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PROCESSING THE COMBINED GOVERNMENT-COMMERCIAL PAYLOAD MIX IN THE SHUTTLE PRELAUNCH ENVIRONMENT

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ABSTRACT

The STS-57 and STS-60 Shuttle launches provide a unique opportunity to demonstrate the partnership between an entrepreneurial space initiative and the government's ongoing Space Shuttle launch program. The SPACEHAB-ONE and SPACEHAB-TWO commercial payloads flew on these missions with a mixture of government payloads. Integration of these two commercial payloads into the Shuttle payload prelaunch processing and download activity provided a unique challenge for the Shuttle payload processing community.

This paper discusses the unique characteristics of this commercial payload and the impacts on payload processing at the Kennedy Space Center. Integrating the commercial payload into the Shuttle payload processing scenario calls for creative approaches to the use of resources; adaptive approaches to the government-industry partnership; and flexible approaches to the roles and responsibilities which are involved.

The roles and responsibilities of the organizations involved and their interactions will be outlined. In addition, the paper will address those aspects of processing which allow the commercial payload to provide its services to its customers in an effective manner.

This paper is concerned with the operational environment of prelaunch processing and time and space limitations preclude addressing financial or contractual issues.

PAYLOAD PROCESSING FLOWS

<u>MISSION DESCRIPTIONS</u>: The STS-57 and STS-60 Space Shuttle missions had, in common, the incorporation of the SPACEHAB payload bay module. The SPACEHAB module is a commercial initiative which

was developed by SPACEHAB, Inc. The company SPACEHAB, Inc. was formed in 1983 to develop a microgravity crew-tended facility that expands and enhances the use of the Space Shuttle in providing microgravity opportunities.

The STS-57 mission of the Shuttle orbiter Endeavour, which was launched June 21, 1993, was the first flight of a SPACEHAB module. In addition to the SPACEHAB-1 module the Endeavour carried a United States government payload from Goddard Spaceflight Center, the Superfluid Helium On-Orbit Transfer (SHOOT). SHOOT was located immediately behind the SPACEHAB-1 and consisted of two dewar tanks used to study the behavior of superfluid liquid helium in microgravity. Just behind the SHOOT payload was the area for the retrieval and stowage of the European Space Agency's EURECA spacecraft. EURECA was launched by the STS-46 mission and retrieved and returned to Earth by the STS-57 Shuttle flight. The last payload in the payload bay for STS-57 was a trusswork support structure termed a GAS Bridge Assembly (GBA) which carried twelve experiments inside NASA Get Away Special (GAS) canisters.

The STS-60 mission of the orbiter Discovery, set for launch on February 3, 1994 as of this writing (mid-January), carried the second SPACEHAB module in the forward end of the payload bay. The SPACEHAB program has two flight modules and STS-60 was the first flight of the second unit. In addition, the STS-60 carried the Wake Shield Facility (WSF) payload in the central area of the payload bay. The WSF is a deployable free-flying spacecraft that takes advantage of the extremely low vacuum levels available to a deployed Shuttle payload for thin film epitaxy operations. The WSF was developed by the Space Vacuum Epitaxy Center, a NASA Center for the Commercial Development of Space, at the University of Houston. The last payload was a GBA, physically the same one that flew on STS-57, but with a different complement of experiments.

SPACEHAB: The SPACEHAB modules are mounted in the forward part of the payload bay. Access to the crew compartment areas of the Shuttle orbiter is via a tunnel of approximately 115 inches length. The SPACEHAB module is a truncated cylinder 110.26 inches long and 134 inches high. It provides approximately 1100 cubic feet of pressurized volume for crew-tended experiments. SPACEHAB module experiments may be mounted in either Shuttle midddeck-type lockers or in racks, however some capability for exterior mounted experiments exists also. SPACEHAB-1 carried 9 material science, 11 life science and 2 technology experiments; while SPACEHAB-2 consisted of 4 material science, 7 life science and 1 technology experiment.

The SPACEHAB corporation is based in Washington, D.C.; however, the integration and operations of the SPACEHAB program is done by the McDonnell Douglas company of Huntsville, Alabama. They have a launch site operations unit located at Port Canaveral where preparation for upcoming SPACEHAB flights and post-flight activities are conducted.

The actual integration of the SPACEHAB into the Shuttle and the prelaunch processing of the combined Shuttle mission payload complement is done by the NASA Kennedy Space Center (KSC). Two major contractor elements are involved; Lockheed Space Operations Corporation (LSOC) and Mcdonnell Douglas Space Systems Co. (MDSSC). LSOC is the Space Shuttle processing contractor for NASA while MDSSC supports NASA for payload processing. The SPACEHAB McDonnell Douglas personnel are not a part of the McDonnell Douglas organization supporting KSC.

The processing of the payloads at KSC prior to launch is done by a mission-specific joint team of Shuttle/payload and NASA/contractor personnel, and it is designated the Mission Processing Team. The team integrates the payload requirements into the launch processing flow, schedules operations, coordinates payload activities with the Shuttle operations and performs actual payload tests and processing operations.

<u>STS-57 PAYLOAD PROCESSING FLOW</u>: The actual processing of the STS-57 SPACEHAB-1, from arrival to launch, was 139 days. The processing flow involved the delivery of the SPACEHAB-1 from the SPACEHAB facility at Port Canaveral to the KSC Operations & Checkout Building (O&C). The delivery of the SPACEHAB was accomplished by using the KSC's Payload Environmental Transfer System (PETS). PETS is an enclosed highway-compatible unit which is used to move Shuttle payloads. PETS can move only one payload at a time.

At the O&C building the SPACEHAB-1 was installed in a test stand where interface testing with a Shuttle simulator took place in order to ensure that the SPACEHAB-to-Shuttle interfaces could be verified after installation in the orbiter. Following this operation the SPACEHAB-1 and the GBA were installed into a payload transfer canister and moved from the O&C building to the Orbiter Processing Facility (OPF). The payload transfer canister can carry up to a full load of orbiter payloads in the same spatial relation to each other and the orbiter as they will experience in the actual orbiter payload bay.

At the OPF the SPACEHAB-1 and the GBA were simultaneously lifted and installed in the Endeavour's payload bay. The payloads were then powered up for testing and the payload-to-orbiter interfaces were verified. Some work inside the SPACEHAB-1 module was done and a pressure decay test of the SPACEHAB-1 module, in conjunction with the orbiter cabin, was done in the OPF. The Endeavour was then moved to the launch pad after being mated to its external tank and solid rocket boosters.

The SHOOT payload was installed in Endeavour at the launch pad and several SPACEHAB-1 experiments and articles of equipment which had to be installed at the launch pad were stowed in the module. SPACEHAB installation and stowage operations occurred at several locations which included; prior to the module arrival at

KSC, in the horizontal orientation at the O&C and also at the OPF, and in the vertical orientation at the launch pad. The SPACEHAB system is flexible and allows the user community to take advantage of either early stowage prior to arrival at the launch pad, or a late stowage in the launch minus 35-29 hour timeframe for time-critical experiments and samples, depending upon the needs of the SPACEHAB's customers.

Stowage of experiments in the SPACEHAB module while the Shuttle is in a vertical orientation at the launch pad involved lowering personnel down from the crew cabin through the connecting tunnel and into the SPACEHAB module. A similar method is used in Spacelab module prelaunch operations and components of the Spacelab equipment - termed the Module Vertical Access Kit (MVAK) - is the same equipment used to support SPACEHAB vertical stowage. SPACEHAB technicians are the personnel actually lowered into the module.

Following the late stowage operations, the module hatch was closed for flight. For experiments and samples which must be loaded within the last 24 hours prior to launch, the SPACEHAB program utilizes orbiter middeck lockers which are loaded after the SPACEHAB module has been closed out. The middeck material may be moved into the SPACEHAB module after the Shuttle achieves orbit in order to support mission operations.

STS-60 PAYLOAD PROCESSING FLOW: The STS-60 prelaunch payload processing flow differed somewhat from the first SPACEHAB mission's flow. SPACEHAB-2 was not delivered to the O&C but was taken directly from the SPACEHAB facility to the OPF using the PETS unit. Normal payload-to-orbiter interface tests were done at the OPF, as well as the pressure decay checks.

The STS-60 GBA was tested in the O&C building, installed in the transfer canister and moved to the KSC's Vertical Processing Facility where the Wake Shield Facility payload had undergone testing. The Wake Shield Facility joined the GBA in the transfer canister and the two were moved to the launch pad for installation into the orbiter Discovery after it had arrived at the launch pad.

The decision on where a given payload will be installed into the orbiter is dependent upon both the payload's characteristics and the times of planned installation. OPF installations are done with the orbiter horizontal, so more complex installations are easier to accomplish there; however, installations are planned for a point approximately two months before launch. Payload installations at the launch pad, with the orbiter vertical, are approximately one month prior to launch.

After STS-60 arrived at the launch pad no further testing of SPACEHAB-2 was scheduled and only MVAK module stowage operations and the installation of experiments and equipment in the orbiter middeck were required.

The total times for SPACEHAB-1 and SPACEHAB-2 in the various KSC facilities are shown in Table 1 below:

	STS-57 SPACEHAB-1	STS-60 SPACEHAB-2
	PLANNED-ACTUAL	PLANNED-ACTUAL
OPERATIONS & CHECKOUT BUILDING	26 - 27	0 - 0
ORBITER PROCESSING FACILITY	29 - 22	35 - 53
VEHICLE ASSEMBLY BUILDING	5 - 35	5 - 6
LAUNCH PAD	25 - 55	32 - 25
TOTAL TIME IN DAYS	85 - 139	72 - 84

Table 1, Times In Days For SPACEHAB-1 And SPACEHAB-2
At KSC Prior To Launch

The major variations from the planned times for the actual times in the SPACEHAB-1 mission processing flow were not payload related. The STS-57 flow involved an orbiter engine changeout operation in the VAB and an orbiter engine turbopump changeout operation at the launch pad. Also, the STS-60 processing flow overlapped the Christmas, 1993 holidays and the orbiter Discovery did not move from the OPF to the VAB until after the first of the year although OPF operations were essentially complete by mid-December. The STS-60 launch had been planned for January 20; however, weekend work reduction efforts, together with the decision not to move to the VAB until after the holiday period added time to the processing flow.

PAYLOAD PROCESSING OBSERVATIONS

ORGANIZATIONAL CULTURE: We expected to encounter a "culture shock" during the initial SPACEHAB-1 mission processing flow and we were not disappointed. There were several areas in which this was encountered. The KSC payload processing organization handles a large variety of government sponsored payloads in a large number of sizes and configurations. Having developed both procedures and a payload processing-environment for prelaunch operations on over 27 major payloads in the previous 30 months, there was a tendency to consider SPACEHAB-1 as "just another payload".

We had to remind ourselves that SPACEHAB did not have the resources that some government organizations did. Although we tried to remain sensitized to this it was not always accomplished easily. We found that interaction with the commercial organization helps to make this easier and helps to eliminate the idea that the commercial organization is difficult to work with.

On the other side of the fence, the commercial organization needs to be aware that the other payloads on the mission and the multiple Shuttle systems may preclude work schedules and operations from being as optimal as the commercial organization may wish. Both the KSC payload and Shuttle organizations as well as commercial payload developers need to be aware of the pressures on one another.

SCHEDULES AND RESOURCES: During the time that the SPACEHAB-1 payload was being processed it became apparent that several characteristics of a commercially developed payload were influences on the processing flow. One of the earliest noted was that the commercial unit did not have the levels of staffing that could support extensive premium shift and overtime schedules. This made it necessary to try to work schedules so as to minimize the SPACEHAB organization's support during premium and overtime work periods. In this we were not always successful. However, as the processing flow progressed we tried to be as sensitive to this issue as possible. It was usually possible to schedule payload operations in the O&C building in concert with these concerns, although once installed in the orbiter the Shuttle orbiter schedules came into play and made it more difficult since the Shuttle organization had to integrate a diverse array of systems and facilities and were subject to many issues.

By the time the SPACEHAB-2 payload was being processed for launch we had been successful in sensitizing much of the Shuttle team to these concerns; however, by this time the Shuttle processing organization was experiencing pressure to reduce costs also. Therefore, the determination of which organization - payload or Shuttle - would get scheduled for premium time operations sometimes became a concern. Very close coordination and attention to planning with the Shuttle schedulers became necessary so that the two organizations could minimize premium time impacts.

In addition to actual processing time, an additional factor was the SPACEHAB personnel's need to support test team meetings, procedure reviews, and other time-consuming KSC activities. For a commercial payload developer such activity adds to the manhours required to support payload processing at the launch site.

FLEXIBILITY IN APPROACH: We spoke of "cultural" issues above and it was sometimes necessary to find creative approaches and move past the usual ways of doing things. An example was the decision to allow the SPACEHAB-2 payload to move directly to the OPF rather than go through testing at the O&C building. This allowed the payload developer more time to ready the unit in their own facility and did not require diverting their test personnel to support O&C testing. To accomplish this, however, extensive analysis of the SPACEHAB-1 interfaces was made to insure that the O&C building test operations would be exact enough to checkout the SPACEHAB interfaces without having to test each successive SPACEHAB at the O&C building. KSC and SPACEHAB personnel worked together to generate a test approach that would accomplish this and the KSC payloads organization performed an analysis to show that it would do the job.

An additional approach that allowed the SPACEHAB-2 to move directly to the orbiter was to change the way the STS-60 GBA was installed in Discovery. GBAs have always been installed in the orbiter during the OPF flow. This allowed their installation in the same lifting operation as that used for other OPF-installed payloads. Had we done the STS-60 unit the same way, it would have been necessary to bring the SPACEHAB-2 to the O&C to be joined with the GBA in the transfer canister so that they could have been taken to the OPF and installed together. This would have added almost a week of transport and transfer operations to SPACEHAB-2 and involved tieing up SPACEHAB personnel in an additional handling operation. Although an change of installation procedures for GBA was necessary to install it at the pad, this approach eliminated the O&C SPACEHAB-2 transfer operations.

FUTURE SPACEHAB MISSIONS: Future SPACEHAB missions may not always have the chance to go directly from their facility to the OPF. SPACEHAB future missions involve flights with the EURECA, Wake Shield Facility, and ORPHEUS-SPAS payloads among others. As manifests are developed we will attempt to schedule a direct facility-to-orbiter installation for SPACEHAB if possible. However, if other payloads on the mission require an OPF installation scenario this may not be possible.

LAUNCH PAD INTEGRATION INTO THE ORBITER: We have been asked to assess the possibility of installing future SPACEHAB modules into the orbiter at the launch pad. This would involve a later delivery of the module and facilitate their pre-delivery operations. A possible obstacle to this approach; however, is the need to do a combined orbiter-SPACEHAB pressure decay check since the GSE can't easily be installed at a launch pad service structure. Therefore requiring an OPF operation.

MODULE VERTICAL ACCESS KIT OPERATIONS: The use of the MVAK equipment for late SPACEHAB access during countdown gives that program added flexibility and allows it to service a much larger pool of potential users. However, the basic support package that SPACEHAB had with KSC only funded one MVAK operation for the SPACEHAB organization. If SPACEHAB required another MVAK they would be charged an optional service fee. This did happen on STS-57 when some modification work became necessary on one of the experiments.

The payload processing team felt that there was a possibility of the first late MVAK stowage operation running long and impacting the rest of the countdown; however, and possibly causing a missed launch date. Therefore, during the STS-57 flow a practice MVAK operation was done at the launch pad in order to ensure that the MVAK late stowage in SPACEHAB could be done in the time planned.

Although the MVAK demonstration was not primarily a stowage operation, we took advantage of the opportunity to stow what could be installed in the module at that point. This relieved some of the pressure on the late stowage during countdown.

No such demonstration was originally planned for STS-60 and the late access MVAK timeline was sufficient for SPACEHAB to accomplish their module stowage. However KSC incorporated an upgraded MVAK unit into its operations during the STS-60. It was felt prudent to check the new MVAK before final stowage use and we took advantage of the opportunity to do some module stowage approximately a week ahead of the countdown. This allowed us to ensure that the late MVAK stowage operation could be done within the allotted time without impacting other countdown activities.

INTERACTION & IMPACTS OF OTHER PAYLOADS: Although the capability to do late access stowage using the MVAK enhances the SPACEHAB operations there may be an impact on other payload operations. For the STS-57 mission the SHOOT payload had been planning to complete its last cryogenic service operations at the launch minus 60.5 hour point. This allowed the SHOOT to make maximum use of its cryogenic reserves during the mission. After an analysis of the timelines in the launch countdown, however, it was found that the launch minus 60.5 hour point would prevent the orbiter payload bay doors being closed in time to support fuel cell operations that had to be completed prior to the SPACEHAB MVAK operations. In order to incorporate the MVAK operations the fuel cell and payload bay door activity had to be moved earlier. This in turn forced the SHOOT service to end at about the launch minus 64 hour point. Fortunately SHOOT was able to modify some service and operation procedures to meet this.

Another illustration of mutual payload impacts was the download, or deintegration, of the STS-57 payload complement. Following the mission the entire payload complement was lifted out of the orbiter and placed into the payload transfer canister. It was then moved to KSC's payload Vertical Processing Facility where the various payloads were removed from the canister, one-by-one, and placed in their individual transporters. The mission involved the successful retrieval of the EURECA satellite; however, EURECA held residual propellants after retrieval. Therefore, EURECA was removed from facility first. This, in combination with orbiter post flight operations, led to the SPACEHAB-1's return to its facility on July 12, 1993 after a July 1, 1993 orbiter landing.

RECOMMENDATIONS

Based upon our experiences with processing the payload mix on Shuttle missions STS-57 and STS-60 several recommendations for future commercial-government Shuttle payload complements may be made.

Early interaction between the commercial payload developer and the KSC payload processing organization is important. For example; we were able to work out many of the organizational roles and responsibilities, as well as operational philosophy, dealing with the SPACEHAB launch pad MVAK operations before the SPACEHAB arrived at KSC. This, however, took many meetings over an extended period of time. Working these issues right before the operation would have been extremely difficult.

It is also necessary that the KSC payload organization keeps the commercial payload developer aware of the processing characteristics of the other payloads on the mission. After the STS-57 flight the SPACEHAB-1 module was returned to its developer later than they had expected; largely due to EURECA deintegration factors. This could have been made known to SPACEHAB earlier.

Although management levels at the KSC were aware of the personnel and financial limits under which commercial payloads must operate, more effort in sensitizing the working level KSC personnel would help in trying to reduce the financial impact of the launch site environment. This is particularly true in regard to joint orbiter and payload planning personnel.

Conversely, it is critical that the KSC payloads organization have a full and complete understanding of resource limits which impact the commercial payloads operational flexibility.

These concerns may become greater in the future as the budgetary limitations, under which we all operate, become more stringent.