October 9, 1973

TESTIMONY BEFORE

HOUSE COMMITTEE ON SCIENCE
AND ASTRONAUTICS

SUBCOMMITTEE ON SPACE SCIENCES
AND APPLICATIONS

Dr. John W. Findlay
Chairman

Space Science Board Summer Study

SCIENTIFIC USES OF THE SPACE SHUTTLE

PROPERTY OF THE U. S. GOVERNMENT
RADIO ASTRONOMY OBSERVATORY
CHARLOTTESVILLE, VA.

OCT 10 1973

During the first two weeks of July 1973 at Woods Hole, Massachusetts, the Space Science Board of the National Academy of Sciences conducted a study of the Scientific Uses of the Space Shuttle. The purpose of this study was to explore the capabilities of the shuttle as a transportation system for supporting space science. The effort was focused on those capabilities unique to the shuttle, in particular its ability to carry into orbit a payload that remains attached to the shuttle and then to return it from orbit in from 1 to 4 weeks--the so-called sortie mode. Interest in the sortie is particularly great because of the recent decision by the Europeans to develop a space laboratory consisting of a pressurized module and unpressurized pallet to be carried in the shuttle bay on some sortie missions. NASA and the European space agency looked to the summer study to provide an understanding of the scientific requirements that might affect the design of the shuttle and space laboratory. The study also considered the use of the shuttle for launching, servicing, and recovering satellites and for launching lunar, planetary, and interplanetary missions.

The study did not consider the broader questions of the justification for developing either the shuttle or the space laboratory. These involve aspects of economics and national goals beyond the specific specialties of the participants. Rather, the study was concerned with the use of the shuttle and space laboratory for science, assuming that they will be developed--an approach recommended by NASA and adopted by the Academy. Some 50 U.S. and 11 foreign scientists took part in the effort, representing the scientific disciplines of Atmospheric and Space Physics; High Energy Astrophysics; Optical, Ultraviolet, Infrared, and Radio Astronomy; Solar Physics; Life Sciences; and Planetary and Lunar Exploration.

For the first half of the study, the participants worked in groups formulating the scientific objectives of their disciplines and describing scientifically desirable instruments suited to shuttle operations. During the second half of the study a working group composed of representatives from the discipline groups focused on the sortie mode while the discipline groups completed their work. Out of the study effort there emerged the following findings which, together with the complete report, have yet to be reviewed by the regular Academy review process and may be modified by that review:

1. The shuttle can be an important asset to scientific research in and beyond the 1980s. All discipline groups in the study found aspects of the shuttle capability important to their science. Each made specific recommendations in its report about scientific needs and, in some cases, about the shuttle characteristics and modes of use.

2. An important aspect of the shuttle system for science will be its ability to carry many large and heavy payloads into orbit with potentially substantial economies. Of all the changes that the shuttle may bring to space science, the increased size and weight of the payloads that can be orbited with the possibility of reducing costs by simplifying design and construction, and the possibility of a high rate of launch were singled out.

3. Many of the potential advantages of the shuttle depend on the development of efficient and flexible procedures for flying multipurpose missions and combined payloads. Most discipline groups found a need for shuttle missions entirely dedicated to their own science but also recognized the potential savings associated with missions with multiple objectives. The study identified some problems of instrument design and integration and, to some extent, the kinds of operational procedures that will be needed for multipurpose missions. This finding drew attention to the need for simplifying as far

as possible all the steps that lie between the first concept of a space experiment and its eventual flight as a part of the shuttle payload.

4. The ability of the shuttle system to recover or service payloads in orbit will be of special value for large and expensive systems such as large observatories; for some less expensive payloads the economic advantages of recovery and of possible servicing are unclear. The importance of recovery and service of payloads placed in orbit is frequently emphasized. However, if smaller, cheaper orbiting spacecraft are considered, advantages are less clear; it may be that incompatibility of shuttle and spacecraft orbits will make visits too costly. Limits of down-payload capacity may also restrict recovery. The economics of payload recovery and servicing must be studied further.

5. Most planetary missions can be launched with a Shuttle/Centaur system. Some missions identified for the 1980s require additional capability such as might be provided by Tug, solar electric, or some other advanced propulsion system.

6. For biomedical research in space, the study identified a clear and essential requirement for the use of the manned pressurized space laboratory.

7. Many disciplines require rapid interaction between man and payload. This function appears to be adequately fulfilled in many cases by the payload specialist and his console. However, for some experiments, in atmospheric or space physics in which continuous involvement of man is required, the pressurized space laboratory is highly desirable. The need for man is present, to some extent, in all disciplines. In high-energy astrophysics it is perhaps the smallest, and biomedical research the greatest. It was the opinion of many study participants that the presence of a payload specialist in the

shuttle orbiter could serve their needs. However, this depends on the amount of his time available and on the degree to which it is possible to use the payload specialist's console as an experiment control center. For some experiments it is possible to have scientists either in a space laboratory or on the ground linked, by a high-data-rate real-time system, with the payload. The latter implies the existence of capabilities similar to those suggested for the proposed independent tracking and data relay satellite (TDRS). The study participants realized that such a TDRS is only in the planning stage and see the need for further work to clarify how realistic this option is.

8. The ability to operate instruments mounted in the shuttle bay, the pallet mode with or without a pressurized laboratory, is an important feature for all disciplines except the life sciences.

9. Payloads carried into orbit by the shuttle and then released as free flyers are major elements in most discipline programs. Most disciplines identified major programs requiring observing times considerably in excess of the 28 maximum duration envisioned for sortie missions; the most cost effective way of carrying out such programs is by using free flying automated spacecraft.

10. For most discipline groups the 28-day sortie mission duration (or even longer if possible) is judged to be very valuable.

I want to emphasize that this study was a first effort. For one thing it did not consider earth-oriented and applications studies, which might well be the subject of a study of the same general character as the one just concluded. Further work would also be desirable in the scientific disciplines--in particular, planetary and lunar exploration for the period after 1980.

The immensely successful Skylab mission has made it abundantly clear that man can play an extremely significant role in space science. Exploring the nature of that role was one of the central concerns of the summer study. The problem centers around the weight of the spacelab needed to provide working space for men in addition to the crew; this weight may place limits on the scientific payload to be carried on some missions. In addition, the 1- to 4-week duration of manned shuttle missions is considerably less than the time that many scientific programs require; such programs are most easily and inexpensively accommodated by unmanned free-flyers.

The life sciences require man working in the shirtsleeve environment of a spacelab module. Other disciplines, if they require a pressurized module at all, would make use of a smaller module than would the life sciences. There is some difficulty in deciding whether real-time control and evaluation would be better supplied from a ground-based scientific group rather than from scientists carried in flight. If a communications system from the shuttle to ground, giving continuous global coverage with a high rate of data interchange, were available, together with a well-designed data reduction and command facility on the ground, then ground control might be preferable to carrying a manned spacelab. This question requires detailed study.

The overall scale of shuttle space science and the proportions of shuttle opportunities which will go to various scientific disciplines can only be established when the magnitude of resources available and a realistic model of shuttle operations becomes more clear. A reasonable range of models will have to be constructed and used for the first planning of scientific missions. This planning will bring to the forefront priority choices which must be faced in the near future. We can already see the need for a significant effort in supporting research and technology to develop payloads for shuttle missions and to enable us to better understand the costs of space science in the 1980s.

The hope that shuttle-borne science would be considerably cheaper and easier to fly than conventionally launched space science was present throughout the study. The first requirement for lower cost shuttle science is a design and management philosophy that provides maximum scientific flexibility and mimumum restrictions and documentation. Many of the steps to be taken are clear for payloads that remain attached to the shuttle throughout the missions. It should be possible to set design and test criteria for flight hardware, and to use a management system similar in scope and pattern to those used at present for rocket-launched payloads which are very low in cost in comparison with satellite payloads. Mounting, pointing, and other systems can be developed in a single form to serve many purposes. For systems which are common to several different experimental packages, it should be possible to develop commercial units which are qualified for shuttle use.

The reduction of overall costs in payloads which are separated from the shuttle is a more complex question which requires detailed cost-effectiveness studies. A very sophisticated large space telescope is worth the cost to re-visit and service or to return to earth. But is this true for a considerably less expensive free-flying telescope? How do the costs of re-visits depend on the overall shuttle flight pattern? Can there be compatibility between the orbits needed for free-flying scientific experiments and those orbits which the shuttle will use for entirely different missions, missions on which the shuttle might have spare capability to re-visit or recover the free-flyers? Such questions must be answered before the choice of the cheapest and best ways of flying scientific missions can be answered.

In summary, the study found that the shuttle will have many capabilities of great value to space science. It will provide opportunities sufficiently different from the ways in which we now do things that they demand innovations in management and execution if we are to minimize costs and realize the full benefits of this new space transportation system.