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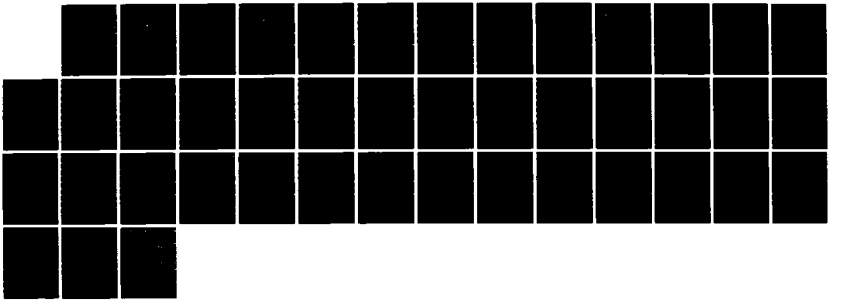

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STUDENT REPORT

STS EXPERIMENT SUPPORT STRUCTURE NEEDS ASSESSMENT

MAJOR WALLACE A. BEAUCHAMP 86-0230

"insights into tomorrow"

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The DOD space-based research and development program has a growing dependence on the Space Transportation System (STS). A shortfall in STS experiment support structures impedes the flight of the DOD payloads. This study looks at the existing support system from a management perspective in order to develop a procurement strategy for additional experiment support structures. The study concludes that a major problem is the existing NASA manifesting system. It recommends procurement of a flexible support structure and increased inventories of NASA sponsored carriers. The increased support includes funding for additional hardware and manpower for NASA.

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PREFACE

The purpose of this study is to determine the necessary equipment procurement actions and procedural changes needed to ensure the DOD space-based research and development program needs are met. It was done at the request of the DOD Space Transportation System Program Office due to their concern over the growing problems in getting DOD R&D payloads onto the shuttle. The study approaches the problem from a management rather than technical standpoint. This is due to the perception that the major difficulty is getting access to the STS and related support equipment rather than a deficiency on the part of existing experiment support structures. The intent of this study is to provide a framework for procurement actions by the STS Program Office.

One of the difficulties faced in conducting the study is that much of the information pertinent to the subject is undocumented. The STS is a relatively new system and many of the procedures, especially administrative, change as experience is gained. Unfortunately, the documentation lags behind the changes. The author, however, was the DOD representative on the National Aeronautics and Space Administration's Flight Assignment Working Group for two years and was present at many meetings where these procedures were discussed. Much of the material used in this report was learned in these meetings. However, to ensure accuracy, data for which no documentation exists was verified through individuals currently working in the STS Program Office. These individuals are cited in the report.

ABOUT THE AUTHOR

Major Wallace A. Beauchamp was commissioned in October 1973 following graduation from Officer Training School. He attended Undergraduate Pilot Training at Columbus Air Force Base, Mississippi, and received his wings in January, 1975. After completing Pilot Instructor Training, he returned to Columbus as a T-38 Instructor Pilot. While at Columbus he also served as a Class Commander for US and foreign students. In 1978 Major Beauchamp joined the 6594th Test Group, Hickam Air Force Base, Hawaii, as an HH-53 pilot. He also worked in the Satellite Operations Division as a recovery mission coordinator. In 1983, Major Beauchamp was transferred to Headquarters Space Division, Los Angeles, California. Assigned to the Space Transportation System Program Office, he held positions as the Chief, STS Utilization Planning, and Director, Spaceflight Requirements.

Major Beauchamp is a Senior Pilot, and also wears the Senior Space Badge. His military education includes Squadron Officer School and the Space Operations Officer Course. He has a bachelor's degree in psychology from Millsaps College, Jackson, Mississippi, and a master's degree in counseling from Mississippi State University. Major Beauchamp is married and has two children.

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Part of our College mission is distribution of the students' problem solving products to DoD sponsors and other interested agencies to enhance insight into contemporary, defense related issues. While the College has accepted this product as meeting academic requirements for graduation, the views and opinions expressed or implied are solely those of the author and should not be construed as carrying official sanction.

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REPORT NUMBER 86-0230

AUTHOR(S) MAJOR WALLACE A. BEAUCHAMP, USAF

TITLE STS EXPERIMENT SUPPORT STRUCTURE NEEDS ASSESSMENT

I. Purpose: To develop a procurement strategy for one or more experiment support structures to ensure the legitimate needs of the DOD R&D community are met.

II. Problem: The DOD space-based R&D program is growing, especially with the advent of the Strategic Defense Initiative. However, the Space Transportation System (STS), which flies many of the R&D payloads, is not able to support all the traffic. Consequently, the DOD is interested in purchasing additional support equipment to help alleviate the shortfall in the STS system.

III. Data: The support available to R&D payloads has grown with the STS itself. Today there are 20 or more experiment support structures available. These structures provide the majority of the support to DOD payloads. The DOD is sponsoring a wide variety of experiments, and will probably continue to do so, although the nature of the experiments will most likely change. The change, associated with the Strategic Defense Initiative, will probably be toward increasing complexity and size. The National Aeronautics and Space Administration has developed an infrastructure to support the R&D community. Associated with the support are a manifesting system with two separate priority systems — one for primary payloads and one for secondary payloads. In addition they have developed an integration system which favors

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simplicity, and a set of in-house experiment support structures optimized for simplicity. The DOD has also developed an organizational structure to support R&D payloads. The Space Test Program and the STS Program Office both have responsibilities to provide generic equipment, experiment and payload integration, and manifesting support. Overall, there is an extensive support structure available to the DOD researcher. However, the infrastructure is as much a problem as anything else.

IV. Conclusions: The major impediment to DOD space-based R&D is the NASA manifesting and integration systems. The strategy to procure any structure must take this into account. In addition, the DOD must implement an overall priority system to ensure efforts to get DOD R&D experiments into space are appropriately directed.

V. Recommendation: The DOD should purchase a carrier flexible enough to satisfy a wide variety of existing experiments and the increasing complexity expected in the future. In addition, the DOD should support existing NASA programs to ensure adequate resources are available for DOD needs. Finally, the DOD should implement an overall priority system.

Chapter One

INTRODUCTION

After 22 flights (as of 15 November 1985) the United States' Space Transportation System (STS) has proven to be a workhorse in regards to its ability to support basic research and development (R&D) experimentation. Over the course of these flights hundreds of experiments supporting basic and applied research and development have been conducted, including 76 separate experiments on mission STS 61-A (3:24). A review of the National Aeronautics and Space Administration's (NASA) STS manifest reveals that the future will hold to the same course. For example, NASA scheduled 36 R&D type experiments, mostly small payloads, on the four flights following STS 61-A (9:6). They have scheduled opportunities for small experiments on 20 of the 46 missions to be flown between November 1985 and July 1988 (9:—). However, the number flown so far lags far behind the demand. There is a tremendous backlog of R&D experiments due to the numerous delays incurred by the shuttle system since it became operational in 1983 (25:—). As a major sponsor of R&D payloads, the DOD is concerned over this aspect of the program (23:—). One suggested way of alleviating the problem within the DOD is to increase the DOD inventory of experiment support equipment to ensure sufficient assets are available for critical research. This study addresses this issue.

There are two ways to approach the question. One is from a purely technical standpoint. That is, the experiment requirements are characterized and compared to the capabilities of the existing experiment support structures. The structure, or structures, best meeting the requirements of the experiments would be purchased. If no structure met the needs, modifications would be recommended. This was the initial approach taken in this study. However, it was found during the initial stages of this study that simply meeting the needs of the experiments by purchasing equipment was not the solution. The experiment/experiment support structure combination would exist within the DOD, but it couldn't get on the shuttle. The problem appeared more management in nature, and that is the focus of this paper.

The Space Transportation System is very young. As it grew, equipment, procedures, and bureaucracy grew with it. The equipment generally met the needs of the spaceflight community, but the procedures and bureaucracy have often worked against some customers. The R&D community is one of these (25:—). This study reviews the needs, equipment, procedures, and bureaucracy in terms of its effect on

the DOD R&D community. The purpose is to develop a procurement strategy to ensure the legitimate needs of the DOD research community are met by attacking the management issues impeding the flight of DOD R&D payloads. The strategy includes both equipment purchase and procedural change, as both are necessary.

The study is constrained in two ways. First, only existing experiment support structures are considered. This is mainly because the sponsor asked that only existing equipment be considered, but also because the Air Staff direction provided to the DOD support organizations can be interpreted as constraining the procurement to only existing equipment. The second study constraint is that this study is a top level look at the system. The program associated with support to the R&D community is extremely complex. This study focuses only on the management aspect. The conclusions and recommendations come from this perspective. Should the study be approached from a purely technical standpoint, the recommendation for a specific carrier might differ but the overall strategy for procurement, the main goal of this study, would still be valid.

To fully cover this issue, Chapter Two surveys the existing experiment support structure inventory and reviews the current experiment listing in terms of utilization of these structures. Chapter Three looks at the way in which NASA supports (and hinders) these payloads through manifesting, integration, and in-house managed structures. Chapter Four outlines the support and procedures used by the two DOD organizations providing launch support to the R&D community. Chapter Five covers the findings, conclusions, and recommendations.

In summary, this study focuses on the needs of the DOD R&D community in relation to access to the STS. The increasing importance of space in the national security arena (14:xi) makes it imperative that the appropriate assets be in place. However, the problem is more management than technical, and the central focus is to suggest a strategy to overcome the management problems. The first step is to look at the structures and experiments to provide a background for the discussion.

Chapter Two

EXPERIMENT SUPPORT STRUCTURES AND EXPERIMENT REQUIREMENTS

As the STS demonstrated an increasing capability to support R&D experimentation, both experimental requirements and resources available to satisfy those requirements grew. The result is a vast array of experiments and an impressive inventory of experiment support structures. In 1981, there were less than 40 experiments (22:5) requesting spaceflight support. Today the number exceeds 100 (25:--). During the same period the number of support structures dedicated to R&D increased to 20, with more under development (2:80; 4:73). (It should be noted the DOD does have two experiment support structures. However, these are dedicated to programs having long term commitments, and when available again would not meet all the needs of the DOD. For that reason they are not included in this study (23:--).) In this chapter both the existing experiment support structure inventory and the DOD payload requirements are reviewed. As stated in the introduction, this is not meant to be a technical discussion. Rather, the purpose of this review is to demonstrate the breadth of the need, and the variety of capability existing to meet that need. As will be seen, the majority of DOD R&D experiments are already scheduled to fly on a particular structure. Consequently, the experiment support structures will be reviewed first in order to provide a background for the subsequent experiment review.

EXPERIMENT SUPPORT STRUCTURES

To meet the growing needs of researchers, the number and variety of shuttle experiment support structures increased as the STS became operational. These structures (also called carriers) provide a wide range of services, from simple mechanical interfaces to free-flying, pointing and tracking capabilities. For the DOD this means an extensive capability exists to support the needs of its R&D community. In this section the current experiment support structure inventory is reviewed. To facilitate this review, the terms used in the descriptions and discussion are first defined. Then the general characteristics of four categories of carriers are reviewed, and advantages/disadvantages of each discussed. These categories were developed for this paper based on a review of the characteristics of the various carriers. All the carriers reviewed in this chapter either currently exist, or are expected to be available in the near-term (3-5 years) from either NASA or commercial sources (4:75; 19:--). In both

cases the source usually provides both the carrier and integration support (21:—). Integration is the mounting of the experiment on the carrier and the carrier into the shuttle. (The carrier/experiment combination is typically called a payload.) However, the carrier can be purchased outright, and the integration services contracted separately (21:—). With this in mind, the definitions relating to the review are offered.

Side-wall mounted structures: experiment support structures mounted along the upper side-wall of the orbiter payload bay.

Across-the-bay structures: carriers attached to each side of the payload bay and, usually, at the base (keel) of the bay.

Keel mounted structures: carriers mounted only at the base (keel) of the orbiter payload bay.

Full-bay structures (also known as pallet structures): structures lining the payload bay, allowing use of the full volume of the bay.

Mid-deck lockers: Lockers situated in the mid- and aft-deck of the crew compartment.

Mass capacity: the total payload weight a given carrier may support.

Experiment mounting area: the mounting surface or volume available for experiments.

Carrier mass: the empty weight of each carrier.

Passive thermal control: temperature maintenance using thermal control surfaces and/or blanket insulation.

Active thermal control: temperature maintenance using fluid cooling systems involving fluid loops, valves, and pumps (1:Ch 5).

The remaining terms used in the descriptions and discussion are self-explanatory. Given these terms the discussion on the four carrier classes follows.

Passive carriers: These are support structures providing only experiment mounting support and mechanical interface with the orbiter. There are eight carriers meeting this description in the current inventory (see Table 1). (The tables used in this chapter were developed using data from sources cited in the text.) These carriers provide the minimum standard services. That is, they do not have planned "pre-wired" connections to any orbiter-provided service (electrical, thermal, data), nor do they provide the service through carrier support equipment. However, at experimenter request (and cost), these services can be provided (1:Ch 5: 19:—). This is the key to the flexibility inherent in these carriers. A single carrier can be

Carrier	Mass Capacity (lbs)	Mounting Area (in)	Carrier Mass (lbs)	Location	Source
1. Adaptive Payload Carrier (APC)	300	14 x 36	19	Side-wall	Commercial
2. GAS Adapter Beam	600	24 x 36	175	Side-wall	NASA
3. Bridge Payload Carrier	1000	24 x 40	150	Side-wall	Commercial
4. Extended APC	1000	24 x 43	76	Side-wall	Commercial
5. Delta Keel Payload Carrier	2000	24 x 40	150	Bay keel	Commercial
6. Capacity of Opportunity Truss	2730	81 sq.ft.	850	Across-the-bay	Commercial
7. Developmental Flight Instrument Carrier	7500	180 x 132	2000	Across-the-bay	NASA
8. Mission Peculiar Support Structure	5000	180 x 40 x 28	1200	Across-the-bay	Commercial

Table 1: Passive Experiment Support Structure Characteristics.

used on one mission to simply mount an experiment with no services provided. On the next, the same carrier can be used to tie into the orbiter to provide a more complex experiment the full range of orbiter support — which is quite extensive (1:Ch 5). This flexibility is important to the question raised in this study. However, the flexibility comes at a cost. The pricing policy of NASA is explained in more detail in a later section. Yet it should be understood that anything NASA considers non-standard must be funded by the customer (25:—). Also, as shown in a later chapter, the addition of the non-standard services increases the total integration time. The bottom line is these carriers have inherent flexibility, but at a price. With this in mind, specifics on some of the carriers are presented next.

The Adaptive Payload Carrier (APC), the Get-Away-Special (GAS - an active carrier) Adapter Beam, the Bridge Payload Carrier and Extended Adaptive Payload Carrier are similar side-wall structures, all currently available. The GAS Adapter Beam and the Bridge Payload Carrier were originally designed to support GAS payloads, but can support other small payloads (19:—).

The Delta Keel Payload Carrier is the single structure attached only to the keel of the orbiter bay. It is currently available, and can be used in conjunction with the other passive carriers to allow full use of the volume of the bay (19:—).

The Capacity of Opportunity Payload Experiment Truss (COPE) and the Development Flight Instrumentation Carrier (DFI) are both NASA carriers. The COPE structure has been certified, but not manufactured. One DFI structure is available, but is not commonly used (9:—; 19:—).

The final structure in this class, the Mission Peculiar Equipment Support Structure (MPESS), is perhaps the most used experiment support structure. It has flown on numerous occasions for a wide variety of experiments and various sponsors (9:—). This is a reflection of its flexibility. In addition, because it has flown so much, it is familiar to NASA and potentially could have a shorter integration schedule than an unfamiliar carrier. Several are currently available (19:—; 21:—).

Active carriers: These are support structures providing experiment mounting support, a mechanical interface with the orbiter, and some level of electrical, thermal, and/or data (command, control, telemetry) support to the experiment. These carriers range from those providing pre-specified levels of support, to those with a standard shuttle interface providing the maximum support available from the orbiter (see Table 2). Some of the carriers provide limited services from carrier-provided support equipment. Others provide limited shuttle interfaces, while the remaining provide full orbiter services through a set of standard interfaces. However, the experiment cannot request unique interfaces with the orbiter (8:Ch 3). The advantage in all cases is that the structures have standard interfaces with the

Carrier	Mass Capacity (lbs)	Mounting Area (in)	Power	Data	Thermal Control	Carrier Mass (lbs)	Location	Source
1. Mid-deck Locker	60	2 cu.ft.	Yes	No	Active	n.a.	Crew Cabin	NASA
2. Get-Away-Special	200	5 cu.ft.	No	Yes (on-off only)	No	300	Side-wall	NASA
3. Hitchhiker M	1200	81 sq.ft.	Yes	Yes	Active	1200	Across-the bay	NASA
4. Hitchhiker G	750	60 x 50	Yes	Yes	No	100	Side-wall	NASA
5. Orbital Flight Test Pallet	2500	180 x 90	Yes	Yes	Active	2500	Across-the bay	NASA
6. Spacelab	7000	552 sq.ft.	Yes	Yes	Active	3300	Full-bay	NASA

Table 2: Active Experiment Support Structure Characteristics.

orbiter, and standard documentation and procedures (25:—). The later discussion on integration cycles will show the importance of this.

Of course, the disadvantage of this class of carriers is the mirror image of the advantage — the pre-specified services are limiting. In some cases it is the level of service. In others flexibility is lost due to standard shuttle interfaces. However, there is great variety in this class, as the following review indicates.

The mid-deck lockers are the only carrier located in the crew compartment. Experiments scheduled into them generally require manipulation by a crew member. Usually, the services available are limited, but NASA has on occasion extended the level. On any flight the number of lockers available varies due to performance factors and crew size. It can range from five to thirteen. NASA manages all locker operations (1:65; 19:—).

The Get-Away-Special is another special program managed by NASA. These GAS structures are self-contained bay structures capable of mounting on either the side-wall or a special across-the-bay bridge. Experiments placed in these structures usually are autonomous, and the only active service is an on-off controller. However, there are now available GAS structures with opening lids and apparatus to eject the payload. There are 30 GAS cans in the current inventory (1:55-56; 19:—).

There are two types of Hitchhiker carriers. Both are managed by NASA, and have similar aims. These structures were developed to provide quick and continued access to the shuttle for experimenters. The level of services are fixed. The experimenter must remain within the envelope specified by NASA, but the integration process is streamlined. The Hitchhiker M is based on the MPESS structure and has more weight carrying capacity than the Hitchhiker G side-wall structure. In both cases, the choice of experiments is managed by the carrier manager, not NASA headquarters. Hitchhikers are not available from commercial sources (23:—).

The final two carriers in this class are both pallet structures. One, the Orbital Flight Test (OFT) Pallet, was used in the STS flight test program. Through its interface with the orbiter, it can provide a full range of orbiter services. There is only one OFT pallet, managed by NASA; it is seldom used (9:—). The second carrier in this class is the Spacelab Pallet. This is the most sophisticated pallet with great capacity and flexibility. It also interfaces with the orbiter for a full range of services. There are several Spacelab pallets, but the demand is great and the current inventory is booked for the next several years (19:—; 23:—).

In summary, this class of carriers provides a wide range of capabilities in standardized configurations. This standardization leads to decreasing complexity in terms of the integration cycle, but

also a reduction in flexibility when compared to the passive carriers. The next two classes have similar, varying capabilities but specialized applications.

Free-flying structures: These are support structures providing some level of the services mentioned previously, as well as, a capability to separate from the orbiter for varying lengths of time. There are three structures in this class (see Table 3). Two points should be remembered concerning these carriers. First, the level of services available is reduced compared to the attached carriers. This stems from the fact that there is limited interface with the shuttle, terminated upon separation from the shuttle (24:—). Secondly, by their nature, the payloads are complex. This is because the payload must be separated from the orbiter using the Remote Manipulator System (RMS), requiring a complex crew interface and maneuvering on the part of the shuttle (19:—). However, this is the only way an experiment can operate outside the enviroment of the shuttle. With this in mind, each of the carriers will be reviewed as there are substantial differences between them.

The first of the free-flyers is the Long Duration Exposure Facility (LDEF). This carrier provides minimal services for a large number of experiments with a requirement for long duration exposure to the space environment. It is a NASA managed structure, and only one exists (19:—). It was launched in April 1984, and has not been recovered (9:—). Mission duration is dictated by the retrieval schedule and orbit decay (25:—).

The Shuttle Pallet Satellite (SPAS) is a German owned structure that has previously flown. It can support up to 2000 pounds of payload and has a mission duration of approximately 40 hours. There is one available at this time (19:—; 24:—).

The final free-flyer is the SPARTAN structure. This is a NASA managed carrier providing limited services to experiments. It has a flight duration of approximately 40 hours. Support is obtained via contract with NASA's Goddard Space Flight Center. Goddard makes decisions on experiment selection (21:—). NASA is scheduling this carrier twice a year to provide opportunities for R&D payloads (9:—). While this carrier does not have the same capability as the SPAS, the Spartan has an advantage in that the interface and integration schedule are well defined by NASA (24:—).

The free-flyer structures have the unique capability of separating from the orbiter for varying lengths of time, and then be retrieved and returned to the experimenter. This capability does cost in terms of complexity and flexibility. The next group reviewed, the specialty carriers, has even more limited applications.

Specialty carriers: These are experiment support structures tailored

Carrier	Mass Capacity (lbs)	Mounting Area (in)	Power	Data	Attitude Control	Thermal	Freefly Duration	Carrier Mass (lbs)	Source
1. Long Duration Exposure Facility	12,600	72 Trays 50x38x12	No	No	Gravity Gradient	No	6 mo. +	22,000	NASA
2. Shuttle Pallet Satellite	7000	111 sq.ft.	Yes	Yes	3-axis Gyro	Passive	40 hours	1200	Comm.
3. SPARTAN	500	30 cu.ft.	Yes	Yes	3-axis Gyro	Passive	40 hours	n/a	NASA

(Note: LDEF is a full-bay pallet, SPAS and SPARTAN both Across-the-bay structures.)

Table 3: Free-flyer Experiment Support Structure Characteristics.

to very specific experiments. Thus, their applicability is reduced.

The Get-Away-Special Bridge, mentioned earlier, is an across-the-bay structure designed to carry 12 GAS payloads. It is a NASA managed structure. The principal advantage is the economy of effort obtained and the utilization of the full bay volume for multiple R&D payloads (19:—).

The final two structures are both pointing and tracking systems. One, the Instrument Pointing System, is a NASA managed attached structure designed for use with the Spacelab pallets — only one exists (1:71-73). The other, the ASTRO-SPAS, is under development in Germany. It is a free-flying variation of the SPAS and is not expected to be available for 3-5 years (4:73-75).

To summarize, there is a wide variety of services available from the existing inventory of experiment support structures. The different classes each provide unique capabilities and within the classes varying advantages and disadvantages exist. In the next section the experiments are reviewed in terms of how they use these capabilities.

EXPERIMENT REQUIREMENTS

The Department of Defense is embarking on an extensive space-based research and development program. The figures cited in the introduction to this chapter illustrate this point. In this section some characteristics of the experiments with current STS spaceflight requests are reviewed. The intent of the review is to illustrate the wide variety of support requested and point out where demand for services of a particular type is great. The importance of this is that ultimately, it is the experimenters' requirements which must be met.

The data on the requirements reviewed in this chapter was provided by the DOD STS Program Office. Both classified and unclassified data were available. However, only unclassified sources were used as the importance is not the strict technical details but the trends and variety. In any case, the unclassified experiments are a representative cross section of the total inventory (25:—).

Of the 100 experiments on the unclassified listings, 55 are designated to fly on existing standard carriers reviewed in this chapter.

- Two have been assembled using the adaptive payload carrier. These are multi-mission payloads and have flown previously.

- Twenty-eight are requesting mid-deck locker space.

- Thirteen are GAS experiments.

- Five have requested space on the second LDEF mission scheduled to fly in May 1987.

- Six are designed for the Hitchhiker structures.

- One experiment is requesting a SPARTAN flight.

An additional 15 experiments are planned as in-bay experiments but not on one of the standard carriers. Two of these will be dedicated payloads with an integral support structure. Three others have structures designed specifically for the experiment. These will fly as primary payloads as part of a mixed cargo. Six experiments indicate a requirement for free-flight but have not selected a carrier. Current indications are the existing inventory of free flyers will meet the needs of these experiments. The final four experiments in this category only indicate a requirement for space in the bay. No specific carrier has been designated. This makes them similar to the remaining experiments (15:—; 16:—).

There are 30 experiments for which no specific flight requirements have been levied. All these experiments are on the current Space Test Program prioritization list. They are seeking launch support from the Space Test Program and, at this time, have only defined the mission objectives and experiment technical specifications. Design for spaceflight has yet to be accomplished, and until this is done no carrier selection is possible (21:—). However, the anticipation is most will design to a particular carrier as this provides the maximum opportunities for flight. Additionally, a previous study found that many of the experiments on the STP priority list indicated a preference for free-flight (22:5).

The experiments reviewed above are only a sample of the total inventory. As stated earlier, the classified experiments were not considered. However, the sponsors of the experiments on both lists have requested spaceflight support from either the DOD STS Program Office or the Space Test Program. Yet more are being developed in laboratories across the nation — many associated with the Strategic Defense Initiative (SDI). The SDI-sponsored experiments exhibit the potential for the same great variety seen in the previous experiments supported through the STP and STS program offices. Yet there is an unknown associated with SDI due to the nature of the research. There is a potential for increased complexity and size (23:—). The point is that it is difficult to predict what the future requirements will be other than to say they will be as varied as today. Thus the choice of a structure, or inventory of structures, based on existing requirements may not fulfill future needs. However, there are some additional factors which, if taken into account, will put the decision on firmer ground. These are the organizational influences of the launch support agencies.

Chapter Three

NASA SUPPORT TO R&D PAYLOADS

As stated in the introduction, NASA has consistently supported R&D payloads — ranging from small crew cabin experiments to dedicated Spacelab missions. The infrastructure behind this support is extensive and involves both administrative procedures for manifesting the payloads and technical services for integrating the experiment onto the carrier (creating a payload) and the payload into the shuttle. Both areas have significant impact on DOD supported payloads. In this chapter the manifesting system, the integration process, and NASA's management of support structures are discussed in turn.

PAYLOAD MANIFESTING

Manifesting is simply the process NASA uses to assign payloads to specific flights. Unfortunately, it is not a simple process because there are multiple payloads on each flight and because both the payload schedules and the shuttle schedules are constantly changing. This section focuses on the manifesting system and its impact on DOD R&D payloads by examining the priorities NASA uses in assigning payloads, their systematic approach to ensure compatibility, and how each interact to create difficulties for the DOD.

The manifesting process is carried out by the Flight Assignment Working Group (FAWG) (8:15). Although NASA considers manifesting an internal process, this group does have a DOD member (25:—). The DOD is represented for three reasons. First, the DOD does operate some portions of the STS, including the Vandenberg launch site, procurement and operation of the inertial upper stage, and some of the radar and tracking organizations (7:—). The second reason is the DOD is the largest single customer on the shuttle (6:33). Recently, the DOD agreed to fly at least one-third of all shuttle missions (25:—) and negotiated to pay a certain portion of the STS fixed cost, regardless of the actual number of DOD flights (23:—). Finally, the DOD has missions important enough that NASA must plan around them (25:—). The DOD FAWG representative looks out for these interests. Unfortunately, the DOD representative also spends considerable time getting R&D experiments on the schedule because NASA considers them secondary payloads and low in priority (25:—). This disparity in priorities is one of the major drawbacks in the support system.

NASA actually has two priority systems — one for primary payloads and one for secondary payloads. The best way to distinguish between the two types is by defining a secondary payload. It is any relatively small (less than five per cent of the total orbiter capacity) payload willing to fly on a space available basis. Space available is defined as the capacity of orbiter services (performance, space, crew time, consumables, etc.) left after the primary assigned payloads' requirements are met. Thus, a secondary payload is a small payload willing to either accept what is available on a given flight or wait until a flight exists which can meet all its requirements. Primary payloads are all large payloads and any small payload unwilling to accept the provisions listed above. NASA's overall priority system is primaries first, secondaries second. Within each of these payload classes separate priority systems exist (25:—).

In practice the priority system for primary payloads is as follows:

1. National Security Missions. Missions certified by the Secretary of the Air Force as necessary to the national security of the United States. These will be flown as close as possible to the scheduled launch date and will not be pre-empted by any other mission;

2. Commercial and other DOD missions. All commercial missions and DOD missions not considered essential to national security. These will be flown as close as possible to the requested flight in the order in which they are booked;

3. NASA sponsored payloads. All NASA sponsored missions. These will be flown as soon as possible but usually after the payloads in priorities 1 and 2 are scheduled (25:—).

The priority system works in the following manner. First, the DOD national security missions are put in the schedule. Next, the commercial and remaining DOD payloads are placed in the schedule as close as possible to their requested launch date. When conflicts in this category occur, priorities are determined using the STS Form 100 (Request for Flight Assignment) submission date. This is referred to as the booking date. Finally, the NASA missions are scheduled into the remaining slots, in an order determined by NASA. There are some exceptions to the priority system. Some NASA missions have critical launch windows, and NASA will establish a firm schedule date for these. When adjustments are made to the schedule, they are made around these missions. In essence, they become Priority 1 missions. However, DOD Priority 1 missions could pre-empt these if necessary (25:—). The Galileo and Ulysses missions scheduled for May 1986 are examples of this type mission. While this priority process seems simple, there are two things which complicate it.

The first of these is the STS operates more like a scheduled bus system than the taxi system nature of the expendable launch vehicles

(ELV). The ELVs support a single payload and generally fly whenever the user wants. The support provided is tailored to the payload and there are no other customers so there is not a problem with compatibility. Typically, the only constraint is launch pad availability (17:2). The shuttle is a bus which plans to leave at a certain time, travels a fixed route, and often has multiple riders. When building the manifest this must be taken into account.

The second complicating factor is that everything in the system is constantly changing. The shuttle has problems, and the whole schedule is delayed. Payloads change requirements, and this upsets the established mix of payloads, and the schedule must be changed. For one reason or another entire flights have been cancelled. It is interesting to note that fully one-half of the flights scheduled at the beginning of 1983 for the period 1983 through 1985 were cancelled (23:—). In any case, the result is the manifest is constantly changing, and the manifesting process is always on-going.

The manifesting system works as follows. The first schedule of any iteration is called a strawman. This strawman manifest is put together using the priorities listed above and broad guidelines on performance and compatibility. This strawman is first assessed by Kennedy Space Center personnel to ensure the ground facilities, support equipment, and orbiters are available and can meet the schedule. Adjustments are made based on this review, and the strawman is released to the remaining FAWG members for a more detailed review (8:15).

The DOD's review consists of ensuring the needs of the DOD payloads are met and the DOD resources required to support the schedule are available. The NASA agencies (primarily Johnson Space Center) conduct a detailed compatibility assessment based on payload requirements and cargo mixes. Detailed structural, thermal, crew activity, avionics, center of gravity, and performance assessments are made to ensure the payloads in each mix are compatible with each other and the shuttle. During these reviews trade-offs are made to ensure each payload's mission objectives can be met. Once a complete assessment is made the adjusted manifest is submitted to NASA management and the DOD for approval. Barring unforseen difficulties, the manifest is then approved and released to the public (8:Ch 4). At this point the process begins all over. Typically, the small payloads are not added to the manifest until after this review process has been completed due to their space available nature discussed earlier (21:—). The system used to manifest these secondary payloads is similar to the primary system. The major differences lie in the priorities NASA assigns the secondary payloads, and the timing aspect mentioned above.

NASA's secondary payload manifesting system has two priority categories — commercial Joint Endeavor Agreement payloads, and all others. Joint Endeavor Agreement (JEA) payloads are usually technology demonstration and/or R&D ventures sponsored by a commercial concern.

NASA subsidizes these payloads in order to encourage the utilization of space by the commercial sector and to broaden the technology base. Given the emphasis President Reagan places on commercialization of space, this priority is not unexpected (25:—).

Once the JEAs are scheduled, NASA manifests the remaining secondary payloads on the basis of booking date and compatibility with the primary payload. Compatibility is judged in the same manner as between primary payloads, except the secondaries are judged against the margin; i.e., they have to meet their requirements within the left-over capacity of the shuttle (1:31). As mentioned earlier, the secondaries either live within the available resources or wait for a later ride. Of more significance to the DOD is the problem of using the booking date to determine priorities (25:—). This means simply first in, first out. If the flow of payloads through the system was orderly, there would be less a problem. However, as mentioned in the introduction, there is a substantial backlog of small payloads. A 1985 study of the backlog by Johnson Space Center personnel concluded it would take approximately two years to fly all the mid-deck experiments on the books at the time. When the study was done, there were 451 GAS experiments requesting flight — only 30 flew in the first two years of the program. No estimate of the length of time required to work off this backlog was made (18:—). The other classes of small payload accommodations had similar backlogs. Since the study, the situation has gotten worse, not better (25:—). What this means to the DOD today is that as new payloads are added to the list, they go on the bottom. NASA, using the first in first out philosophy, attempts to fly the older payloads first. Given the volatility of the STS schedule, the newer payloads have little hope of getting a quick ride. This uncertainty is aggravated by the late manifesting decisions made by NASA concerning secondary payloads.

Secondary payloads usually are not manifested until after the Cargo Integration Review (CIR) for a particular mission (18:—). This occurs approximately nine months prior to flight (10:—). The NASA manifests runs slightly over three years for the primary payloads (9:—). However, due to the changing nature of the cargo mixes, NASA management prefers to delay decisions on the secondaries until the final performance numbers are in. These are reviewed at the CIR (25:—). This late manifesting, combined with the low priority given most secondary payloads, results in considerable uncertainty for the experimenters (21:—). This uncertainty means the experimenter must be ready to fly as soon as possible to take advantage of any opportunity. To do so the experiment must first go through the NASA integration cycle.

PAYLOAD INTEGRATION

The NASA integration process is designed to ensure the needs of the customer are met while also ensuring the payload is compatible with

the orbiter. The process involves

- preparation of the Payload Integration Plan (PIP),
- preparation of the Interface Control Document (ICD),
- the safety review process,
- the detailed engineering analyses, and
- the integration review cycle (8:Ch 2).

The timing of this system is fixed for various types of payloads, and cannot be by-passed. However, in certain cases the timing can be accelerated (25:—).

Of the different segments of the process, perhaps the most critical is the preparation of the PIP. This document

- defines roles and responsibilities,
- defines the technical baseline,
- defines the integration tasks, and
- establishes the schedule for the integration tasks (8:7).

In short, it drives all the remaining integration activities. The other activities involved in the integration cycle usually occur after the start of the PIP preparation process. Each of the activities plays a role in ensuring compatibility between the orbiter and the payload. For example, the ICD, prepared shortly after the PIP, specifies the interface between the orbiter and the payload (8:11). The safety review process, of critical concern to NASA, runs throughout the cycle (8:13). The timetable of these tasks is shown at Figure 1.

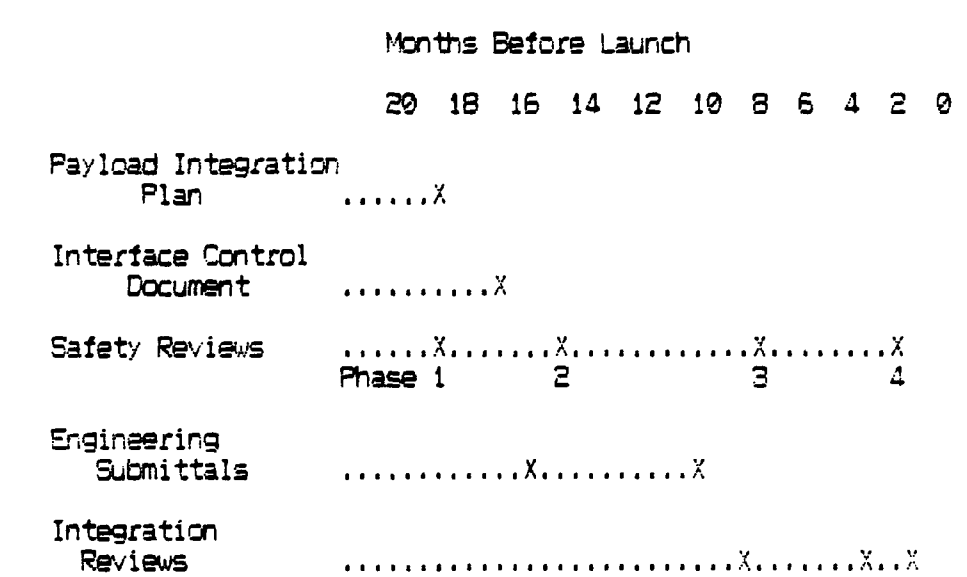

Figure 1: Typical Payload Integration Schedule (8:8).

The cycle shown is for a typical payload. Typical can be translated as a non-complex primary payload. Certain payloads have longer cycles. These include most DOD dedicated payloads, all the Spacelab payloads, and any payload with unique requirements (8:8). This later category includes large experiment support structures with multiple experiments and high crew activity requirements. However, there are some classes of payloads having shorter cycles. Table 4 shows some typical integration times for some of the experiment structures mentioned earlier. The time savings come from the relative simplicity of these smaller payloads, and the experience NASA obtained on previous flights of the structures (25:—). Based on working with known configurations, NASA has streamlined the integration cycle by creating standard documentation and engineering analyses. For example, NASA JSC has defined a small payload configuration for a small experiment and published a standard PIP and ICD for it (8:21). If the experimenter stays within that standard, the payload is considered simple. Once the experimenter requests services outside this standard, it becomes a non-standard, more complex payload (25:—). As shown in Table 4, this incurs a six month penalty. This concept of standard carrier specifications leads to the last area of influence — NASA managed carriers.

Configuration	Integration Time Prior to Flight
Simple Crew Compartment	5 to 13 months
Complex Crew Compartment	13 to 24 months
GAS	12 to 18 months
Simple Sidewall	12 to 24 months
Complex Sidewall	18 to 30 months
Other carriers (Hitchhiker, SPAS, etc)	12 to 36+ months

Table 4: Typical R&D Payload Integration Times (25:—).

NASA MANAGED EXPERIMENT SUPPORT STRUCTURES

In order to extend the level of support to NASA and other researchers, NASA has developed some standard carriers and manages both the experiment-to-carrier integration and the payload-to-orbiter integration. These carriers, reviewed in Chapter Two, include the Get Away Special, both Hitchhiker structures, the Spartan structure, the Long Duration Exposure Facility, the mid-deck lockers, and the Spacelab pallets (19:—). Within this group, four have special advantages over the rest of the carriers reviewed. The GAS, mid-deck locker, and two Hitchhiker structures have programs which can provide quick access to the shuttle. Essentially, NASA has established certain levels of services associated with each of these carriers, sometimes known as the Small Payload Accomodations Package (25:—). Experiments designed within these criteria can reduce significantly the time and effort of integration. There is one additional important factor. NASA has, in place, the personnel, facilities, procedures, and hardware for these programs. The experimenter only has to provide the hardware associated with the experiment (25:—). There are, however, some drawbacks.

An earlier review of the small payload accommodations services indicated some payloads proposed by the DOD researchers would not fit within the envelope. This does not mean the carriers are not capable of handling the requirements. The level of services offered as part of the small payload package was minimal to simplify the integration

process. This was accomplished by severely restricting the interface with the shuttle and crew (25:—). The same carriers could provide a higher level of service by increasing the interface. However, NASA then treats the payload as unique, and the integration cycle becomes more complex (3:Ch 4). In either case the problem of getting on the manifest still exists. However, NASA has made some effort to ensure exposure of these carriers by scheduling in advance the flight of the Hitchhiker structures, the Spartan structure, and an occasional GAS bridge. These are scheduled without decisions concerning the experiment to be flown (25:—).

NASA support to R&D has been extensive in the past and continues to grow. Their efforts to simplify the integration cycle for some of the carriers can be of great benefit to the research community. However, the problems existing within the scheduling system — the frequent delays and the priority systems — create tremendous difficulties. The next chapter will focus on the two DOD organizations tasked with the job of working around these problems and getting the critical DOD R&D missions flown in a timely manner.

Chapter Four

DOD ORGANIZATIONAL SUPPORT TO R&D PAYLOADS

As mentioned in Chapter Two, there has been a tremendous increase in the level of DOD space-based R&D activity on the STS in the last few years. In order to support this activity, there are two organizations, both located at Air Force Systems Command's Space Division Headquarters, providing support. In this chapter the activity of these two organizations is reviewed in terms of how this activity influences the choice of carriers. These programs are the Space Test Program and the Space Transportation System Program Office. The Space Test Program has provided support to DOD space-based research for many years, and will be discussed first.

THE SPACE TEST PROGRAM

The Space Test Program (STP) is a tri-service program, managed by the Air Force, chartered and funded to provide spaceflight opportunities for DOD research experiments. Since 1966 STP has flown over 100 experiments, mainly on expendable launch vehicles (ELVs). Recently, however, much of its work is directed toward preparing payloads for the shuttle (1:11-19). There are three areas needing emphasis in regards to the STS -- the STP priority system, their charter to buy generic spacecraft, and their philosophy for packaging experiments. Each are important in terms of the questions addressed in this study.

The STP priority system impacts the decisions only indirectly, but it does have some influence. The regulation governing the STP process states that a board will meet annually to prioritize the experiments submitted for consideration. These experiments come from all the uniformed services as well as other DOD R&D organizations. The board, in its annual meeting, listens to the proposals and ranks the experiments based on military relevance, cost, schedule, etc., (13:Ch 3). The priorities established through this system are used by the STP office in determining funding and support for the experiments (13:Ch 2). They fly them in the order listed, based on the fit between opportunity and the requirements of the payload. However, not all the experiments handled by STP go through the annual prioritization process. STP recently instituted a Quick Response Shuttle Payload (QRSP) program (5:1). This program is designed to fly payloads in as little as nine months if an opportunity comes available (5:1). The

payloads qualifying for this program typically are small payloads with minimum requirements — very similar to the small payload accommodations package forwarded by NASA. In most cases the QRSP experiments do not use the same equipment as the experiments on the STP priority list. However, there does appear to be a possibility of conflict as the traffic model increases (25:—). Also, some programs applying for QRSP status do not meet the simplicity requirements. In any case, the QRSP system exists outside the standard prioritization cycle. Another area where the priority system is impacted is the packaging philosophy of STP.

One of STP's philosophical approaches to packaging experiments is a holdover from their experience with ELVs. When flying on an ELV the tendency is to put as many experiments as possible on the flight. Often, a single large experiment would serve as the primary, with secondaries added when possible. However, the total package was an STP payload (1:25). STP has carried this over to the STS. A couple of things result from this philosophy. First, these packages use the larger experimental support structures and, consequently, are scheduled as primary payloads on the manifest (25:—). However, their priority is equal to the commercial payloads in most cases and face the possibility of continued movement in the schedule. A second result is the small payload may have a longer wait for a ride than if flying alone and it certainly faces a longer and more expensive integration cycle. The longer integration cycle comes from the fact that the total payload is now considered complex by NASA, and the shorter cycles no longer apply. The increased expense comes from the longer time the investigator spends on the project and the increased cost of the additional analyses necessary to ensure compatibility between the carrier, the shuttle, and the other payloads (23:—). This discussion applies to the payloads (experiment/carrier combination) managed in-house by STP. These are built when one of the experiments supported by STP has the priority to generate a primary payload. However, most experiments are flown using space available on other carriers. The program managers do use this avenue when possible (13:5).

The primary method STP uses to take advantage of space available flights is to contract directly with NASA for space on the NASA managed experiment support structures. In fact STP has arranged space on all of the space available structures - both Hitchhikers, GAS, LDEF, Spartan, and mid-deck lockers (21:—). The LDEF is a special case in terms of manifesting, as it flies rarely. The other payloads, however, fall under the rules discussed in Chapter Three. That is, the experiments placed on these carriers are NASA sponsored and have a low priority. Due to this relatively low priority, they face the same possibilities for delay as the small payloads on the larger DOD sponsored structures discussed above. The combination of the priority system and the manner in which the payloads are packaged only increases the likelihood of delay. This is one of the reasons STP is interested in purchasing generic equipment (23:—).

The Space Test Program, in its role as a launch support agency, has direction to supply standard experimental support equipment to the users. Specifically, the STP Program Management Directive (PMD) states "...STP will develop and use standard hardware when practical..." (11:1). It further states "...STP will provide only standard hardware and services..." (11:2). This is interpreted to mean STP will provide DOD experimenters the necessary support equipment needed to conduct space experimentation. However, the structure should not be unique to a single experiment. Air Force Regulation 80-2, the STP governing regulation, supports this. It states "...If an experiment requires support beyond that provided by the standard hardware, this additional support is funded by the experimental sponsors..." (13:6). The implication of this is a single experiment cannot drive the requirement for an STP provided experimental support structure.

In summary, the Space Test Program office is a major supporter of DOD space-based R&D. Its philosophy, priority system, and direction to provide support hardware all have significant influence on any decision concerning the type of equipment the DOD should buy. There is, however, another organization providing support to DOD R&D. This is the STS Program Office.

THE SPACE TRANSPORTATION SYSTEM PROGRAM OFFICE

The DOD's Space Transportation System Program Office (STSPO), as the principle interface with NASA in regards to shuttle matters, is tasked with the manifesting of all DOD payloads, as well as, the management of integration activities for DOD payloads onto the shuttle (12:3). This responsibility brings with it significant influence on DOD space-based R&D activities. In this section, three areas are discussed: STSPO organizational direction to provide standard equipment; the manifesting priority uncertainties; and the influence of the flight reimbursement system. These are each covered in turn.

The STSPO also has direction to purchase standard equipment to support DOD payloads. Their PMD directs the STSPO to "...develop, acquire, integrate, and maintain common payload support equipment..." (12:5). While this direction might appear to conflict with the STP direction, in actuality it reinforces Space Division's charter to provide standard experiment support equipment. Both organizations realize the need to coordinate any purchase to ensure the proper mix is acquired. There is, unfortunately, a problem with the next point to be considered — the manifesting priorities.

The Space Test Program has long had the lead in supporting the bulk of the R&D experiments requesting spaceflight. However, with the advent of the shuttle the STS Program Office has become actively involved by assisting STP in integrating some payloads onto the shuttle and manifesting all DOD payloads (21:—). In this latter role some conflicts have crept into the system. As discussed earlier, STP has a

priority system for R&D payloads and a QRSP program with no priority process. However, not all R&D experiments come through STP. The STP provides its services to experimenters not authorized their own means of flight: i.e., they can't buy a ride (13:3). Yet one of the major R&D customers in the DOD, the Strategic Defense Initiative Organization, does have authorization to purchase flights and falls outside the STP priority system. The difficulty this creates is there is no overall manifesting priority list for all the DOD payloads. The STSPO, charged with the job of manifesting these payloads, has a difficult time making decisions without an overall priority system. In the past the job was simplified by the low number of experiments ready for flight. However, as the number goes up, the problem gets worse. Some efforts are being made to resolve this problem, including the creation of a joint STP/STSPO Customer Service Office. This office is the initial point of contact for all new payloads and should provide manifesters with more visibility into the traffic. However, without a single priority system, the manifesting problem will not go away (25:—).

The final area of consideration in this section is the STSPO management of the Orbiter Flight Charge (OFC) reimbursement to NASA. Under the provisions of the MOA between NASA and the DOD, the DOD pays for each shuttle mission and receives certain standard services in return. The number of missions to be flown each year is projected three years in advance and payment made one year prior to the year of flight. Once a payment is made, if a flight was cancelled the DOD received a credit in later years (20:—). This created some problems for NASA due to the tremendous fluidity in the DOD launch schedule (23:—). To alleviate this a new agreement was reached in 1985. Under its provisions, effective in 1989, the DOD will fly one-third of all shuttle flights over the following 10 years. The reimbursement for these flights consists of a fixed cost and a variable cost. The fixed cost ($30 million per flight, FY82 dollars) will be paid the year prior for one-third the total flights scheduled. This payment is not reimbursable, even if no DOD flights are flown. The variable cost ($30 million per flight, FY82 dollars) will be paid only if the flight is flown (23:—). For example, if 24 flights are scheduled in a given year (the assumed mature system flight rate), the DOD will pay NASA $240M the year prior. This money will not be reimbursed in any case. If, during the flight year, the DOD flies four missions, NASA will be paid an additional $120M. This impacts the R&D payloads in two ways.

The first concerns availability of space for the smaller payloads. Under the old agreement the DOD did not pay an Orbiter Flight Charge for small payloads. This was because the DOD and NASA could not agree on a price. This lack of payment allowed NASA to give DOD small payloads a low priority, and the DOD had no leverage. Under the new agreement, however, the commitment to buy one-third of all flights implies a right to use one third of all space, including small payload accommodations. The second potential impact concerns the priority given DOD R&D missions (and for that matter, all Priority 2 DOD

missions). Because the DOD has already paid the fixed cost portion of one-third of the flights, any DOD flight requested by the DOD staying within the one-third limit must be flown. (Additionally, R&D payloads will likely get increased support within the DOD because the fixed cost portion of these flights will have already been paid.) This should give the STSPO manifesting personnel tremendous leverage when requesting flight dates in the future (25:--).

In summary, the STSPO provides manifesting support to all DOD payloads, pays for all DOD payloads, and provides standard equipment to these payloads. While only one of these directly concerns small payload structures, the other two areas have significant influence on the manner in which they are used and must be considered in the following analysis section.

Chapter Five

FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

In the preceding chapters the factors influencing the strategy required to cope with the problems associated with the DOD space-based R&D community requesting flight on the STS were reviewed. In this chapter, the information presented in this review is summarized by presenting specific findings, the conclusions coming out of those findings, and recommendations offered on the basis of the conclusions.

FINDINGS

Using the information presented in Chapters One through Four, the following are the specific findings pertinent to the question asked in this study.

- There are numerous experiment support structures available capable of meeting a wide variety of needs.

— Eight are passive carriers. Two are from NASA and six from commercial sources. Of these, the MPESS has flown most often.

— Six are active carriers, and all are sponsored by NASA.

— Three are free-flyers. Two are from NASA and one from a commercial source.

— Three are specialty carriers. One supports GAS payloads, while the others are pointing and tracking support carriers.

- Of the four groups of carriers reviewed, the passive carriers have the most inherent flexibility, while the active group has the most inherent capability.

- The majority of experiments listed in the current DOD inventory plan to use one of the existing standard carriers. Those not designated against a particular structure will most likely use one of the existing structures.

- The NASA uses two priority systems — primary and secondary. In each, DOD R&D payloads compete for scarce space with non-DOD experiments. In any case, both the DOD and non-DOD experiments have relatively low priority.

- The length of the NASA integration cycle is dependent on the complexity of the payload. Any non-standard configuration increases payload complexity.

- The NASA sponsors R&D experiment support structures with standard configurations and streamlined integration cycles. The NASA has in-house facilities to support these structures.

- The DOD Space Test Program has a priority system for experiments not authorized their own means of spaceflight. In addition, they have instituted a Quick Response Shuttle Payload program designed to provide rapid opportunities for flight. The QRSP experiments fall outside the normal prioritization process.

- The STP design philosophy encourages both primary payloads and the use of space available services.

- The primary space available avenue of STP sponsored experiments is NASA sponsored carriers.

- The STP has Air Staff direction to provide researchers with standard experiment support equipment.

- The Space Division STS Program Office has complementary direction to obtain standard experiment support equipment.

- The research community has in the past come to both the STP and STS program offices. The newly formed SD Customer Service Office is now the single point of contact for all new payloads. However, there is still no single experiment priority list.

- The DOD has committed to fly one-third all STS missions over the next 10 years. The DOD will pay both a fixed price and a variable price. The fixed price portion of the payment will be paid regardless of the number of flights flown by the DOD.

- Once the fixed price portion of the bill is paid, flights within the one-third allotment will only pay the variable portion of the Orbiter Flight Charge.

CONCLUSIONS

The data reviewed in the previous chapter, summarized in the findings listed above, lead to several conclusions. These conclusions are listed below and form the basis of the recommendations listed in the last section of the study.

- The DOD R&D community is sponsoring a great variety of experiments. This is based not on a technical review of the

experiments but on the variety of experiment support structures used. This variety in structures leads to the conclusion the experiments have differing objectives and technical requirements. There is some evidence to indicate free-flying capability is relatively important.

- Second, the DOD R&D community is apparently satisfied with the capabilities of the existing structures. In any case, if the structure cannot meet the need, the experimenter must provide his own support (or at least pay for it).

- There is uncertainty concerning the configuration of future R&D experiments. This is due to the advent of the SDI, and the changing nature of the research. For this reason it is concluded that any carriers procured must have considerable flexibility. Additionally, there should be some caution taken against over-committing to a particular inventory until more is known about future requirements.

- The major difficulty in getting DOD R&D payloads flown is the priority system used by NASA in manifesting payloads. For various reasons DOD R&D payloads have a low priority in relation to other DOD and commercial payloads. The integration cycle is reduced when NASA is familiar with the carrier.

- Increasing complexity results in an increased integration cycle. This also costs the experimenter money, but the increased complexity may be necessary to ensure all needed services are obtained.

- The NASA sponsored experiment support structures have a variety of capabilities, and NASA has the in-house facilities to integrate the experiment to the carrier and the payload into the shuttle.

- The Space Test Program is on sound footing. The one major drawback is the lack of a consistent priority system.

- The STS Program Office is also on sound footing. The work with STP in resolving conflicts should result in a better operation. Again, the lack of a single priority system is the major drawback.

As a reminder, the overall purpose of this study is to suggest a strategy to ensure needed DOD R&D gets flown on the shuttle in a timely manner. The specific need identified was for in-house experiment support structures. The conclusions reviewed above are specific to the different sections covered in the study. Overall, the general conclusion is the DOD should use caution in buying support structures, and should emphasize flexibility and familiarity. Of those reviewed, the single carrier best meeting these criteria is the MPESS. While a free-flying capability was identified as relatively important, any decision to buy a free-flying structure should be delayed until a specific experiment with sufficient priority to qualify as a primary payload is identified. At the same time, the DOD should increase the use of NASA owned structures and put pressure on NASA to ensure the DOD

gets priority. The way to do this is two-fold. First, the DOD should help fund the NASA sponsored structure programs to ensure adequate resources are available for DOD use. Second, given the new financial arrangement with NASA, the DOD should insist NASA give priority to all DOD payloads, designated national security or not, as long as the total flight model does not exceed the one-third traffic model agreed upon. In this way the DOD can be assured it gets the proper priority for its missions.

RECOMMENDATIONS

Based on the above conclusions, the following specific recommendations are made.

1. The DOD should buy one MPESS experiment support structure.

2. The DOD should enter into an agreement with NASA to help fund the NASA sponsored carrier programs. The funding should go to the purchase of additional hardware dedicated to the DOD, and to provide an increased capacity to handle the additional work.

3. The DOD should manifest all payloads within the one-third limit as priority 1.

4. The DOD should institute a master payload priority list.

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