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SUBJECT: Optical Contamination in Space: A Program for Decision - Case 105-5

DATE: March 5, 1970

FROM: A. C. Buffalano

ABSTRACT

Is the optical environment of a manned space station going to interfere with scientific experiments? Will the ATM scientific instruments have to be covered during "dirty" periods of a spacecraft day? At this time insufficient data exists to answer these questions and, since only a little more data can be obtained before the DWS-I mission, the decision to uncover the ATM instruments will be made on the basis of a) the little data available before the flight, b) data returned in real time from the contamination experiments on DWS-I, or c) considerations unrelated to the environment.

Once the scientific instruments are uncovered they too become, in a sense, contamination measuring devices. In this memorandum we show the decision making process which will follow this event on DWS-I whether or not significant contamination related failures occur in the scientific instruments.

In either case, an optical environment handbook should be prepared for use by future experiment designers. Such a document would contain estimates of contamination levels and models of the environment based on a synthesis of manned and unmanned spacecraft experience.

Small, inexpensive, real time contamination monitoring devices seem most desirable in the post DWS-I period. These are being developed at Marshall Space Flight Center under the direction of James Dozier, chairman of the Contamination Control Board. This development might be reflected in the present NASA Space Station Study (Phase B). In this study the DWS-I contamination instruments are simply being reconfigured, but it does not seem likely that they will actually be required.

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MEMORANDUM FOR FILE

Introduction

Is the optical environment of a manned space station going to interfere with scientific experiments? Will NASA be forced to restrict observations to 'clean' times of the working day? Or is the problem a red herring which will go away after the successful operation of the first AAP Dry Workshop (DWS-I).

During the last few years more heat than light has been generated over this question because hard engineering data is unavailable. We do know, however, that the spacecraft leaks and outgasses, that paint and dust float off the surface, and that waste water dumps produce large clouds of particulates.

NASA is presently planning to quantify these observations by performing several contamination experiments which should establish the light scattering and debris deposition levels during the DWS-I mission. (In this memorandum we will differentiate contamination experiments from scientific experiments as follows: a contamination experiment's primary function is to measure a spacecraft environmental parameter while a scientific experiment hopefully senses the spacecraft environment only as a small perturbation or "noise" superimposed on the object of scientific interest).

Apollo Applications Program

At present, the questions above cannot be answered with the available data. Furthermore, only a little more data can be taken in the Apollo program before the flight of DWS-I. Therefore, the decision to uncover the ATM instruments will be made on the basis of a) the little data available before the flight, b) data returned in real time from the contamination experiments on DWS-I, or c) considerations unrelated to the environment.

However, as long as the ATM instruments are exposed the decision making process shown in Figure 1 will follow.

If no significant contamination related failures occur in the scientific instruments or if only small interference is experienced, the contamination problem will be bounded. An analysis of the contamination measurements and the noise in the scientific instruments due to the environment should be organized into a document which would catalogue the known characteristics of the spacecraft environment and be made routinely available to future experimenters. Additional material would be added as it became available.

Further contamination measuring experiments would probably be unwarranted since the environment is not itself an object of scientific interest. This does not mean that additional data is undesirable but rather that new information is probably best obtained by analyzing the noise of scientific measurements rather than by flying more sophisticated contamination experiments. It is crucial to understand why this is so. In the absence of failures or interference on DWS-I, the only justification for flying a device to measure some new environmental parameter is that the measurement will be necessary in support of a future scientific instrument. The measuring device must involve a total mission cost significantly less than the scientific instrument's and be available for flight sooner (in the same program) and be as sensitive as the actual scientific instrument or clearly NASA could simply fly the scientific instrument to see what happens. While the author does not contend that it is impossible that some experiment for a future manned space flight might justify such a preliminary measurement, it does seem unlikely because:

a) DWS-I carries a representative set of scientific experiments. If these are successful, the future working premise will be that similar instruments will also succeed.

b) As the benefits of a shuttle reduce the cost of experiments by providing the capability for maintenance, repair, and updating, the advantage of an "insurance" measurement decreases.

c) As more experiments are run successfully, the additional data they provide about the environment reduces the probability that some vital information will be missing in the design stage of the next instrument.

d) The most directly applicable and credible environment data is obtained from an instrument similar to the one to be flown. But similar instruments, whether for contamination measurements or scientific use, have similar costs and similar lead times so that there will be real justification for simply flying the scientific experiment. There will be no cost benefit from flying a preliminary instrument.

If failures occur on DWS-I, the second decision point will be reached. First, it might be possible to reduce the source level by making spacecraft changes. Second, unless the environment is catastrophically damaging it might be necessary to restrict observations to relatively clean times of the spacecraft day. This will require the deployment of contamination monitors which are different from contamination experiments in that they operate continuously to monitor critical environmental parameters. Based on the failure modes and the number of experiments involved it will be necessary to decide whether it is less expensive to build an environment monitoring subsystem into the spacecraft for common use by all experimenters or to provide each affected experiment with a monitor of its own. If the failure modes are unrelated, it is likely that separate monitors would be economical. If many instruments are affected or if monitoring a few parameters is sufficient, deployment of a subsystem might be desirable. Such a system might involve continuous, in situ measurements of light scattered from particulate debris around the spacecraft or the rate at which material was impacting the spacecraft surface. These parameters would be displayed in the spacecraft where the astronaut would compare the levels with acceptable levels specified in advance by each experimenter.

The 'Blue Book' Study*

In this context one inadequacy of the present Space Station 'Blue Book' becomes apparent: contamination experiments are included in the payload recommended for the study. These experiments are versions of the DWS-I contamination experiments reconfigured for the Space Station. But clearly if any contamination oriented program is justified in that time frame it will be a real time, in situ monitoring program quite unlike the present DWS-I program. Photometers, mass spectrometers and quartz crystal microbalances will be desirable, not sample exposure racks requiring sample return and analysis on the ground. The detectors would not be operated through an airlock on a part time basis as on DWS-I. These fundamental differences are being entirely ignored in the present study even though monitoring instruments of this type are now being developed and evaluated by the Contamination Control Board under James Dozier at MSFC.

*Candidate Experiment Program for Manned Space Stations (Phase B)

Recommendations

1. Whatever the results of the DWS-I flight, a comprehensive document giving the likely environment of the spacecraft will be required for future experiment designers. This document would be based on the accumulated experience of manned and unmanned space flights and should be continually updated. Data should be organized so as to permit designers to calculate upper bounds on contaminant levels and scaling criteria should be established to allow extrapolation to new spacecraft.

2. A special effort should be made to obtain whatever environmental data one can from successful scientific experiments. Doing so reduces the probability that special hardware will have to be flown at a later date. This effort should begin immediately with Apollo flights. As shown in Figure 2, the DWS-I program should answer many important questions. However, it will return no data at all on the molecular environment of the spacecraft. This makes it extremely important that the mass spectrometer scheduled for flight on Apollo 16 be used to provide this data. Similarly, photography on Apollo missions can be used to determine if a continuous cloud of large scatterers surrounds the spacecraft. There are other experiments presently scheduled for flight in the Apollo program whose "noise" could provide valuable contamination data. This opportunity to increase the available data before DWS-I should not be wasted.

3. NASA should emphasize the development of small, inexpensive, real time, in situ contamination monitors. As suggested by the Ad Hoc Committee on Space Contamination, NASA should adopt the attitude that contamination monitoring is a housekeeping chore if it is required at all. It is certainly not an object of scientific interest. It is not "Airlock Physics".

4. During the present Space Station study, active consideration should be given to the design of in situ, real time contamination monitoring systems, since these are the devices which will probably be required.

5. NASA should serioulsy consider the addition of quartz crystal microbalances to T-027 on DWS-I. Unfolding temporal data on contaminant fluxes will be very difficult unless a real time device is added.

A. C. Buffalano

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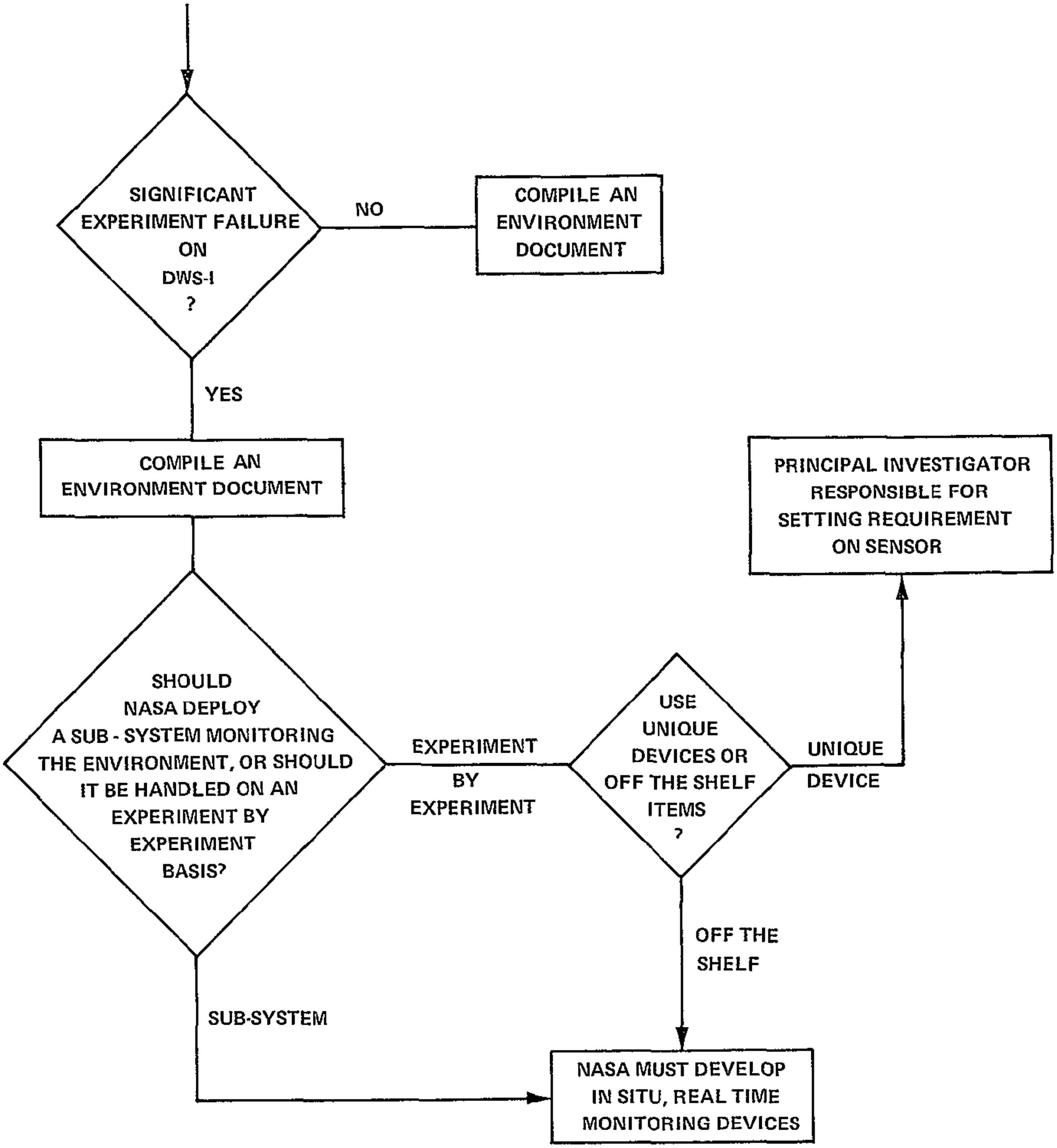

FIGURE 1 - DECISION TREE

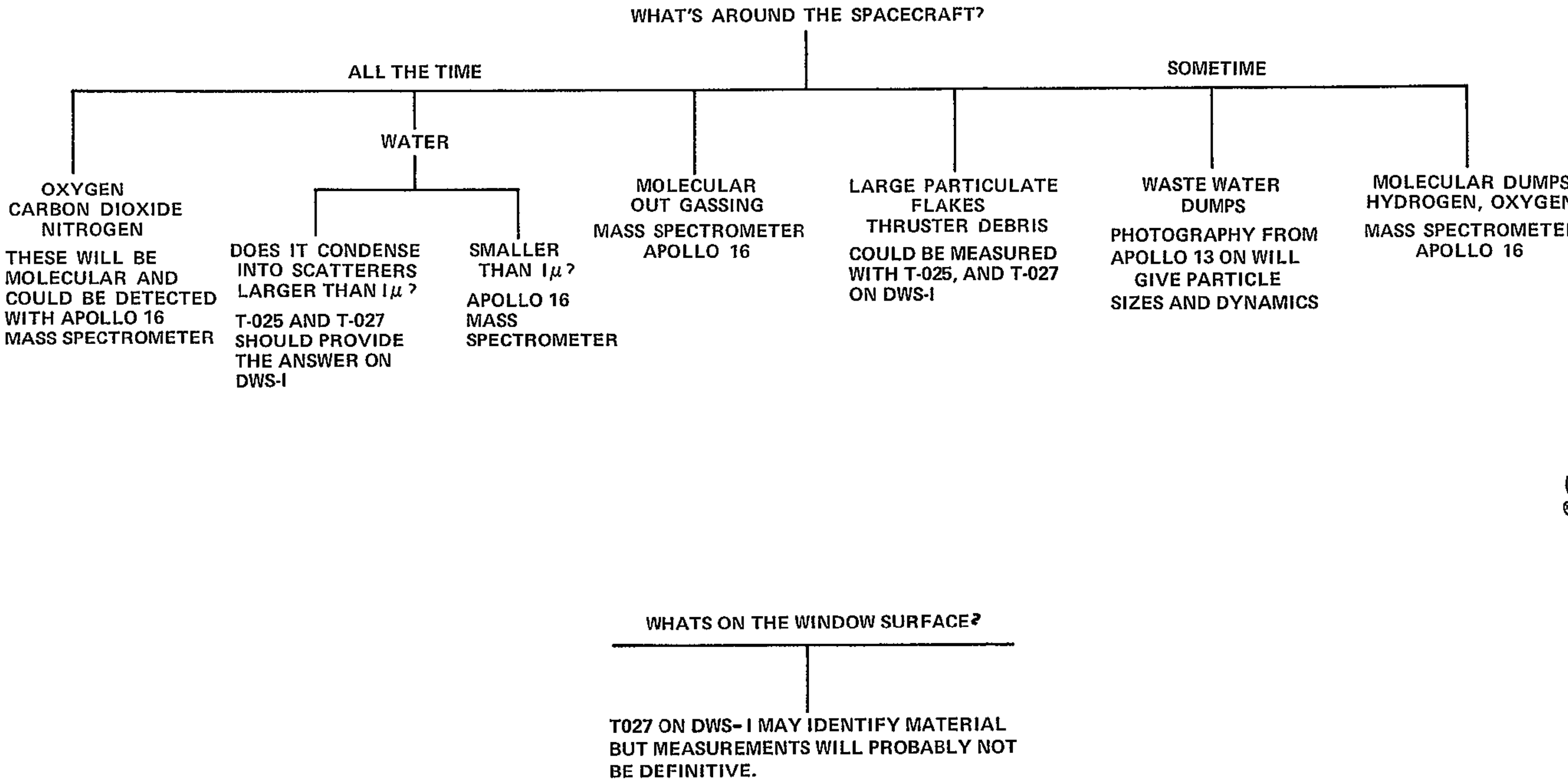

FIGURE 2 - DATA TREE

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From: A. C. Buffalano

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