Apr 28th, 3:00 PM

Paper Sessions IV-B - Shuttle and Space Station Scientific Payloads: Their Role in the Next Generation

R. L. Schuiling
NASA, John F. Kennedy Space Center

SHUTTLE AND SPACE STATION SCIENTIFIC PAYLOADS: THEIR ROLE IN THE NEXT GENERATION

R. L. Schuiling

NASA
John F. Kennedy Space Center

ABSTRACT

This paper presents an overview of the scientific payloads which will be flown aboard the Space Shuttle in the next era of spaceflight operations. In addition, planning for Space Station payloads is now far enough along for us to identify many of the Space Stations' major payload initiatives. Those payloads which are currently manifested for flight have their planned launch years noted. The Shuttle payloads may be either deployed from the Shuttle, deployed and retrieved for return to Earth, or they may remain in the payload bay for the entire mission, depending on the individual payload mission research objectives.

INTRODUCTION

The Space Shuttle provides a flexible payload transport capability that is adaptable to a wide variety of payloads and payload requirements. Utilization of Shuttle-provided services also may relieve a payload developer of the necessity to design, develop, and fund power generation systems, command systems, telemetry systems, and cooling systems as these may be provided by the Shuttle itself.

Shuttle payloads are primarily carried in two areas. Large payloads, or those requiring direct access to space are carried in the Shuttle orbiter's payload bay. This area is 15 feet in diameter and 60 feet long. Those payloads which are small, require human access during flight, and require minimal orbiter services may be carried in lockers located in the orbiter middeck area. The middeck is located just below the flight deck, contains the crew entrance to the orbiter, and is the primary crew activity area during the flight. The number and variety of middeck experiments is so large, that space considerations preclude describing individual middeck payloads in this paper.

The inherent flexibility and adaptability of the Space Shuttle system to payload operations means that a wide variety of paylaod types will be using it. This, of course, makes catagorization of the payload community difficult. Configuration, discipline, and operational concepts vary so much that a strict taxonomy of payloads would place many in more than one catagory. In addition, there are some "families" of payloads wherein a program has a number of similar payloads with interchangable components.

In general, however, payloads are usually flown on some carrier which provides needed subsystem support to the experiment operation. These carriers can usually be used repeatedly on subsequent Shuttle missions after they have been assembled with a new complement of experiments. Deployable payloads or those which plan to fly on only one flight may use their own dedicated flight experiment carriers.

Payload carriers which are often used include Spacelab modules, Spacelab pallets, Mission Peculiar Equipiment Support Structures (MPESS), and Get Away Special (GAS) support beams.

Spacelab modules provide pressurized experiment space with access from the orbiter middeck area for the crew via a pressurized tunnel. The Spacelab pallet provides Spacelab systems services for experiments which are mounted on a broad-U shaped unpressurized structure, while a pressurized container which is termed an "Igloo" holds the Spacelab computers and other components requiring pressurization. Individual Spacelab missions may be made up of pressurized modules, unpressurized pallets, special purpose support structures, or a mix of these. When Spacelab pressurized module missions are flown, they may use one (termed a short module) or two (termed a long module) of the pressurized modules. An additional feature of the Spacelab program is the provision of an Instrument Pointing System (IPS) upon which experiments requiring pointing capability may be mounted. The IPS would only be flown on those missions requiring this capability.

In addition to their use in the Spacelab program, the unpressurized pallets are also used without the Spacelab systems services. In these instances they may support experiments which do not require the services of the Spacelab systems, or which provide their own systems support.

The MPESS is a trusswork support which is often used as a carrier for a variety of smaller payloads in the orbiter payload bay. It is basically a cross-payload-bay support structure, however, a number of subsystems may be flown in support of particular payloads.

The GAS beam is a payload bay wall-mounted carrier which is used to support GAS canisters or other small payloads. It is a mechanical mounting system and does not provide susbsytems as such.

SPACELAB PAYLOADS

The Spacelab program has a number of flights manifested. The initial Spacelab mission is ASTRO-1 which is set for 1990. ASTRO-1 consists of three ultraviolet astronomical instruments which are mounted on an IPS. ASTRO-1 is a two-pallet payload with an Igloo. An addition to ASTRO-1 is the Broad Band X-Ray Telescope (BBXRT). The BBXRT had been planned to fly on a different payload at a later date, however, the increase in the allowable landing weight of the Shuttle orbiter Columbia made possible the addition of added capability to ASTRO-1's mission. The attractiveness of the SN1987A supernova made BBXRT a desirable addition to ASTRO-1.

BBXRT has its own support structure and pointing system, but it is connected to ASTRO-1 and it is being handled as part of the ASTRO-1 from a programmatic standpoint. The second ASTRO mission, ASTRO-2 is planned for 1992. ASTRO-2 will have the same ultraviolet astronomical instruments as ASTRO-1, but will not have the BBXRT, which will fly again on a different payload. ASTRO-3 is in the planning stages, but not yet manifested.

The first Spacelab Life Sciences mission SLS-1 is also set for 1990. SLS-1 will investigate the effects of weightlessness on both human and animal subjects. SLS-1 will consist of two Spacelab pressurized modules forming a long module. The orbiter crew will access the SLS-1 after it reaches orbit by way of the connecting tunnel. Once in the SLS-1, the crew will work with experimental equipment and animal facilities which are located in racks located on either side of a central aisle. SLS missions SLS-2 and SLS-3 are manifested in 1992 and 1993. These also use the long module configuration.

Also manifested for a 1990 flight is the Department of Defense Starlab mission. Starlab consists of a long module and a pallet and it will conduct a variety of experiments in optics and tracking.

The Atmosphere Laboratory for Applications and Science (ATLAS) series of Spacelabs has its debut planned for 1990, also. ATLAS-1 is the first of a series of missions designed to measure solar output and Earth atmosphere conditions over an 11 year solar cycle. The ATLAS series is currently manifested for flights in 1991, 1992, and 1993. The ATLAS-1 configuration is an Igloo and two pallets. Future ATLAS missions may vary the number of pallets flown, however, an Igloo and at least one pallet are planned in each instance.

The adaptability of the Space Shuttle orbiter payload capability to international activity is shown by the flights of Spacelabs J and D2 in 1991. The SL-J mission is a microgravity material science and processing mission utilizing a long module pressurized Spacelab. Japan will provide a number of racks of materials science experiments as well as life sciences experiments. NASA experiments in life and material science will also be flown on SL-J.

The SL-D2 mission is basically a German mission using Spacelab components. the emphasis will be on materials science, however, some life sciences, robotics, and observational experiments will be flown also. The SL-D2 mission will consist of a pressurized long module and a German-supplied unpressurized support structure mounted behind the long module. Spacelab-D3, a follow-on, will fly in 1994 with a similar configuration.

The Spacelab program provides an opportunity to begin to develop the skills and the equipment needed in preparation for operations in the Space Station pressurized modules. Major payload programs which will be active in these developmental activities include the International Microgravity Laboratory and the United States Microgravity Laboratory projects.

The International Microgravity Laboratory (IML) currently has several flights manifested. These missions, all pressurized long module flights are planned to begin with IML-1 in 1991, followed by IML-2 in 1992, and IML-3 in 1994, The IML series are designed to conduct research in microgravity conditions; primarily in the material and life science fields.

The United States Microgravity Laboratory (USML) series is being developed to study microgravity Space Station applications and emphasizes government, academic, and commercial participation within the United States. The USML Spacelab missions are planned to last 12 to 13 days by utilizing an extended duration orbiter capability. Additional expendable supplies will allow these missions to exceed the seven to nine day period planned for most Spacelab missions. The USML series uses the pressurized long module configuration with an added MPESS capability. USML-1 is planned for launch in 1992 and USML-2 in 1993.

The High Resolution Solar Observatory (HRSO) also uses the Igloo with the spacelab pallet, together with the IPS. HRSO will make very accurate and very stable images of the sun in the visible wavelength range to determine physical processes at work on the Sun. The HRSO is currently in the planning stage and is not yet scheduled for flight.

Also in the planning stage and using the Igloo and pallet configuration is the Space Plasma laboratory (SPL). SPL will have its experiments mounted on a pallet to study the plasma processes which occur in the near-space environment.

The Sunlab payload is being developed to obtain scientific data in the field of solar physics. Its instruments will be mounted on an IPS supported by a pallet-Igloo combination. Although Sunlab is being planned for a series of flights, it has not yet reached the point of being assigned a launch date.

PALLET PAYLOADS

In addition to their role in Spacelab Program payload flights, the U-shaped pallet is also utilized to carry non-Spacelab payloads. These pallets, when not used in support of a Spacelab program mission, would not normally utilize the Igloo which contains Spacelab computer, memory, and other Spacelab support systems. Suport systems would largely be provided as a subset of the individual payload's components for the specific payload to be mounted on the pallet.

The Tethered Satellite System (TSS) makes innovative use of the dynamics of orbital mechanics to investigate regions of the Earth's upper atmosphere and the space environment at a distance from the Space Shuttle. The TSS consists of a satellite which is reeled out and away from the Shuttle while attached by a tether to the reel. Orbital mechanics principles assist in carrying the satellite away from the Shuttle, in either an upward or downward direction. After completing the investigations, the satellite is reeled in and returns to Earth with the Shuttle. The first TSS flight, TSS-1 is planned for 1991 and includes the satellite and its reel system mounted on a pallet, together with a series of science experiments mounted on an MPESS.

During the mid-1980s, two Shuttle flights carried experiments which engaged in radar mapping activities. A continuation of that work will be done by the Shuttle Radar Laboratory (SRL) flights. The SRL will conduct Earth imaging radar research utilizing a pallet-mounted radar antenna. The parameters studied will provide geophysical data for current analysis and will also provide a database in support of the proposed Earth observation activities aboard the Space Station. SRL flights are manifested for 1992, 1993, and 1994.

The Aero Assist Flight Experiment (AAFE) will use pallets to carry a deployable spacecraft that will study the use of an aerobrake surface in order to build a database on the use of the atmosphere for slowing returning spacecraft. the AAFE will carry thrusters that will enable it to be powered through the upper atmosphere. It will later be recovered by the Shuttle for study. The AAFE flight is planned for 1993.

The Lidar In Space Technology Experiment (LITE) will utilize a laser transmitter and a telescope reciever mounted upon a pallet to study lidar system operations in space. The LITE payload will measure cloud tops, planetary boundry layer height, tropospheric and stratosperic aerosols, and also temperature and density parameters. The LITE has been manifested for a flight in 1993.

An additional use of the pallet a a carrier is the MAST payload. The MAST carries an extensible truss system which will be deployed on-orbit to study the dynamics of structures, evaluate thermal distortions in space structures, and correlate ground analytical projections of structural behavior parameters with actual flight experience. The information to be provided by MAST will be of great value in the proposed use of large structures in future space operations.

MPESS MISSIONS

The MPESS can also be utilized for a number of smaller payloads. The MPESS may be equiped with the capability for using the Shuttle cooling system interface for payloads which generate high levels of heat or it may be flown without the cooling capability.

The Material Science Laboratory (MSL) series of payloads will utilize the MPESS as the carrier for their experiments. The MSL-2 payload has already been flown and a number of others, both with and without Shuttle-cooling requirements, are in the planning stage for the early 1990s.

The United States Microgravity Project (USMP) will use two MPESSs to carry microgravity experiments. USMP-1 is planned for 1992 and the USMP-2 and USMP-3 are planned for 1993.

Also utilizing the MPESS as a carrier is the Superfluid Helium On-Orbit Transfer (SHOOT) payload. The SHOOT will investigate the operations involved in transferring superfluid helium in orbital operations. Two liquid helium dewars will be mounted on an MPESS for the mission.

Another series of payloads using the MPESS is the Hitchhiker-M (HHM) series. The Hitchhiker series of payloads are designed for late addition to the Shuttle manifest. Consequently, they utilize a minimum of Shuttle services and their experiments are operated from a ground control center rather than from the Shuttle flight deck; thereby minimizing the amount of the integration effort and the time to integrate the Shuttle-payload combination. The HHM was originally to be managed by Marshall Space Flight Center and the Hitchhiker-G (HHG) was a Goddard Spaceflight Center project. However, both projects are now managed by Goddard. The two hitchhikers differ basically in their respective mounting characteristics as the HHM provides an MPESS for experiments requiring a larger mounting structure, and the HHG provides a flat plate which uses a GAS beam mount to attach to the Shuttle payload bay wall for experiments requiring a smaller mounting capability. A variety of Hitchhiker experiments are now in development for Shuttle flights, however, as they are only added to the Shuttle manifest at a late date their planned flight dates are not available.

HHM equipment, however, will be used for the flight of the Space Test Project-One (STP-1) in 1990. The STP-1 will carry several experiments for the study of atmospheric limb, spacecraft glow, and liquid feed phenomenae.

The MPESS may also be used as a GAS bridge to carry twelve Get-Away-Special canisters. The GAS canisters have minimal Shuttle interfaces and minimal experiment space. They were developed to provide low-cost access to space and the experiment must provide its own power and any other subsystem. They are turned on or off via a relay by the flight crew. The GAS canisters may be mounted on the GAS bridge, or against the Shuttle payload bay wall on a plate termed a GAS Beam.

RETRIEVAL PAYLOADS

An additional feature of the Shuttle is its capability to deploy and also retrieve payloads on-orbit. This is usually done using the Shuttle Remote Manipulator System (RMS) to lift payloads out of the Payload Bay, or to bring them back in.

The Spartan series of payloads consists of a number of low cost astronomical instruments which are mounted on the MPESS in the payload bay. Once in orbit, the instrument is unlatched from the

MPESS and the RMS takes it out of the bay and places it outside the Shuttle. The Shuttle then moves off to continue the mission and the Spartan instrument undertakes a series of observations on its own. The Spartan has pointing capability but no translational capability and the Shuttle must return and retrieve the Spartan with the RMS. The RMS replaces the Spartan on the MPESS and the instrument returns to Earth with the Shuttle. The Spartan mission instruments differ, depending upon the objectives of each flight.

A similar concept to Spartan is the European Retrievable Carrier or "EURECA", which is also deployed from the Shuttle and later is retrieved by the RMS. However, the EURECA has its own propulsion system and can move off under its own power and later return to the area of the Shuttle. The Eureca is designed for microgravity research and the first EURECA is planned to carry 15 experiments on the EURECA platform. The initial EURECA launch is planned for August of 1991, with the initial retrieval by a later Shuttle flight in March of 1992.

The Shuttle Pallet Satellite (SPAS) is also a deployable and retrievable experiment carrier. Despite its name, it does not use a Spacelab pallet but uses a European deployable carrier which is retrieved on the same Shuttle mission. The Infrared Background Signiture Survey payload will fly on a SPAS structure in 1990, the ORPHEUS experiment in 1992, the CHRISTA experiment in 1993, and the SPAS is proposed as the carrier for the German orbital materials laboratory (DOM).

In addition to deploying and retrieving payloads, the Shuttle can also retrieve satellites which are first launched on an expendable rocket. The Japanese Space Flyer Unit (SFU) is planned to be launched on a Japanese Delta-II to study the space environment. It will then be retrieved by a Shuttle in 1993.

INDUSTRIAL RESEARCH

The future Shuttle scientific payloads also include inovative operational approaches to industrial research. Two currently manifested programs are the Industrial Space Facility (ISF) and Spacehab.

The ISF concept envisions launching a pressurized space platform in the Shuttle payload bay. This will be deployed on-orbit with a series of experiments mounted inside it. It will be left, unmanned, in orbit and the experiments will operate over a period of time. On a later Shuttle mission, the Shuttle crew will retrieve the results of the experiments. Access to the ISF from the Shuttle will be through a connecting tunnel for personnel. In addition, a supply module may be carried to the orbiting ISF by the Shuttle and attached to the ISF for resupply. The supply moduele is also used to take samples and data back to Earth on the same Shuttle mission. ISF flights are scheduled to begin in 1993.

The Spacehab concept envisions an extension to the Shuttle middeck area which is placed in the forward end of the payload bay and connected to the Shuttle middeck area by way of the current airlock hatch leading from the middeck into the payload bay. This is the same location that the Spacelab pressureized modules use for the access tunnel connecting them to the middeck. During flight, the Spacehab will provide direct access from the middeck to an expanded area in which middeck-type experiments may be mounted. The Spacehab initial flight is planned for 1991.

ASTRONOMICAL STUDIES

In the area of astronomical and plannetary studies, a variety of payloads are planned for the future. In addition to those payloads in the Spacelab and Spartan programs which are aimed for astronomical areas, planetary probes and a number of orbiting observational satellites are planned.

The Galileo planetary probe is currently scheduled to be deployed from the Shuttle payload bay in October of 1989. The Galileo will use an Inertial Upper Stage (IUS) to propel the spacecraft on a mission to the planet Jupiter. Upon arriving in the vicinity of Jupiter, a probe will be released which will investigate the planet, its satellites, its atmosphere, and its environment. Experimental data will be sent by the probe back to the Galileo spacecraft for relay to Earth.

The Ulysses (formerly the International Solar-Polar Mission) will be deployed from a Shuttle in 1990 and will utilize an IUS/PAM upper stage to take it on a trajectory that will allow it to investigate the areas of the Sun's poles. The spacecraft will be put into a trajectory that will take it out of the ecliptic plane and it will orbit the Sun over its North and South poles.

The X-Ray Timing Explorer (XTE) payload is designed to study time periodic X-Ray pulsations from black holes, galactic centers, and other compact sources. The XTE is planned to be deployed from a Shuttle in 1994.

The Hubble Space Telescope (HST), currently planned for December of 1989, will place a 2.4 meter optical telescope into orbit about the Earth. The HST will be deployed from the Shuttle by the RMS and will transmit observational data back to a control station on the ground. The HST is designed to operate for a period of fifteen years. An additional capability of the program is the provision for periodic planned maintenance missions and for unplanned repair missions using a Spacelab pallet carrier.

The Gamma Ray Observatory (GRO) is scheduled for a 1990 launch to study gamma ray emmissions from steller and galactic sources. The GRO is planned to be deployed from the Shuttle and the expected lifetime in orbit is several years.

The Advanced X-Ray Astrophysics Facility (AXAF) is proposed to study emmisions of astronomical sources in the X-Ray spectrum. The contract for the AXAF has only recently been let and the program is not yet manifested for a Shuttle flight. As with the other observatory satellites, the AXAF will be deployed by the Shuttle and will relay observational data back to Earth.

The Series of payloads including the HST, GRO, and AXAF has been termed "The Great Observatories" as they will open up consistent observational capability from above the Earth's atmosphere in three major areas of the spectrum. A fourth prposed observatory, the Space Infrared Test Facility (SIRTF) has not yet been appoved for development and flight. If SIRTF were developed, however, it would extend the spectrum of observational capability for the Great Observatory series into the infrared area.

Also not yet approved for development but under study is the Comet Rendezvous and Flyby (CRAF) payload. The CRAF would involve a rendezvous with a comet by a spacecraft carrying a penetrating probe. The spacecraft would carry out observations of the comet from close range and also fire the probe into the comet body. The probe would send data to the spacecraft for relay back to the Earth.

A additional astronomical payload designed to be carried in the payload bay for one mission is the Shuttle High Energy Astrophysics Laboratory (SHEAL) which uses the BBXRT experiment together with payload bay wall mounted X-Ray spectrometers.

UPPER ATMOSPHERE

The Upper Atmosphere Research Satellite (UARS) is scheduled for deployment by the Shuttle in 1991 to study the upper atmosphere, its role in climate, and the impact of human activities upon it.

The Wide Angle Michelson Doppler Imaging Interferometer (WAMDII) will utilize the same carrier and subsystems as the BBXRT to study winds, temperatures, and turbulence in the atmosphere in 1991. WAMDII is a non-deployable payload and the carrier, pointing system, and susbsystems will return with the Shuttle for future use.

SPACE STATION

The introduction of the Space Station capabilities into orbital operations in the mid-late 1990s will provide a greatly increased opportunity for scientific research. Planning for the payloads to be supported by the Space Station has been underway for some time. Shuttle-carried scientific payloads for Space Station operation fall into two major catagories. Those payloads which will be utilized inside the pressurized modules of the station form one major area. Current plans envision a number of dedicated facilities within the station, as well as the capability to mount and support a variety of experiments in racks within the pressurized volume of the station.

Facilities envisioned for the station include a 1.8 meter centrifuge, a furnace facility with eight furnaces, a fluid physics/dynamics facility,a containerless processing facility, a biotechnology facility, and crystal growth facilities.

The second major catagory of station payloads are those attached to the exterior of the station in an unpressurized environment. A variety of experiments are proposed for this catagory including the Solar Terrestrial Observatory (STO), the Advanced Solar Observatory (SO), and experiments involving Earth observation studies, tropical rainfall measurement, astrometric telescope observations, and cosmic dust collection. A number of novel approaches to astronomical study are proposed such as an occulter facility which will use a boom to position a mask for coronal studies and the conversion of one of the Shuttle external tanks into a Gamma-Ray imaging device with forty times the sensitive area of the GRO. Also proposed for assembly at the Space Station, followed by transfer to a higher orbit, is the twenty meter Large Deployable Reflector (LDR), which is made up of a sixty segment mirror.

In addition, it is proposed that a number of locations on the station's exterior be used to support sensors measuring the interaction of the station itself with the plasma environment.

An added Space Station program is that of Small and Rapid Response (SARR) payloads. The SARR payloads are proposed to be those which can be manifested onto the Shuttle flight schedule at a very late date and then transported to the station in standard carriers. The SARR payloads which require external mounting would be mounted on the station trusswork. SARR capability would also be offered for internal experiments.

It is also interesting to note that the planning for Space Station operations frequently makes use of a number of individual experiments which have flown on previous Shuttle flights as components of other missions. Thus, the economy of recoverable experiments and the advantage of being able to extend an experiment's investigations based on its past findings is amply illustrated

CONCLUSION

The role of scientific payloads in the Space Shuttle and Space Station operations will continue to expand. We have seen that the flexibility of the Shuttle in supporting a wide variety of instruments and the capability of reflying experiments when additional avenues of interest appear have made the complete Shuttle-payload system one of the nations greatest research assets. Over the next generation of operations the potential of the planned scientific payloads together with the addition of the Space Station to complement Shuttle operations will provide continued flexibility for an expanded program of research in the space environment.