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CHAPTER IV

FUTURE OUTLOOK AND COMMENTS

INTRODUCTION

In this session of the Shuttle Environment Workshop Proceedings, the events of the Workshop Panel sessions are summarized and a synopsis of the future of the Shuttle and the Shuttle environment is given.

This workshop was organized by the NASA Office of Space Sciences and Applications (OSSA). This office is responsible for making use of the shuttle. It does not build it. Thus, the experimenters and users work with OSSA to use the shuttle that is being built by the Space Flight Office. The Office of Space Science and Applications represents investigators and users - a most important group because it is their requirements and their needs that drive our work.

During the Workshop, there were Panel sessions in the IR, UV, and Space Plasma areas. These Panels represented the experimenters in these technologies. These Panels discussed what is happening with the Shuttle, what it means for users, and what kind of activities NASA will be doing in future missions.

The recommendations from the Shuttle Environment Workshop will be sent to those who can make decisions. It may not mean you will get full satisfaction, because decisions of this type usually cost money and money is limited. NASA does not have unlimited funds but within the funding limits, NASA will do the best it can.

In the following paragraphs of this chapter, comments and future projections in a number of areas addressed during the workshop are presented. The material is taken from transcripts of individual remarks made in the final workshop session. The subjects and authors are:

- Environmental Measurements - L. Leger, JSC
- Contamination Effects - E. Miller, MSFC
- Orbiter Constraints on Deployable Payloads - R. Brown, JSC
- Documentation and Environmental Information - R. Colonna, JSC
- Ultraviolet Experiments - T. Gull, GSFC
- Infrared Experiments - W. Hovis, NOAA
- Plasma Experiments - R. Williamson, Stanford University
- Shuttle Lidar - T. Wilkerson, University of Maryland.

The following paragraphs indicate what the Shuttle future may hold.

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ENVIRONMENTAL MEASUREMENTS

In summarizing the environmental measurements made on the Shuttle, it may be stated that NASA was surprised by the oxygen effects on surfaces, and the resulting effects in orbit. These effects confused the basic intent of trying to find contamination from the vehicle and, in fact, may be classified as a contamination that needs additional definition. However, NASA feels the measurements that have been made to date constitute a very significant data base in terms of measuring the environment on the Shuttle.

It should be noted that during the previous flights of the Shuttle, not all environments were measured. However, the specific parameters that are needed for payload development and decision processes and what needs to be done in the future have been characterized by the basic measurements that were made. The OSS measurements indicate that for quescent periods, background light levels comparable to the galactic background can be achieved. The OSTA-1 payload provided a good indication that we have a very good vehicle from an Earth resources measurement standpoint.

Although the data obtained from all the measurements represents a very sizable data base, we cannot, within the period of four flights and within the constraints experienced, identify whether or not there is a background around the vehicle that might interfere with optical measurements that are critically sensitive to the opposite ends of the spectrum, i.e., UV and infrared. Over the next ten or twelve flights, NASA should continue to define the environment and at the same time try and understand the Shuttle environment's behavior, its development, and its characteristics.

Through that timeframe, the utilization of the already planned payloads is one way to augment the original measurements. However, there are some exceptions. For example, the problem of the oxygen effect on materials will require special studies and is being addressed at this time.

The other item of concern to experimenters is that they want orbiter data for assessment of their missions. Ways are being developed to provide this kind of information in an expedient fashion to payloads in the near future.

In the interim, we have to answer questions such as: what are the vernier control RCS systems doing to IR measurements, UV measurements? With that definition, it is hoped that we can operate the vernier system within a very reasonable mode acceptable to both the remaining portion of the vehicle and payload and get significant measurement times without perturbations by any vehicle-induced parameter.

With the additional ten flights, the perturbation in that environment should be defined. Hopefully, the users will find that verniers will not perturb their UV experiments and that the perturbations on the IR will be identified. We also hope to control contamination so that we can use the vehicle as it was really intended to be used and concentrate on making the scientific measurements, rather than concentrating on taking contamination measurements which have been a major consideration in the first four flights.

CONTAMINATION EFFECTS

The IECM experiment carried on the Shuttle was an instrument specifically designed to characterize the environment generally, whereas the scientific instruments that will be flying in the future will have the capability to measure their specific contamination requirements.

Examples of this have been seen in the OSS-1 mission where the electromagnetic environment payload which took excellent electromagnetic environment measurements. Another example is the infrared telescope where, initially, MSFC tried to get a similar instrument onboard as part of the IECM, but due to the cost, it was decided to wait until an infrared telescope was flown. The Infrared Telescope (IRT) selected for the Spacelab 2 mission will provide the best contamination measurement from the standpoint of the requirements of an infrared telescope. Other instruments, such as the UV instruments on the Spacelab 1, will provide similar specific UV contamination information. It should provide much better data than the IECM.

While the Shuttle environment and cross contamination are major concerns, experimenters should not lose sight of the need to maintain contamination control while the instruments are being built. The Space Telescope is a good example where studies have been performed that say the Shuttle environment will contribute very little to the Space Telescope contamination throughout the launch and deployment. However, the inside of the Space Telescope itself could cause a big problem, so they are having to select and process these materials very carefully. We expect that they will do a good job so that it will survive its own contamination. Thus, principal investigators should not lose sight of the need to clean up their own instruments.

ORBITER CONSTRAINTS ON DEPLOYABLE PAYLOADS

From the orbiter standpoint, NASA is trying to accommodate each experimenter's requirements, even though it may not be apparent. JSC has established a few constraints and requirements for the payload which are basically for the deployable type payloads.

These constraints are what NASA feels are necessary for making up the payloads, and for accomplishing a particular mission without having to juggle payloads each time a new deployable payload comes onboard.

The constraints that have been placed on deployable payloads are: (1) instruments have to be able to tolerate the Sun in the bay for 30 minutes and, (2) instruments must point in deep space for up to 90 minutes. The majority of the time, or the rest of the time, the missions will be flying in ZLV (Z Axis, Local, Vertical) or payload bay down towards the earth, which is the most benign attitude that is acceptable with deployable type payload.

For the majority of the experiments that will be flying on sortie-type missions, they will be looking at a fairly benign environment, if it is flown with a deployable payload.

The temperature for the ZLV in the payload bay is running anywhere from 0 to 20 degrees Fahrenheit, unless there is a lot of power dissipated right in the particular payload.

An example of the things that the orbiter will be doing for an operational mission is the STS-6, which will fly the Tracking and Data Relay Satellite (TDRS). NASA has accepted a constraint of a maximum of five minutes of Sun in the bay during that mission at any given time. For this mission, some specific maneuvers will be made to keep the Sun out of the bay.

In summary, it should be noted that during the operational timeframe, NASA will be working with the payloads trying to match the mission with a payload that is compatible with the experimenters' requirements.

DOCUMENTATION AND ENVIRONMENTAL INFORMATION

There has been a thread of continuity from manufacturers, users and scientists in the requests that have been made of the STS, particularly for a readily available data base for various types of information. However, from each of the three different groups, there was a slightly different variation on the type of data required.

Another common request is for a simplification of the documentation process and total integration process.

To respond to these two requests, two actions are underway. JSC has initiated very positive actions: the Mission Integration Office has started an activity to review the integration process in detail and will attempt to combine and simplify the documentation requirements. There is an attempt to combine a number of the document annexes so that instead of having nine, there will be only four or five. Hopefully, as time goes on, there will be less than four.

JSC has also begun work to create an STS Customer or User Service Center. One of the major activities is to provide a source for a uniform set of data for all the users. This will be the place to go to ask questions.

The intent is to provide an answer to all of the requests in terms of providing documentation. These activities have been started, and we hope to have them in place in the very near future.

ULTRAVIOLET EXPERIMENTS

The use of the Shuttle in the UV astronomy area will develop mainly in two directions that are very compatible with each other.

(1) The first direction is that, as new experiments are developed, the Principal Investigators want to test them. In the past, tests have been made on rocket payloads which are very, very short - 100 seconds or a few hundred seconds. This is not enough time. The prospect of having days or weeks to fly in the Shuttle payload is most exciting and interesting.

It is hoped that in the future, as we go through the Spacelabs and the OSS series, operations on the Shuttle can be simplified to the point of where, although they are more complicated than with rocket payloads, they are a lot less complicated than satellite operations, from the standpoint of getting launched and becoming operational.

(2) There is a large community that will be using the Shuttle in the future to test new concepts in UV astronomy, X-ray astronomy and solar physics. There is an even larger community, throughout the world, that has great interest in using facilities that NASA will be building, placing on the Shuttle, testing them out and eventually putting them on platforms and free flyers. That is the direction in which the major facilities in astronomy will be going.

That is exactly where the Space Telescope is heading. It is exciting to realize that in just a few years there is going to be a large telescope in orbit, and we expect it to last 10 or 20 years or more. It will be a major thrust in the field of astronomy.

An analogy to this is the International Ultraviolet Explorer. The IUE was launched in January, four and a half years ago. At the time, there was not as much interest in the community as eventually came out. Four and a half years later, that satellite is operating beautifully.

In the IUE, it took several years to see any degradation in terms of sensitivity in the detectors. We may be seeing 5 to 10 percent in one of the detectors at this time. The greater concerns are keeping the gyros going long enough to observe for another five years. Credit should go to the international team that is assembled in Britain, the European Space Agency, and NASA.

Success can be measured by the realization that the data from the IUE have been disseminated to astronomers throughout the world in a very well coordinated guest observer program. Over a third of the astronomers throughout the world have had access to those data, and the number of publications coming out of IUE keeps increasing.

This is the community that we, as Shuttle users and potential users, should be addressing. We need to be anticipating what is the experiment that is going to occur five to ten years from now that the community can use to forward research in the new frontiers of astronomy at that time.

The OSS-3 mission is one that we are working on in the meantime. We are going to be working with direct imagery in the ultraviolet, going to limits far exceeding anything previously expected, and doing polarization measurements, probing the extreme ultraviolet from 900 angstroms down to perhaps 400 angstroms, to find out how far we can see within our galaxy, and beyond.

As we learn from the OSS-3 experiments, we will be designing new experiments, new satellites and concepts that will be tried out first on the Shuttle, and then eventually made into a free flyer or put on platform. An example is the Solar Optical Telescope that is intended to be on the Shuttle by 1988.

A one-meter aperture telescope called Starlab has been studied for the past seven years. The Canadians and Australians have now joined the US, and an agreement is being worked out in which the Canadians will build the telescope so they can learn the technology and get involved in space. This is their major program in astronomy in space. The Australians have offered to build the instrumentation. They have been doing research for several years with ground-based telescopes. They recently obtained a major funding of $2.5 million over the next few years to go into the Phase B studies of the instrumentation. This is their major astronomy space program for the next decade. The US is being asked to put this on the Shuttle, but we really want to put it on the platform. This is one of the instruments we want to see placed on the platform and used in orbit.

There are other instruments being studied that will be coming through in the near future. The far ultraviolet is becoming the last frontier in astronomy. In the spectrum between 100 angstroms and 900 angstroms, there is very little information known at this time, and the community is getting more and more interested in what can be done.

This community can be supported in the future with experiments first tried out on Shuttle, and then by satellites that are brought up and put overboard either to go into regular orbit, or perhaps geosynchronous orbit.

INFRARED EXPERIMENTS

It should be realized that the Shuttle offers an opportunity to do things that have never been done before. In the past we had to live in a 10 by 10 space, but now with the Shuttle, we have much more room. It will take a while to realize the freedom. We have worked with spacecraft having typically a ton of weight, 500 watts of power, for so long, it is hard to believe that things can get bigger. What can be done with the Shuttle?

One possibility is the assembly of large collectors in space. We are limited now in microwave measurements by diffraction effects to no better than 25 or 30-kilometer resolution for all weather measurements. With the Shuttle, we will be able to assemble collectors from the Shuttle hundreds of meters in size. In the future, we expect to do that.

Also with the Shuttle, we will be able to make important atmosphere-free measurements. We are awaiting the measurements of the solar spectral radiance that are going to be made by the European team on Spacelab 1.

Astronomy done in orbit is free from atmospheric limits, and in this area we will be growing by leaps and bounds.

Another area where the Shuttle will contribute is in justifying flight of active sensors such as lasers. People keep asking, Can you prove they work? The lowest power laser that is worth flying consumes about 2000 watts. Standard spacecraft today have 500 watts of power. At present, we cannot prove that lasers work from spacecraft, but we can certainly prove it from the Shuttle. The Shuttle will provide the means for flying bigger satellites, since there is now a way for launching them.

Another exciting thing is the ability to retrieve the experiments or the material from space, such as will be the case with the Long Durational Experimental Facility (LDEF) that will be in orbit a year before it is recovered. This will bring back material from the Shuttle itself, and lead to better designs of component reliability. From an experimenters standpoint, it has been maddening for 20 years to have the experiments go bad and not be able to get any closer than 600 miles to find out what went wrong with the instrument. The Shuttle enables us to get our hands on the experiments that have actually flown, to see what happened in space.

The Shuttle also offers the opportunity to re-excite the American people the same way as the first Explorer did. We should take advantage of that opportunity and get back the support of the American people for these major and important expeditions.

PLASMA EXPERIMENTS

From our previous flight experience, we found the orbiter to be a very good platform for conducting active experiments. During the OSS mission, we obtained science results and looked at the environment of the orbiter. Although these scientific results were not reported here, the fact that these experiments could be conducted is a demonstration of the capabilities of the orbiter within the environment.

We would like to know more about the orbit environment so we can do more with the orbiter. The recommendations made here are intended to make it better.

Over the next few years, a number of payloads have been identified which will be involved with the plasma aspects of the orbiter. Next month, STS-5 will fly a camera that is designed to take a look at the vehicle glow problem. There are some real problems internally in getting time line availability, even though the instrument is onboard. Although there is some time line in one night-time pass, substantially more time is needed. I feel that the time line should be expanded, or at least looked at and expanded if at all possible.

In September 1983, Spacelab 1 will carry probably the most complicated payload that will fly for many years to come. This flight will include a large number of plasma diagnostics instruments as well as active experiments.

It will include a 7.6 kilovolt, 1.7 ampere electron accelerator provided by the Japanese in conjunction with the United States. It also will include a magneto-plasmadynamic (MPO) arc jet of several kiloJoules of energy per pulse. There will be low light level television cameras and spectrometric measurements extending from the visible through the ultraviolet.

The Shuttle will also fly ion and electron accelerators for ESA experiments. A number of plasma diagnostic instruments will again be flown.

Spacelab 1 will provide a tremendous wealth of information of the environment around the vehicle, and it will give information on the plasma clouds. This flight will also produce information about the glow and about the operation of particle beams and high voltages within the payload bay area.

Spacelab 2, scheduled for late 1984, will fly a diagnostic package that will be the same one that was on OSS-1. It will be released to fly away from the orbiter, and will obtain measurements of electric fields far away and also make wake measurements.

The electron gun from OSS-1 will be on board to make measurements of the electrical charge on the vehicle and determine the nature of the dielectric surface interaction with the surrounding plasma. This information should be of substantial value in future programs.

Spacelab 6 is scheduled in the 1986-1987 timeframe. This mission has a full complement of diagnostic instrumentation and active experiments. It will refly the low light level Television Camera, and a new version of the plasma diagnostics package.

The significantly different instruments will be the WISP payload which is an HF/VLF transmitter with a long antenna. It is designed over the period of the project to go to very low frequency with voltages that approach ten kilovolts on the long antenna.

In another program, polar orbits will be begun in a few years. These will be launched from Vandenberg AFB. The Air Force has a very active program to study the interaction of the orbiter with the polar environment, specifically the energetic electron and ion beams which will bathe the orbiter as it goes through polar regions, through the auroral zone and into the polar cap. These effects deserve serious consideration, since they have not been treated in the results obtained to date.

In the distant future, solar power array modules are scheduled. These include 25 to 100 kilowatt solar arrays for low earth orbit. They also involve high voltages, dielectrics, high currents, and plasma interaction. The plans to fly such payloads really demand that we understand the interactions that we have begun taking a look at on the first four missions, specifically on STS-3.

Future space stations will be very large structures. Such large structures have not flown in the past. The physical size of large structures will give rise to higher potentials than have ever been experienced previously. We had better understand the electrical interaction of those large structures with the near earth environment, lest we have some more surprises such as the vehicle glow.

There is one system that is currently planned to be built called the Tethered Satellite System. One version of this is a long insulated wire which may have a length of 10-100 kilometers. This will certainly be the largest structure put into low earth orbit. It also can answer many of the questions about large space station structures. It extends only in one dimension for a great distance. For many of the questions that we have in plasma physics, that will be sufficient.

There is another aspect of the environment that should be treated, that might not seem like an environmental problem. That is access to data. Many of the questions that we had could have been answered in the near future through data analysis of previous missions. Some of them could have been done during preflight, given sufficient access to the information.

It is felt that the agency, at the present time, is unable to handle data in a timely manner. It is a recognized problem within the agency, and will require long-term solutions. Some of the requests that have been made, such as asking for the operational information, take continual contact to correct these problems. The problem also extends to documentation. We have continually asked for documentation, and have heard other Spacelab PIs on Spacelab 1, 2, 6 and other missions asking for documentation. They need access to it.

NASA should consider that the user community needs to have information. This includes information in the POCC, for example, of attitude and time line data; and of the position of the RMS. It is available. It is the format that is the problem, and it is a question of handling the data.

With respect to the post-mission data handling, it should be noted that we only recently received the attitude data from the mission launched March 22. This was six months late. To date we have not received data on the attitude thruster of the control jets. Regardless of the data problem, we are very pleased with our flight experience and are very pleased with what happened during our mission.

SHUTTLE LIDAR

Because there is a NASA committee concerned with the Shuttle lidar, these remarks are addressed to that general class of experiments. Shuttle lidars are very much in the future because such instruments have not yet been scheduled for Shuttle flights. In this respect, there is reason for hope and caution both.

The day of active optical systems in space will surely come. The Shuttle lidar concept refers to the atmospheric probing from orbit using fluorescence methods for the upper atmosphere and differential absorption/scattering methods for the lower atmosphere. These are the ideas that have been examined by NASA's "Atmospheric Lidar Working Group."

The ultimate goal of many in the lidar field is global monitoring by means of active systems that can do height profiling directly. There also are other applications in the Department of Defense. There is another activity in which both NOAA and NASA are very active, namely the possibility of global wind measurements using coherent Doppler lidar. The first proposal in this area was to use coherent CO_2 systems in the 10-micron range; recently there has been some discussion of using coherent Nd systems operating around one-micron wavelength. With such global wind measurements, complete flow pictures of the atmospheric circulation at different altitudes could be developed.

So there is a serious and compelling prospect of using active laser systems to measure globally the motion, constituents, and the state variables such as temperature and pressure in the atmosphere.

A fair amount of optical power, and therefore a lot of pulsed electrical power, will be required to run a true lidar or laser radar system. There is some concern by those interested in lidar measurements that this should not create problems for other Shuttle experimenters with the high current pulses running around in the spacecraft. We are quite aware of the ground loop problems that can create electromagnetic contamination problems for everybody.

We are becoming confident about it, however, because lidar systems are now being operated run in high-altitude aircraft such as the U-2 and B-57, and medium altitude aircraft like NASA's 990, P-3, and Electra. They are also being flown in heavy balloons into the stratosphere to altitudes of 30-40 kilometers. The day of "hands off" remote operations of these systems is virtually at hand.

Thus, this lidar class of instruments is an oncoming development, for a number of scientific and technical reasons. We look forward to the experimentation with these systems on the Shuttle, and ultimately to more comprehensive, long-term experiments in the future.