

# Shuttle Small Payloads: How to Fly Shuttle in the “Faster, Cheaper, Better” World

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*Abstract--*With “faster, cheaper, better” pervading the requirements for present spacecraft designs, the Shuttle Small Payloads Project offers unique access to users of the Space Shuttle. “Payloads of Opportunity,” such as Hitchhikers, combine for manned spaceflight customers the advantages of ground commanding and telemetry with quick turn-around and low-cost. This paper presents the capabilities of the Hitchhiker carrier systems. It also discusses typical ground integration and mission operations services available to Hitchhiker customers.

## TABLE OF CONTENTS

1. INTRODUCTION
2. OVERVIEW
3. CARRIER DESCRIPTION
4. GROUND OPERATIONS
5. MISSION OPERATIONS
6. MANIFESTING AND PROGRAMMATICS
7. FUTURE CAPABILITIES
8. SUMMARY

### 1. INTRODUCTION

The “faster, cheaper, better” approach to payloads is nothing new to NASA’s Goddard Space Flight Center (GSFC). The Shuttle Small Payloads Project (SSPP) has been flying quick-reaction, low-cost, highly successful Hitchhiker and Get-Away Special (GAS) payloads since the beginning of the space shuttle program. Since then, 14 Hitchhikers and over 100 GAS payloads have flown.

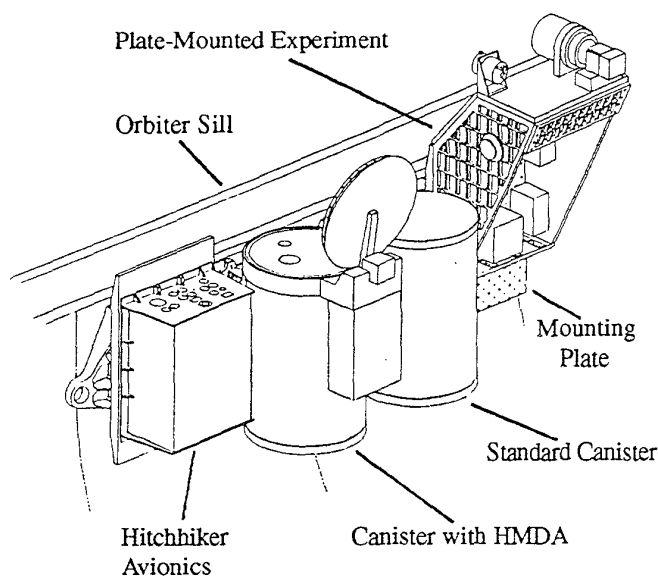
This paper will highlight the Hitchhiker program’s history and capabilities, including services available to customers. Also presented are summaries of typical ground and mission operations scenarios, as well as manifesting and programmatic issues. Finally, future enhancements to Hitchhiker’s capabilities are presented.

### 2. OVERVIEW

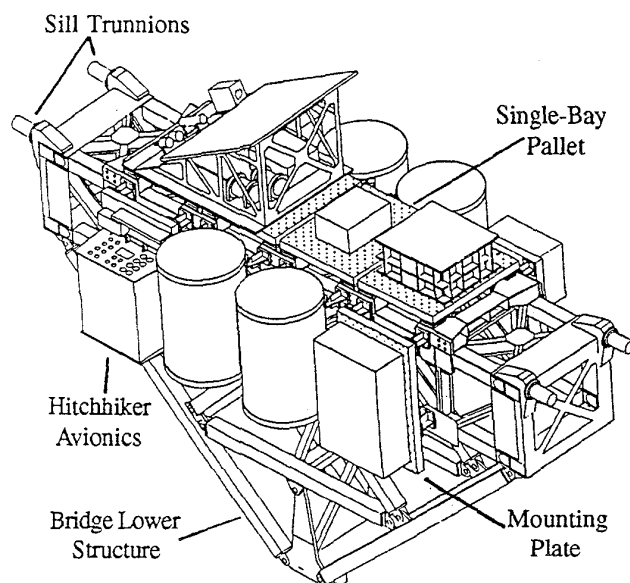
#### *Capabilities*

The Hitchhiker carrier system provides manned spaceflight customers the advantages of ground commanding and telemetry with quick turn-around and low-cost. As the name implies, Hitchhikers are “payloads of opportunity,” allowing maximum flexibility in manifesting by using standard Space Transportation System (STS) interfaces and modular subsystem components.

A typical Hitchhiker customer utilizes standard services for power, command, and data through the Hitchhiker Avionics as a shuttle attached payload. The Hitchhiker system allows customers to send commands and receive telemetry while stationed at the Hitchhiker Payload Operations Control Center (POCC) at GSFC. Optional services are available for crew command and monitoring, if required. Two basic payload configurations are utilized: side-mounted to the orbiter’s payload bay (HH-S, Figure 1) and the cross-bay bridge (HH-C, Figure 2).



**Figure 1.** Typical HH-S Configuration



**Figure 2.** Typical HH-C Configuration

### *History*

The Hitchhiker Program was started in 1984 by NASA's Office of Space Flight to provide opportunities for quick-reaction, low-cost payloads for launch on the space shuttle. The Hitchhiker system was designed with standard, basic payload-to-orbiter interfaces and standard, user-friendly customer-to-carrier interfaces. By minimizing payload-unique integration and design requirements, development time and recurring costs are reduced. Further, "in-house" development, operations, and management at GSFC has helped to make the Hitchhiker project an extremely cost-effective means of flying payloads on the shuttle.

The first Hitchhiker mission was flown on STS-61C in January of 1986. Since then, the average flight rate for Hitchhikers has been more than one per year. Thirteen other Hitchhikers have included experiments in materials science, thermal engineering, astronomy, remote sensing, and most recently, space station structural dynamics. Table 1 summarizes the Hitchhiker mission history and those payloads currently manifested on future shuttle flights.

### 3. CARRIER DESCRIPTION

The Hitchhiker carrier system incorporates individual, standard subsystem components in a payload configuration tailored to the requirements of a given mission. These include mechanical, electrical, and thermal subsystems. Many components are reflown as part of the cost-savings aspect of the Hitchhiker program.

#### *Mechanical*

Mechanical interfaces to the experiments include plates, pallets, and canisters. Plates of various sizes are available to mount customer components. These plates are then either attached to a "GAS adapter beam" for orbiter side mounting, or to the side of the bridge structure for cross-bay installation. Single- and double-bay pallets are used to mount hardware to the top of the bridge.

Canisters are used to contain experiment components in either a pressurized or unpressurized volume. Canister accessories include an upper end-plate with aperture and the Hitchhiker Motorized Door Assembly (HMDA).

**Table 1. Hitchhiker Mission History and Current Manifest**

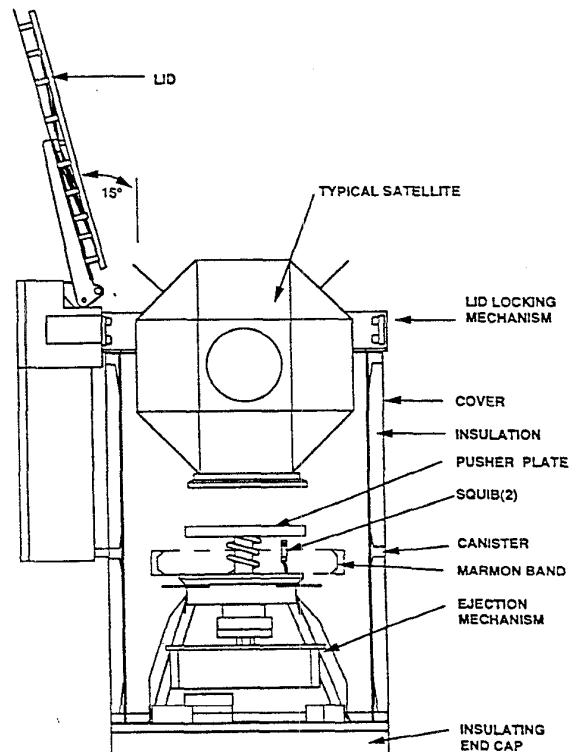
Payload	Mission	Launch	Experiment Disciplines
HH-G1	STS-61C	1/12/86	Space environment, thermal engineering
BBXRT	STS-35	12/2/90	X-ray astronomy
STP-1	STS-39	4/28/91	UV glow, computer engineering, IR astronomy, fluid dynamics
ASP	STS-52	10/22/92	Attitude sensing
GCP	STS-53	12/2/92	Shuttle glow, thermal engineering
DXS	STS-54	1/13/93	X-ray astronomy
SHOOT	STS-57	6/21/93	Cryogenic transfer
COB/GBA	STS-60	2/3/94	Thermal engineering, space debris tracking, satellite ejection
OAST-2	STS-62	3/4/94	IR emissions, solar cells, background radiation, thermal engng
CGP/O-2	STS-63	23/95	Cryogenics, shuttle glow, IMAX camera, space debris tracking
ROMPS	STS-64	9/9/94	Robotics
IEH-1	STS-69	9/7/95	UV astronomy, shuttle glow, materials science
CAPL-2/GBA	STS-69	9/7/95	Thermal engineering
GPP	STS-74	11/11/95	Shuttle glow, structural dynamics
SLA-1/GBA	STS-72	1/96	Laser altimetry, tracking
TEAMS	STS-77	5/96	Navigation, thermal engng, tanking technology, satellite deploy
TAS-1	STS-85	7/97	Tethered satellite, thermal engng, fluid dynamics, laser altimetry
IEH-2	STS-85	7/97	UV astronomy, shuttle glow, solar physics
PASDE-2	STS-86	9/97	Structural dynamics
MIGHTYSAT 1	STS-87	10/97	Electrical engineering, satellite deploy
IEH-3	STS-90	4/98	UV astronomy, shuttle glow, IR imaging
TAS-2	STS-109	11/00	TBD
TAS-3	STS-112	5/01	TBD

In addition, a Hitchhiker Ejection System (HES) may be used for deploying small objects having a maximum earth weight of 150 pounds (Figure 3).

#### *Electrical*

The primary electrical interface to the customer is the Hitchhiker Avionics unit. This unit distributes orbiter 28-volt D.C. power through a maximum of eight customer "ports," which are controlled via ground command. Three types of commanding are available: 28V bi-level and pulse commands issued from Hitchhiker's Advanced Carrier Customer Equipment Support System (ACCESS); 1200-baud asynchronous uplink issued from the customer's ground support equipment (CGSE); and serial commanding, also issued via CGSE.

Experiment telemetry is received by the CGSE through ACCESS using either the 1200-baud low-rate asynchronous downlink or the medium-rate channel which can accommodate up to 1.4-Mbps total for all customers. A



**Figure 3. Hitchhiker Ejection System**

50-Mbps, high data rate is also available. Other telemetry interfaces include IRIG-B timing and orbiter ancillary (orbit and attitude) data.

Optional crew interfaces on the orbiter Aft Flight Deck are available for CCTV, for hardwire switching and monitoring of safety-critical circuits, and for software commanding and telemetry via the Payload and General Support Computer (PGSC). Video switching between customers can be accommodated using the Hitchhiker Video Interface Unit (HVIU).

#### *Transparent Data System*

The Hitchhiker flight and ground data system functions as a "transparent data system" (Figure 4). That is, the Hitchhiker provides the interface formatting required for experiment commands and telemetry, so the CGSE and experiment see the same data formats regardless of the level of payload integration. In this way, the same customer GSE and software that is used for experiment development can also be used during preflight testing and later for mission operations.

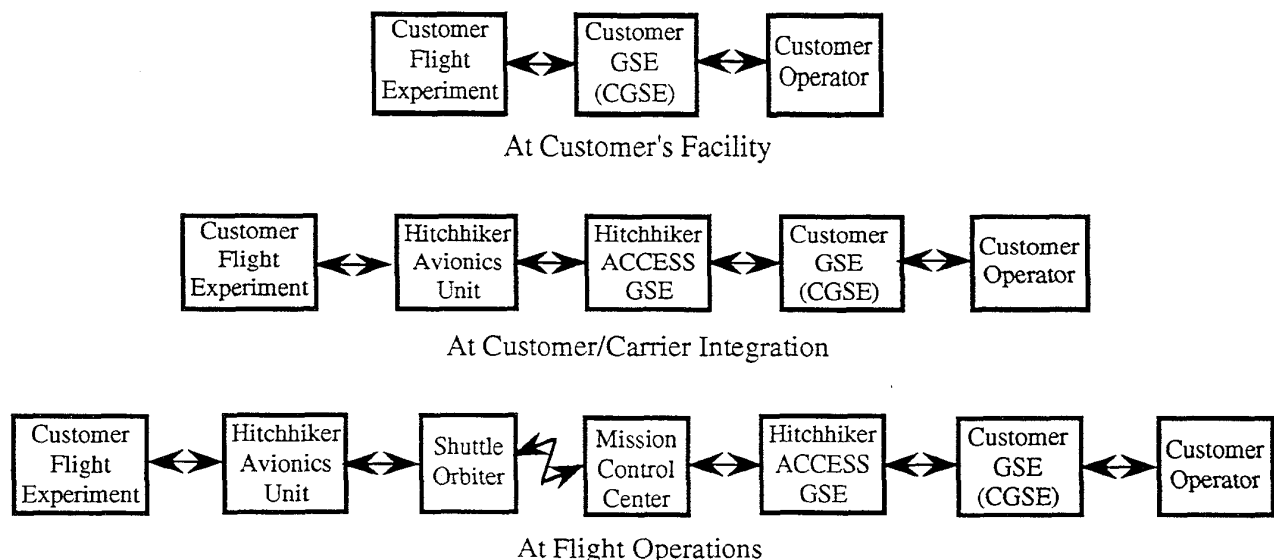
#### *Thermal*

Thermal subsystem hardware includes thermistors and thermostatically controlled heaters mounted on the carrier hardware. Insulating blankets for flight hardware may also be provided by Hitchhiker. No active cooling interfaces with the orbiter are required; heat rejection is effected primarily through radiation.

#### *Hitchhiker-Junior*

Even greater manifesting flexibility is afforded for customers who do not require ground command and telemetry. The Hitchhiker-Junior (HH-J) system provides canister customers with 28-volt orbiter power, crew-commanded operation, and data display and storage via the PGSC. Since the Hitchhiker Avionics unit and mission support from HH-J customers are not required, this option costs even less than standard Hitchhiker accommodations.

This description of Hitchhiker carrier components is not meant to limit the possibilities for accommodating special payload



**Figure 4.** Hitchhiker Transparent Data System

configurations. Experiment-specific mounting hardware, electrical interfaces, or thermal control can usually be provided by Hitchhiker as an optional service.

Details regarding the Hitchhiker carrier accommodations can be found in the "Hitchhiker Customer Accommodations and Requirements Specifications" (CARS) document [1].

#### 4. GROUND OPERATIONS

##### *Preintegration Testing*

Months prior to delivery for flight, the customer may perform a preintegration test at GSFC using prototype or flight hardware in development. This test is offered to the customer as an early opportunity to verify the function of the interfaces between the experiment and the Hitchhiker Avionics, and between the CGSE and ACCESS. Preintegration testing is usually performed well in advance of final delivery, early enough to allow time to make any modifications, if necessary.

It is expected that, prior to customer hardware delivery to GSFC, the experiment will be fully tested and qualified for flight at the customer's facility. This includes any environmental (e.g., vibration, thermal-vacuum, electromagnetic compatibility) testing required.

##### *GSFC Integration and Test*

Upon final delivery for preflight integration, approximately eight months prior to launch, the customer performs a post-ship stand-alone functional test. This is usually conducted in a class 100,000 cleanroom facility which supports Hitchhiker integration. Throughout preflight operations, the customer's flight hardware may be accommodated with optional services, such as a dry nitrogen purge.

Integration of the experiment with the Hitchhiker carrier begins with mechanical integration of flight components, either into a canister or onto a plate or pallet. All experiment hardware is then electrically integrated with the Hitchhiker Avionics, which includes continuity and isolation resistance checks. After all electrical connections are

made, functional tests are performed with the Hitchhiker, ACCESS, and CGSE. Finally, thermal blankets are installed, as required.

Once all experiments and payload components are integrated, the entire payload is moved to the electromagnetic compatibility (EMC) test facility. An EMC test is performed to the requirements specified in the shuttle "core" interface control document, ICD-2-19001 [2]. Usually at this time, telemetry is also recorded for later use during mission simulations.

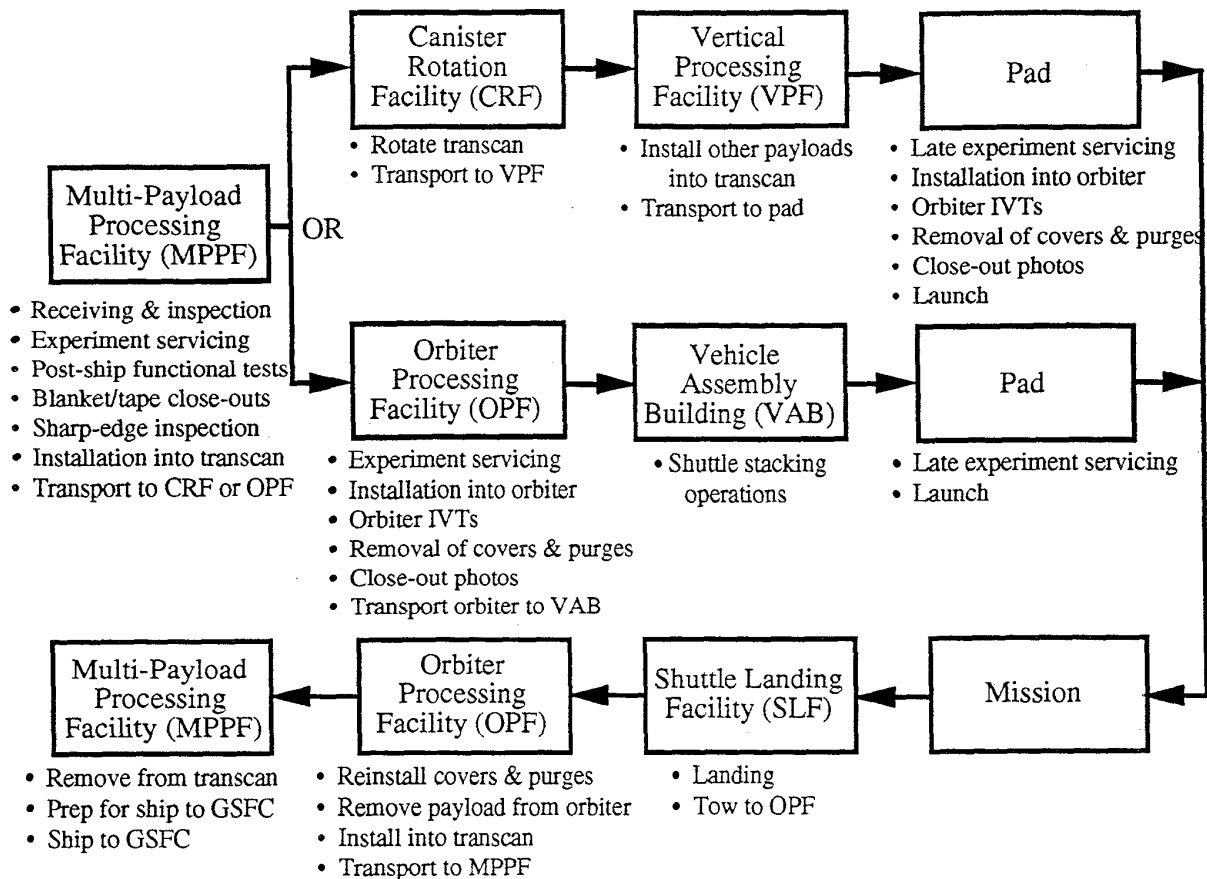
##### *KSC Prelaunch Operations*

Following the EMC test, the payload and GSE are shipped via truck to the Kennedy Space Center (KSC) launch site. Following arrival at KSC, the payload is transferred into the Multi-Payload Processing Facility (MPPF), a class 100,000 cleanroom facility. The payload is then functionally tested and prepared for orbiter integration. This includes short functional tests of each experiment using the CGSE and the ACCESS.

After all electrical operations are complete, the payload is loaded into KSC's payload transport canister (transcan) for transfer to the orbiter. Orbiter integration is accomplished either horizontally in the Orbiter Processing Facility (OPF) or vertically at the pad, depending on schedule and on access required for integration (Figure 5).

Following orbiter electrical connections, an interface verification test (IVT) is performed with the payload. The purpose of this test is to perform the minimum testing required to verify copper path interfaces between the payload and the orbiter, and is not considered a functional test. During the IVT, Hitchhiker is controlled by KSC from the Launch Control Center (LCC) and monitored by Hitchhiker and customer personnel at the MPPF.

After the IVT and prior to final payload-bay door closure, close-out operations are performed. These include removing any purge or trickle-charge lines, removing any non-flight covers, and taking payload close-out photographs. Also prior to launch, several mission simulations are usually conducted from the POCC at GSFC.



**Figure 5.** Hitchhiker Ground Operations at KSC

### *Postlanding Operations*

Following the mission, nominal landing is at KSC. The payload is deintegrated from the orbiter at the OPF and is transferred via transport canister to the MPPF. Usually, no post-flight testing is conducted at KSC.

The payload is then shipped back to GSFC for carrier and experiment deintegration, at which time the hardware is returned to the customer. This occurs approximately one month after a landing at KSC. Contingency post-flight testing may also be performed, if necessary.

### *Additional Information*

Some suggestions to help ensure smooth payload processing at GSFC and KSC can be found in Carson [3].

## 5. MISSION OPERATIONS

Hitchhiker mission operations are based on customer requirements negotiated with the SSPP several months prior to the mission, from which mission timelines are established. Services such as available command/telemetry windows and special attitudes are based on these mission timelines. However, due to their low cost and high flexibility in manifesting, Hitchhikers are usually considered secondary payloads. As such, Hitchhiker's use of orbiter services is contingent on the availability afforded by real-time orbiter or primary payload operations requirements.

### *Payload Operations Control Center*

As mentioned earlier, mission operations are conducted from the Hitchhiker POCC, located in GSFC's Attached Shuttle Payload Center

(ASPC). The same CGSE used for ground testing supports mission operations to send near-real-time experiment commands and receive telemetry via the ACCESS. The POCC provides displays of orbit position, attitude, ancillary data, voice, and downlink video.

#### *Mission Sequence*

Hitchhiker remains unpowered during shuttle ascent; therefore, no commanding or telemetry is available during this phase. Within four hours after launch, the Hitchhiker Avionics is activated by crew switching. Following Hitchhiker status verification, experiment activation and commanding may commence. Approximately five hours prior to landing, the experiments and Hitchhiker Avionics are deactivated.

On-orbit data is recorded and processed post-mission. Data may be provided to customers approximately one-month after the mission in either 8-mm tape or compact-disk format.

#### *Additional Information*

Additional information regarding Hitchhiker mission operations can be found in Anderson [4].

### 6. MANIFESTING AND PROGRAMMATICS

#### *Request for Flight*

Prospective Hitchhiker customers generally present their proposals for flight to the SSPP via a Request for Flight (NASA Form 1628). Those customers supporting the DoD should request Hitchhiker accommodations through the USAF Space Systems Division.

#### *Customer Payload Requirements*

If the experiment is deemed feasible and compatible with Hitchhiker capabilities, the customer submits a Customer Payload Requirements (CPR) document for preliminary consideration. This document specifies: all customer interface requirements such as carrier mechanical and electrical interfaces; ground operations requirements, like environmental constraints and servicing; and mission operations requirements, such as power, commanding, and orbiter orientation. The CPR is generally completed, with assistance from the SSPP, approximately two years prior

to launch.

#### *Safety*

Safety documentation required from the customer includes the flight and ground safety data packages, due shortly after the CPR is submitted. Due to the nature of manned spaceflight requirements, users of the STS are required to identify and control hazards to personnel and flight hardware. Areas which must be considered include collision, contamination, corrosion, electric shock, explosion, fire, and radiation.

#### *Other Documentation*

GSFC is responsible for developing the experiment-to-Hitchhiker interface control document (ICD), as well as all payload-level documentation such as the Payload Integration Plan (PIP) and Flight Data File (FDF). Procedures for customer ground operations at KSC are provided by the customer and due to GSFC approximately two months prior to use.

#### *Meetings*

Preliminary meetings between the customer and GSFC (technical interchange meetings, or TIMs) usually begin during the CPR drafting process and continue through payload development. These are followed by phased safety reviews, design reviews, and payload operations working group (POWG) meetings. The customer works with the Hitchhiker mission manager to coordinate scheduling.

#### *Costs*

Costs to individual Hitchhiker customers depend on services required, the number of customers manifested, and who the customer is. For NASA-sponsored customers, there is no cost for standard services provided. DoD customers are charged approximately \$370K per experiment for standard services. The foreign reimbursable cost for a Hitchhiker mounting slot is about \$1.2 million. Any optional services are charged on a case-by-case basis.

### 7. FUTURE CAPABILITIES

#### *Advanced Carrier Electronics*

Enhancements to the Hitchhiker carrier

capabilities are currently being developed (Figure 6). One of these is the Advanced Carrier Electronics (ACE), which will provide customers with 2-Mbps telemetry capacity, stored command sequence capability, on-board data storage, and increased redundancy. More modular in concept than the existing Hitchhiker Avionics, the ACE will provide even greater flexibility in manifesting and customer accommodations.

#### *Hitchhiker Maneuverable Carrier*

The Hitchhiker Maneuverable Carrier (HMC) will provide deployment capability from the payload bay using the orbiter's Remote Manipulator System (RMS). The proposed

design will provide a mounting plate for instruments up to 500 pounds, and include limited power and data services during RMS operations. This carrier will allow Hitchhiker customers the opportunity to conduct experiments outside of the immediate orbiter environment and independent of orbiter orientation.

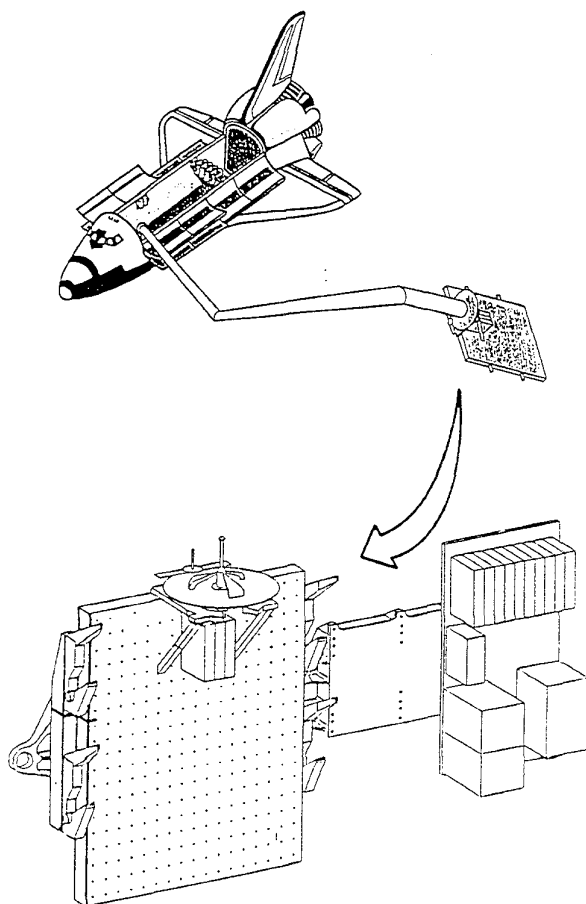
These and other proposed enhancements may very well turn Hitchhiker from what is already "faster, cheaper, better" into the "fastest, cheapest, best" way to conduct manned spaceflight experiments.

#### 8. SUMMARY

After ten years of service, the Hitchhiker carrier system has proven itself as a quick-reaction, low-cost, effective payload system for shuttle customers. Hitchhiker utilizes standard interfaces and modular components to provide maximum flexibility in manifesting. By minimizing payload-unique integration and design requirements, development time and recurring costs are reduced. Hitchhiker provides customers with ground command and telemetry capability in a carrier tailored to their specific mission requirements.

To obtain more information on Hitchhikers or on other SSPP flight opportunities, please visit the SSPP homepage ([sspp.gsfc.nasa.gov](http://sspp.gsfc.nasa.gov)) or contact:

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**Figure 6.** Hitchhiker Enhancements:  
Advanced Carrier Electronics and  
Hitchhiker Maneuverable Carrier

#### REFERENCES AND NOTES

- [1] Shuttle Small Payloads Project, *Hitchhiker Customer Accommodations and Requirements Specifications*, Greenbelt, Maryland: National Aeronautics and Space Administration, Goddard Space Flight Center, 1994.

[2] Space Shuttle Integration and Operations Office, *Shuttle Orbiter/Cargo Standard Interfaces, ICD-2-19001, Revision K (with changes)*, Houston, Texas: National Aeronautics and Space Administration, Lyndon B. Johnson Space Center, 1995.

[3] Maggie Carson, "Helpful Hints to Painless Payload Processing," 1995 Shuttle Small Payloads Symposium Proceedings, September 25-28, 1995.

[4] Kathryn Anderson, "Hitchhiker Mission Operations: Past, Present, and Future," 1995 Shuttle Small Payloads Symposium Proceedings, September 25-28, 1995.

[5] Shuttle Small Payloads Project, *Shuttle Small Payloads Capabilities*, Greenbelt, Maryland: National Aeronautics and Space Administration, Goddard Space Flight Center, 1992.

*Mike Wright is a Hitchhiker integration and test engineer at Goddard Space Flight Center. He started his career in 1982 at the Kennedy Space Center, where he was involved in orbiter and payload operations, including work on the first Hitchhiker flight in January 1986. He transferred to Goddard in 1989, where he worked on the Hubble Space Telescope and then on the SAMPEX Small Explorer satellite. During his career, Mike has been involved in more than 25 missions, his most recent being the International Extreme-Ultraviolet Hitchhiker which flew in September of last year on STS-69. He earned his BS in Space Sciences and MS in Space Technology from Florida Institute of Technology, and MSW from the Catholic University of America.*