THE EVOLUTION OF SMALL PAYLOAD CARRIER SYSTEMS

by

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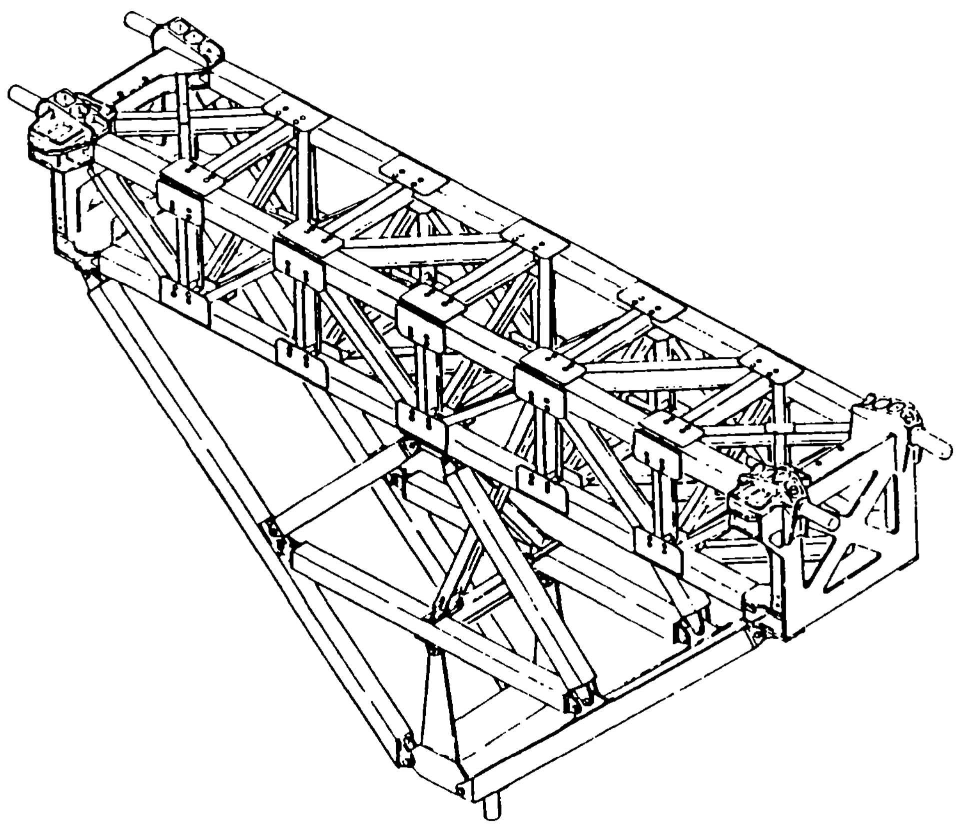
IN THE BEGINNING . . . . MPESS

The need for a special structure for small Shuttle payloads began to emerge in October 1978 during the development of the design requirements for two material science experiments. In contrast to a dedicated Spacelab Mission this payload was to occupy only part of the Orbiter cargo bay.

These requirements led to the design of a bridge-like structure which would span the cargo bay but occupy only 3 feet of its length. The new structure was named the "Missions Peculiar Equipment Support Structure" (MPESS).



The basic design requirements were as follows:

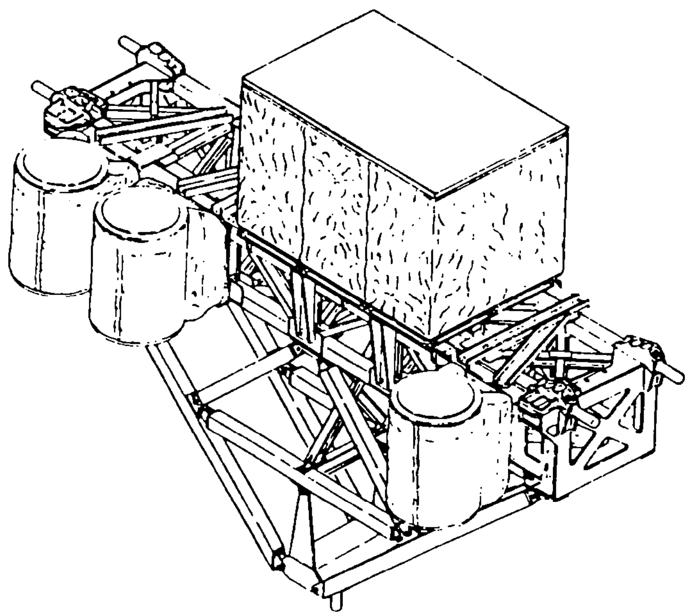
- Support structure for small number of experiments

- Occupy minimal length of cargo bay

- Standard interface hole pattern
- Provide support at an elevated position
- Employ standard Spacelab pallet trunnion
- Natural frequency between the STS liftoff and landing frequency.

The bridge-like structure is a riveted and bolted truss with machined end fittings which interface with the Spacelab trunnions. The structure is fabricated from aluminum alloy and assembled with stainless steel fasteners.

The first payload to use the support structure was the MSFC managed "OSTA-2" Material Science payload.



Teledyne Brown Engineering's (TBE) dedicated team began their work on the integration of the OSTA-2 (Office of Space and Terrestrial Applications) payload over three years ago, with a basic concept of the written objective, the type of scientific instruments to be flown, and understanding of the Orbiter system and capability.

Sponsored jointly by NASA and the West German Ministry for Research and Technology, OSTA-2 was a payload system carrying two main sets of experiments for the investigation of materials processing in the low gravity environment of space.

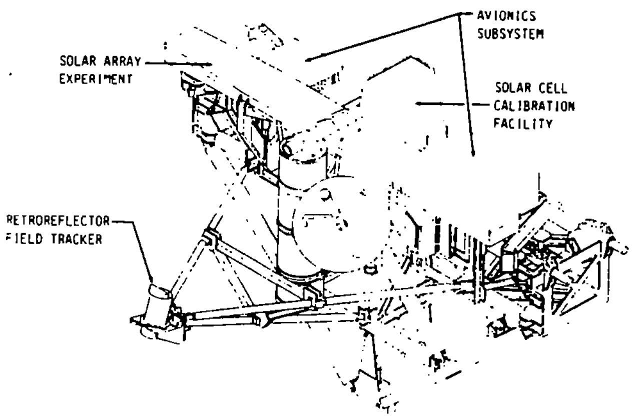
The Materials Experiment Assembly (MEA) experiment, sponsored by NASA, studied new ways of mixing metals in zero-gravity to make advanced alloys and semiconductors not possible on Earth.

The second part of the OSTA-2 was referred to as the MAUS Experiment. MAUS stands for the German Phrase Meterialwissenchaftliche Autonome Experimente unter Schwerelosigkeit (Autonomous Material Science Experiments Under Zero Gravity). The MAUS Experiments studied fluid dynamics, the way metals mix and disperse, in zero-gravity environment.

On June 18, 1983, STS-7 was launched, the first Space Shuttle to carry a major payload system (OSTA-2) integrated by PMIC (Payload Mission Integration Contract) of TBE's Space Programs Division.

The next experiment assembly to find the MPESS compatible to its requirements was the OAST-1 payload. This configuration consists of solar array and solar cell experiments. Unlike OSTA-2, external avionics equipment is required to monitor and control the operation of the experiments.

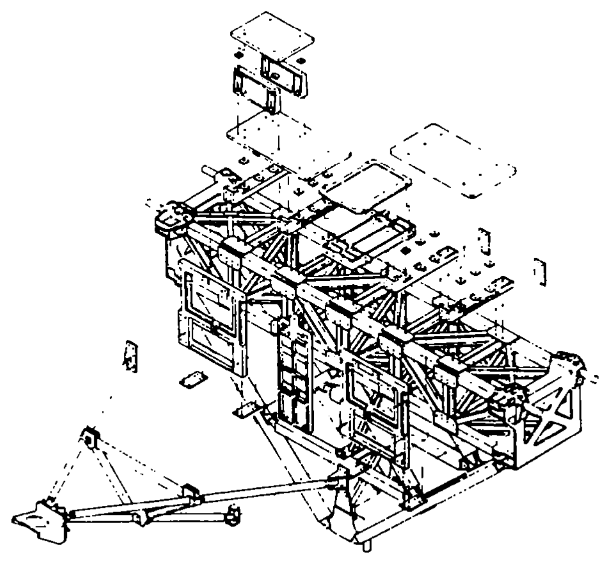
The OAST-1 (Office of Aeronautical and Space Technology) will be carried on the Shuttle in the summer of 1984 and will be the first Shuttle payload dedicated to space technology objectives. It will deploy a large solar array structure (31.5 x 4.0 meters) in space.



A common requirement for many future space projects is the need for large, deployable solar array panels. In order to support such requirements, the OAST-1 payload will demonstrate and obtain dynamics data for such a structure.

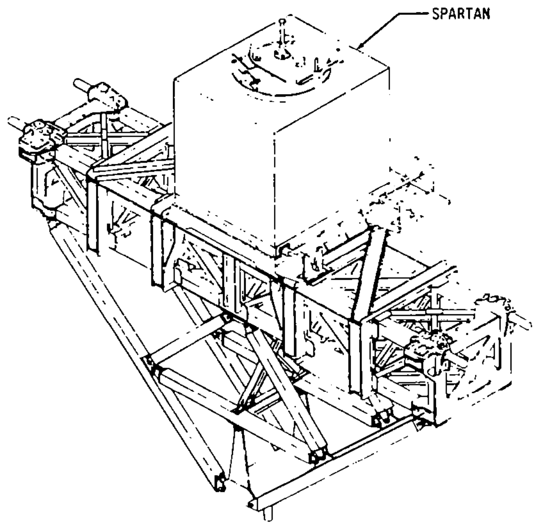
The OAST-1 mission will also carry a solar cell experiment whose objective is to validate calibration techniques used for high altitude balloon flight test for solar cells.

A major aspect of the payload integration task is the design and development of mission peculiar hardware: unique interfacing hardware beyond the basic support structure.

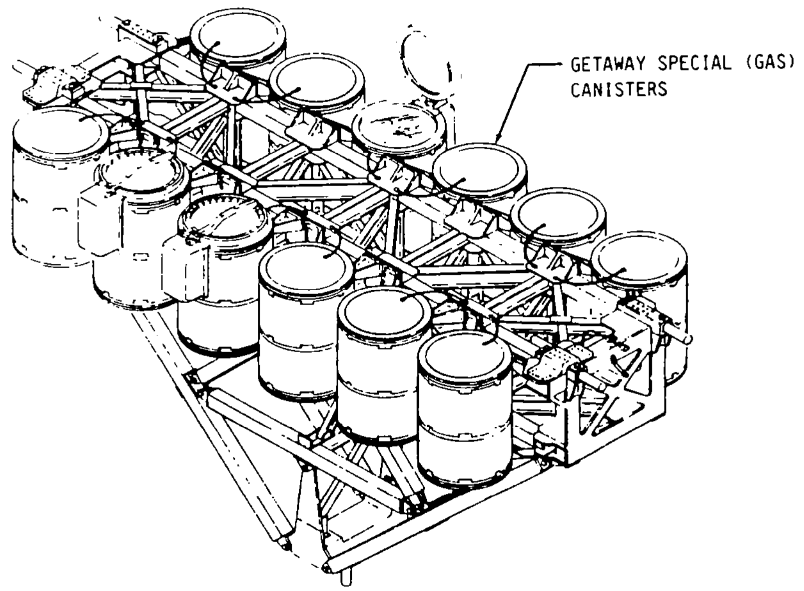


The MPESS has recently been adapted for two Goddard Space Flight Center (GSFC) programs – the Spartan and Gas Bridge.

In the Spartan application, the MPESS will carry a deployable free-flying satellite. The Spartan flight support structure is an adaptation of the MPESS that carries an MSFC release/engage mechanism (REM) with a Spartan carrier attached to the REM. The REM allows the Spartan carrier to be deployed with the RMS.



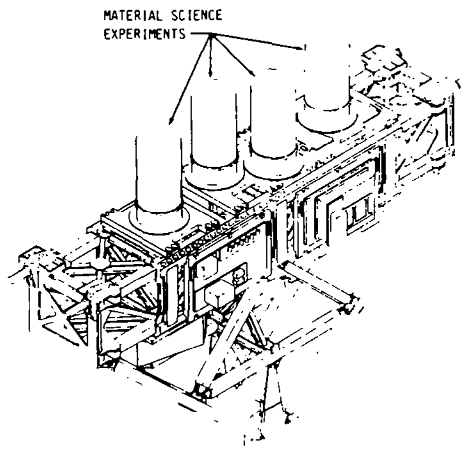
In the Gas Bridge program up to 12 canisters will be mounted on the sides of the MPESS. The Gas Bridge Assembly (GBA) was developed for any combination of 5 to 12 gas canisters, weighing 350 to 400 lbs with varying c.g. envelopes. The GBA design accounts for maximum thermal environments (hot and cold) and it is reusable up to 20 missions with a minimum of recertification and refurbishment. The GBA design is based on the MPESS structural concept, which was upgraded to carry 4500 lb for a total payload weight of 6200 lb.



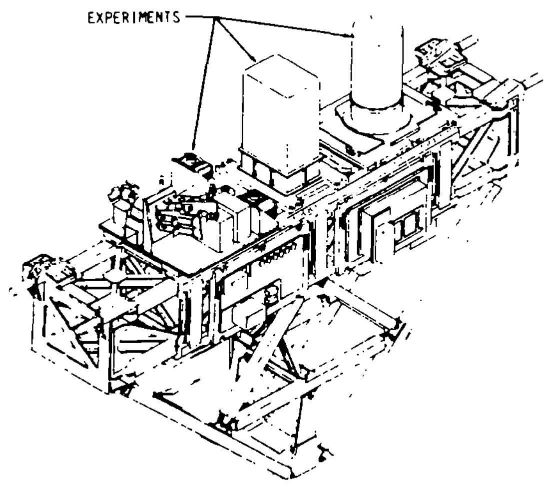
EVOLUTION TO SMALL PAYLOAD CARRIER SYSTEMS

Design considerations were eventually given to the development of a carrier system which integrated the basic MPESS with standard subsystem capability: power distribution, command and data, thermal control, etc. This activity resulted in the TBE proposed carrier system named the Small Payload Flight System (SPFS), the Hitchhiker Carrier Design and the new MSFC Materials Science Laboratory (MSL).

Teledyne Brown Engineering is now completing the development of the Material Sciences Laboratory (MSL) for MSFC. The MSL is based on the MPESS, but will include subsystems for power distribution, command and data handling, high density tape recording of data, environmental control, and low-gravity acceleration measurement. The MSL is scheduled to carry the MSL-2 payload in December 1984.



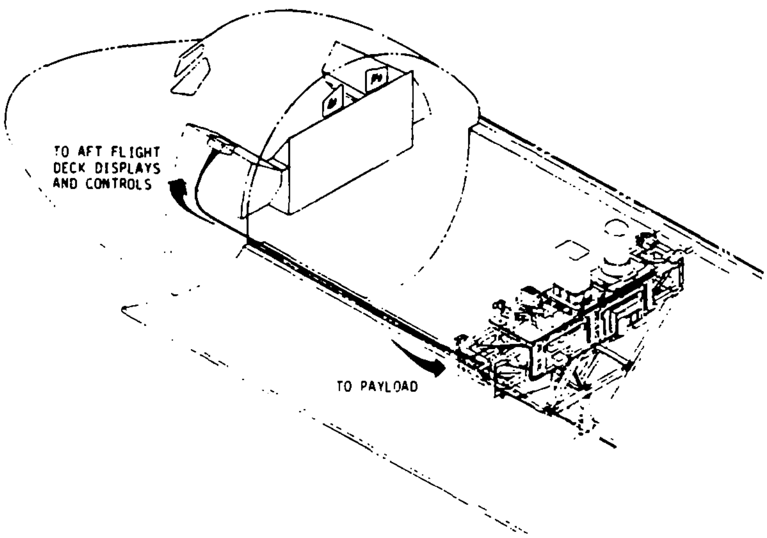
The evolution of the MPESS-based carrier fleet has led Teledyne Brown Engineering to study the potential need for a commercial carrier system which would be owned and operated by the company and designed to provide low cost, quick turnaround, and frequent flight opportunities to the user. The result of this research is the small payload flight systems (SPFS) representing a step forward in the MPESS carrier evolution and designed toward the ultimate goal of commercialization in space.



SPFS SYSTEM DESCRIPTION

SPFS is a carrier system to which experiment equipment can be mounted in the Orbiter cargo bay. It is short in length, can be located in a wide range of stations, and offers the standard one-quarter section allocation of STS resources. In addition, the system is designed to meet launch dates as close as 6 months from manifesting.

Standard experiment-to-carrier interface and a fixed configuration for subsystem equipment are fundamental to the SPFS concept. These features minimize the cost and shorten the schedule for payload integration, and also reduce the time from manifesting to return of experiment data and hardware. The SPFS carrier system with candidate experiment systems mounted and integrated is shown below:



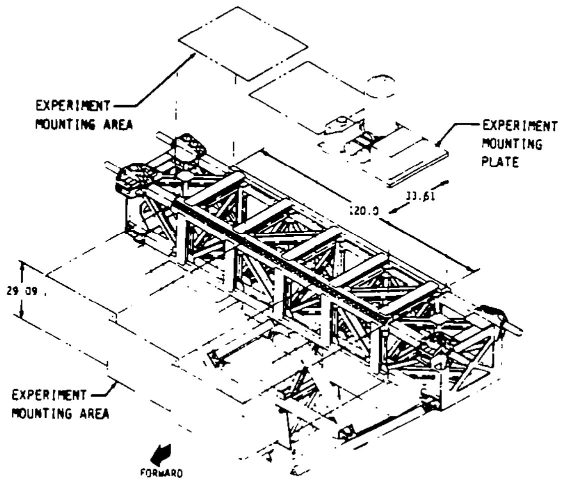
The SPFS with subsystems will support up to three experiments on each mission. Subsystem provisions will include a standard structural mounting system, electrical power switching and distribution, command and data management and environmental control. The subsystem provisions and the nominal envelope of accommodations available to the experiments are as follows:

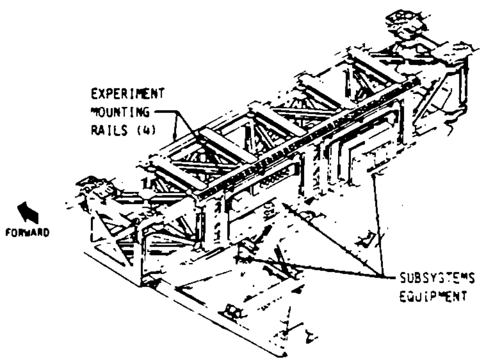
Subsystem	Total Available
Structural/Mechanical	
Mass capability (lb)	3,000
Mounting area (ft^2)	58
Electrical Power	
DC power, peak (W)	2,427
DC power, continuous (W)	1,550
Total energy (kWh)	115

Command/Data Management	
Switch/indicator pairs	10
Health data channels	176
Exp. command channels	128
Exp. command channels	16
Timing channels (GMT or MET)	3
ECS	
Coldplates	2
Coldplate heat rejection (kW)	2.1
Cooling internal (kW)	2.1

STRUCTURAL/MECHANICAL SUBSYSTEM

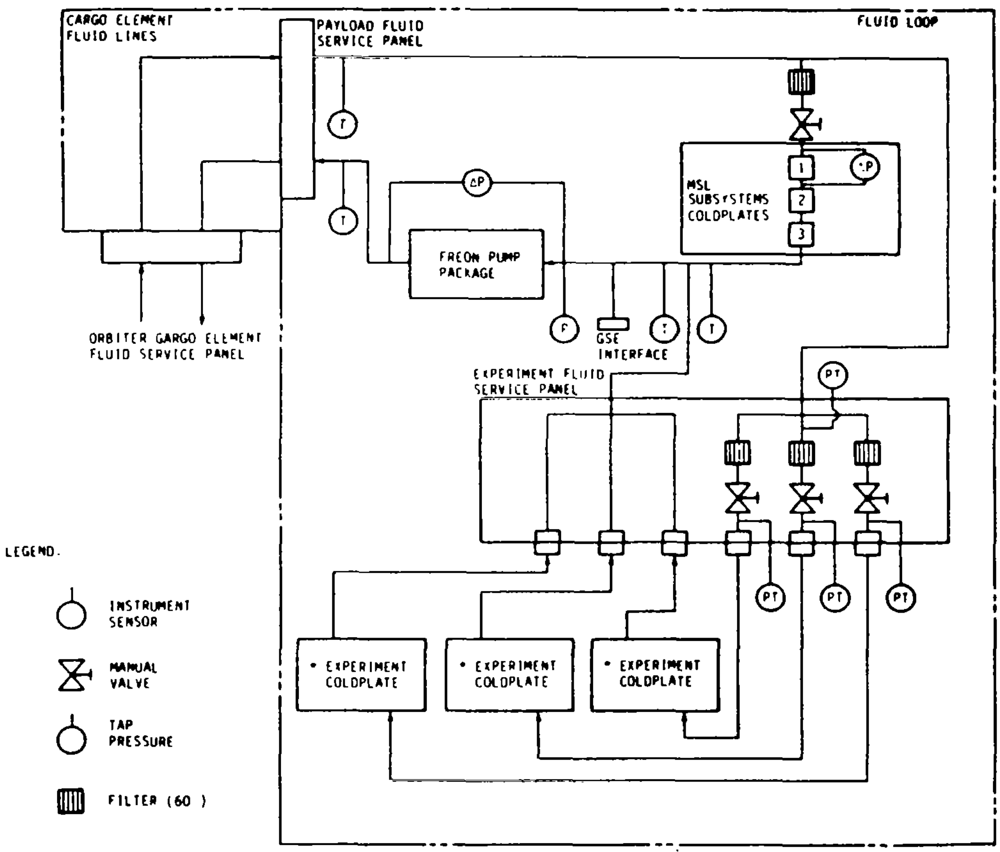
The SPFS carrier provides standard structural mounting for small experiment systems. A structural rail and plate system provides a standardized interface approach which reduces new hardware requirements and recurring analysis for reflight of the carrier.





ENVIRONMENTAL CONTROL SUBSYSTEM

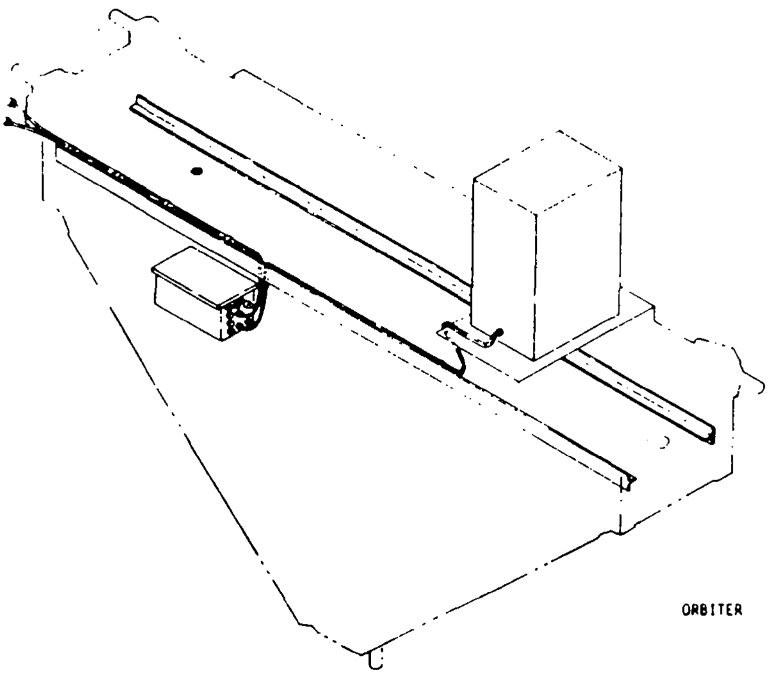
A freon coolant loop system circulates coolant between the SPFS subsystem coldplates, the experiment coldplates, experiment heat exchangers and the Orbiter payload heat exchanger. Freon circulation is provided by the SPFS pump. Multilayer insulation, heater elements, and surface coatings are used, as necessary, for additional thermal control.

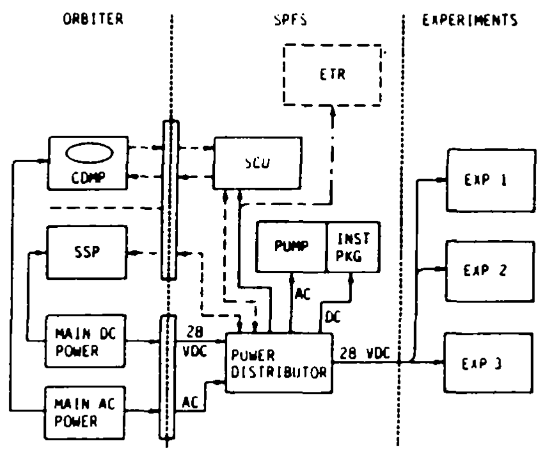


* OR EXPERIMENT FLUID LOOP IN LIEU OF EXPERIMENT COLDPLATE

POWER CONTROL SUBSYSTEM

The SPFS concept includes a power distributor to provide 28 Vdc power to the subsystems and experiments. Latching relays in the distributor enable individual circuits to be energized from the AFD by crew commands. A switch on the AFD standard switch panel will activate the power distributor main power, while commands which control power circuits to the experiments are entered at the Command Display Management Panel (CDMP).

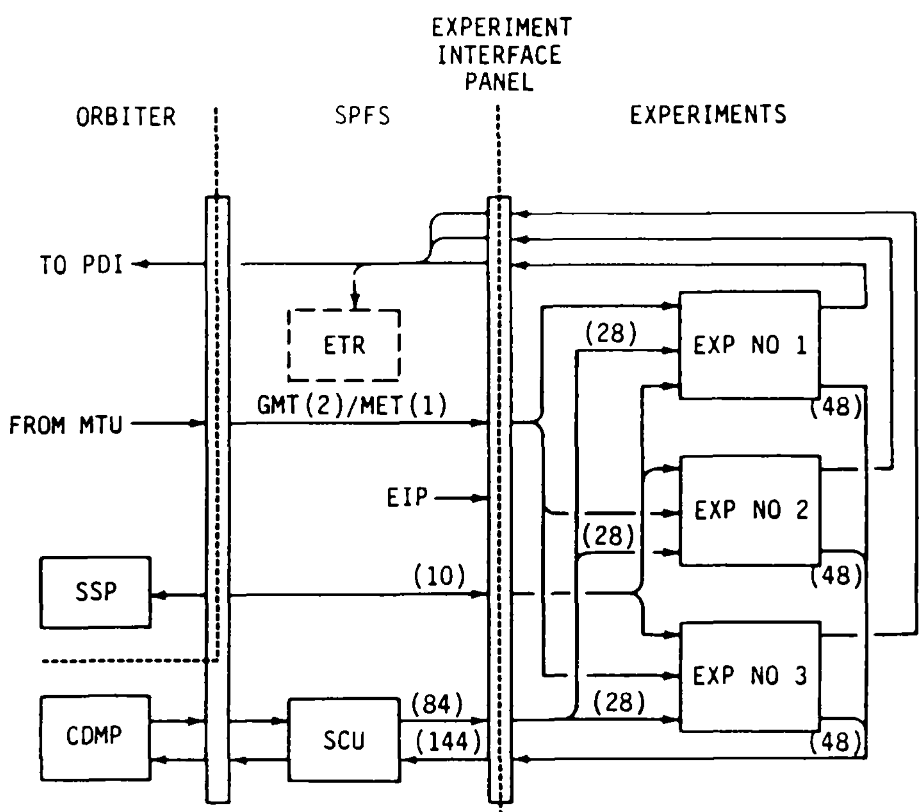




COMMAND AND DATA SYSTEM

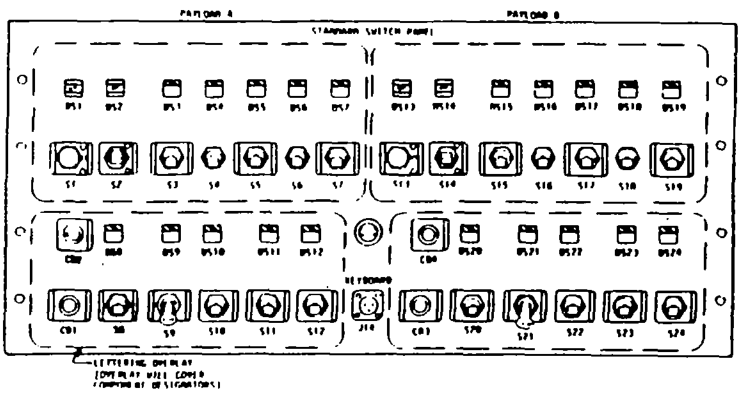
Experiments are expected to range from those that are autonomous to those that will require the full SPFS resources. The following SPFS command and data accommodations are presently planned:

- Aft flight deck standard switch panel operations
- Crew control using the CDMP
  - Crew initiated commands and command sequences
  - Onboard display of health/status data.
- Experiment data downlinking at up to 16 kbps
- Experiment PCM data recording at up to 512 kbps
- Experiment timing accurate to $\pm$ 10 msec
- Preflight interface verification at the user facility
- Crew training.



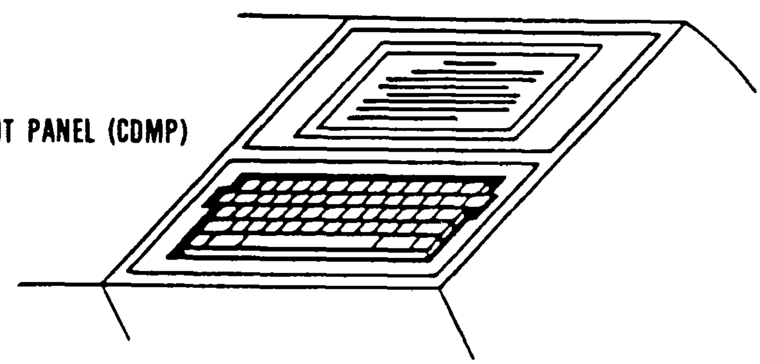
CREW INTERFACE

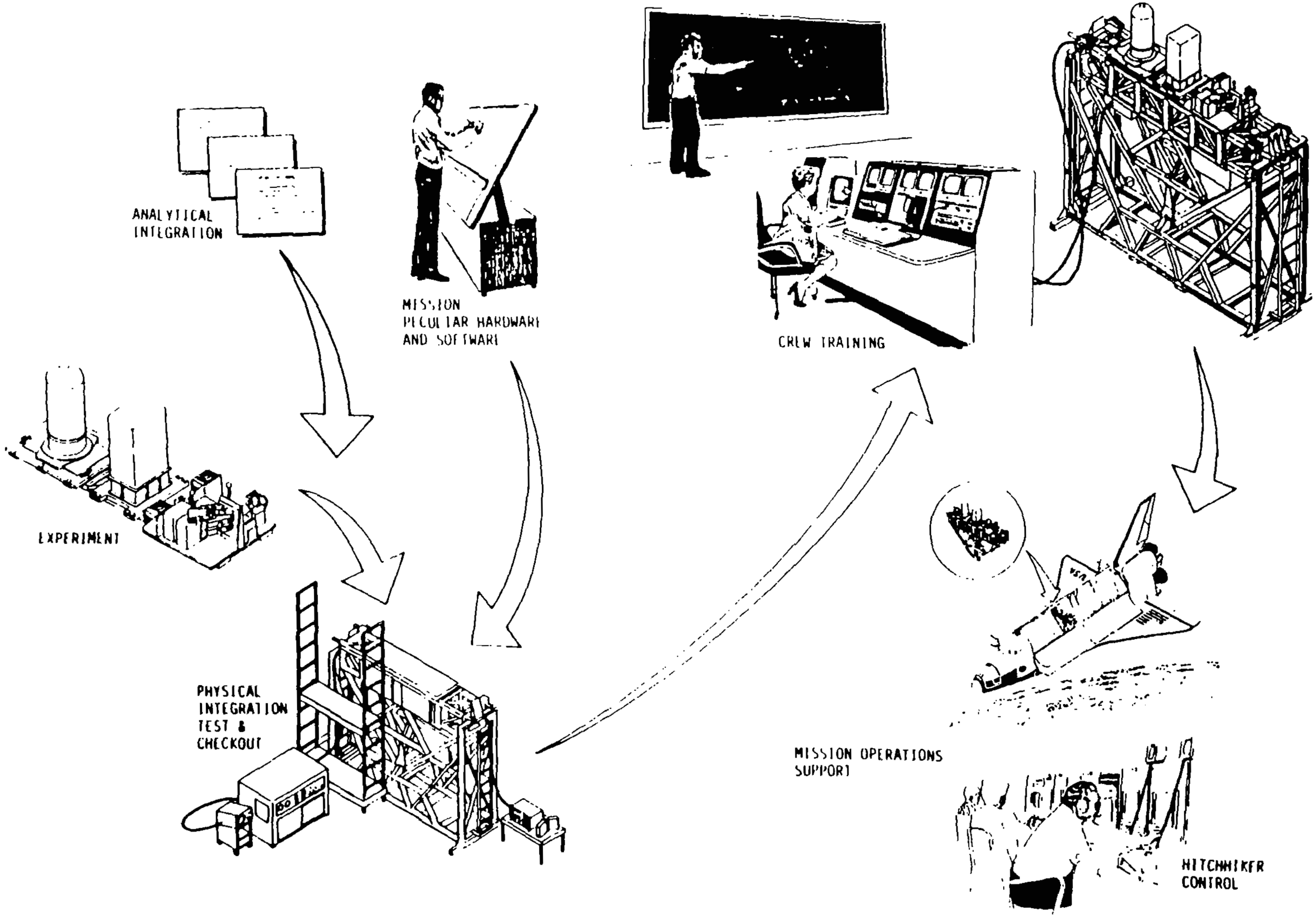
Experiment operation may be autonomous or permit crew interaction from the aft flight deck Standard Switch Panel (SSP) and the SPFS CDMP. Through the CDMP the crew may change the operational mode of the experiment system, initiate a special sequence, change data rate, check critical voltages, etc.



STANDARD SWITCH PANEL (SSP)

COMMAND/DISPLAY MANAGEMENT PANEL (CDMP)





THE RANGE OF SERVICES WHICH TELEDYNE BROWN ENGINEERING EXPECTS TO PROVIDE TO THE USER.