Planetary Programs, Office of Space Science and Applications, NASA Headquarters, Washington, D.C.
All of the computations are based on models developed by Tierney (1968). In his report he considered the problem in several parts. He first considered the problem of estimating the bioburden on a spacecraft just prior to launch and the problem of reductions in the bioburden while the spacecraft is in cis-lunar space. Vis-à-vis the distribution of organisms on the lunar surface, two types of impacts of the spacecraft onto the lunar surface were considered: Soft landing and hard impact. Finally, a study was made of the survival of the microorganisms after they are dispersed on the surface and the possibilities are explored of further transport after their deposition by impact. Section 4 will discuss the implementation of the models.

In the final section, Section 5, we will present some of the conclusions and some of the results which have been obtained by the use of this Lunar Inventory Section of the Planetary Quarantine Lunar Information System.

2. Estimates of Bioburden at Launch on Lunar Bound Spacecraft

In order to obtain the input information necessary for the maintenance of an accurate and complete inventory of microbiological contamination deposited on the lunar surface by spacecraft, NASA has established an extensive program for sampling microbiological contamination on spacecraft.

Estimates of the number of viable microorganisms present on the surface of space hardware were determined by the swab-rinse method during the assembly and testing of the hardware. Sampling sites were those considered to be representative of the entire spacecraft and accessible throughout the sampling period.

Surfaces to be sampled were outlined with sterile templates (4 square inches). Areas less than 4 square inches were determined by direct measurement. Sterile cotton swabs were immersed in sterile buffered distilled water and rubbed over the surfaces. After sampling, the head of each swab was placed in a sterile screw cap test tube containing sterile buffered water, and the handle was broken off below any portion that was touched by the sampler. Tubes were taken immediately to the laboratory where they were placed in an ultrasonic tank and insonated at 25 kH (NASA, 1968; Puleo et al., 1967a; Puleo et al., 1967b). After insonation, portions from each tube were plated with appropriate media. In order to eliminate airborne contaminants, all laboratory procedures were performed in a horizontal laminar flow clean bench. Complete details of the sampling procedures are described in NASA Standard Procedures for the Microbiological Examination of Space Hardware (NASA, 1968).

Surveyor spacecraft were the first U.S. unmanned spacecraft which were studied. Levels of microbial contamination were determined on Surveyors 2, 3, 4, 5, 6, and 7. A total of twenty sites (80 square inches) were examined for the presence of microbial contamination at various periods throughout assembly and testing. The mean number of viable microorganisms residing on a unit area of the spacecraft surface was obtained for both bacterial spores and vegetative cells, and this is shown in Table I.

Since there is a possibility that microorganisms from the surfaces of the shrouds and adapters could be transferred to the Surveyors' surfaces after being released by