NASA HITCHHIKER PROGRAM
CUSTOMER PAYLOAD REQUIREMENTS (CPR)

Dr. Stephen Horan

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CUSTOMER PAYLOAD: Low-Power Communications and Telemetry Experiment

CUSTOMER: Manuel J. Lujan Space Tele-Engineering Program
Klipsch School of Electrical and Computer Engineering
New Mexico State University
Box 30001, MSC 3-O
Las Cruces, NM 88003-8001

DATE: September 16, 1998

CUSTOMER APPROVAL:

____
Payload Manager Date

____
Payload Organization Date

NASA APPROVAL:

____
HH Mission Manager Date

____
HH Project Manager Date

TABLE E.1
CUSTOMER DATA

CUSTOMER PAYLOAD NAME: Low-Power Communications and Telemetry Experiment

CUSTOMER PAYLOAD ACRONYM: LPCTE

CUSTOMER NAME, ADDRESS, AND TELEPHONE NUMBER: Manuel J. Lujan Space Tele-Engineering Program, New Mexico State University, Box 30001, MSC 3-O, Las Cruces, NM 88003-8001; (505) 646-5870; FAX (505) 646-6417

NAMES AND PHONE NUMBERS OF CUSTOMER CONTACTS:

PROGRAM MANAGER: Dr. Stephen Horan 505-646-5870 shoran@nmsu.edu

PAYLOAD MANAGER: ______

SAFETY: ______

ELECTRICAL: ______

SOFTWARE: ______

MECHANICAL: ______

THERMAL: ______

OPERATIONS: ______

SCIENCE: ______

CALENDAR INTERVAL DURING WHICH FLIGHT IS REQUESTED: FY 2001

EARLIEST DATE AT WHICH QUALIFIED PAYLOAD WILL BE AVAILABLE: January 2001

2. PAYLOAD DESCRIPTION

The Low-Power Communications and Telemetry Experiment is a technology demonstration experiment to demonstrate techniques that can be applied to small-satellite communications system design. The experiment has three phases: data communications via the Tracking and Data Relay Satellite System (TDRSS), prototype demonstration of demand-access communications through TDRSS, and passive telemetry transmission via laser communications with the ground.

2.1 MISSION OBJECTIVES

The mission objective is to demonstrate each of the three types of technology intended for future small-satellite communications system design. Each experiment in the overall package is designed to exercise a different technology objective that may be found in the overall satellite communications and telemetry system design.

The data communications through TDRSS portion is designed to demonstrate that low-power communications systems with non-gimbaled antenna systems can transport significant quantities of data through TDRSS to the ground based on only transmitting through a TDRS when the experiment is near the TDRS subsatellite point. The remaining time, the payload communications system is not active.

The demand access experiment is to demonstrate that the request for a demand access service can be transmitted through TDRS and received and decoded at the ground station. In this mode, the TDRS does not track the experiment but signal processing components at the White Sands Complex are used to detect and track the transmitted request.

The laser communications experiment is designed to demonstrate passive transmission of telemetry data from the experiment. This mode uses a ground-based laser source to illuminate the experiment and modulate the beam with the data. Ground-based reception recovers the data from the reflected beam back to the ground station.

2.2 PHYSICAL DESCRIPTION

The LPCTE experiment will require the following canister options:

1. Insulated HH canister with Hitchhiker Motorized Door Assembly(HMDA)
2. Experiment mounting plate
3. The top mounting plate will need to be modified to provide an aperture for the passive telemetry experiment and for electrical connections for the antenna system
4. Crew interface connections and power connections.

The experiment package will be mounted in the opening-lid-canister using a standard 5 ft^3 Hitchhiker canister. The payload is provided power and communications support through the Hitchhiker standard interface connections on the lower endplate. The payload will require an interface for crew-activated switches to control the payload operations. The payload will not require ground-based commands to control the payload. Data from the payload will be transferred via the payload communications system. The general configuration for the payload is illustrated in Figure E.1. The payload will need to be pointed at the surface of the earth for the laser communications portion of the experiment and facing out away from the center of the earth during the two RF portions of the experiment.

Table E.2 - Payload Assemblies

Assembly Name	Weight (lbs)	Size			Mount Type	FOV (deg)	OPERATING TEMPERATURE		NON-OPERATING TEMPERATURE		STORAGE TEMPERATURE	
		X (in)	Y (in)	Z (in)			MIN	MAX	MIN	MAX	MIN	MAX
Experiment Package	100	20	20	30	HH	40	15	25	0	45	10	35

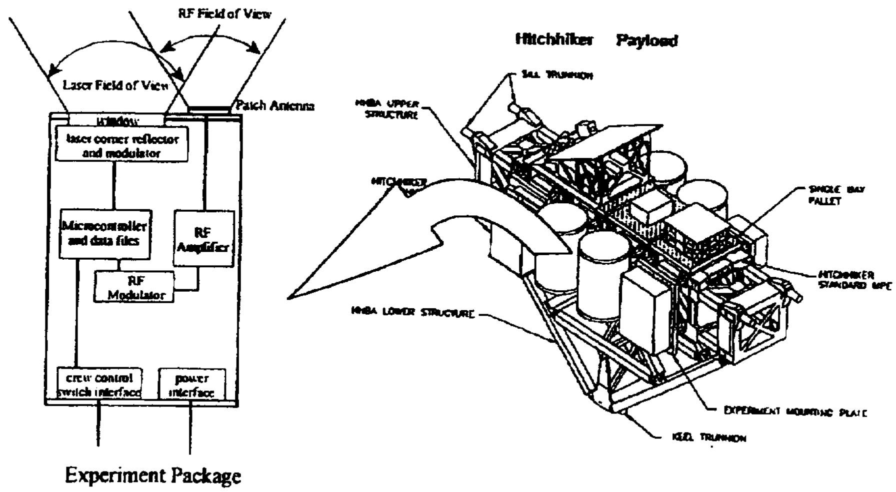


Figure E.1 - LPCTE Experiment Package General Arrangement

2.3 PAYLOAD FUNCTIONAL DESCRIPTION AND METHOD

The LPCTE experiment has three functional sub-experiments to emulate the communications needs that may be found in a small satellite communications and telemetry system design. The sub experiments are designed to emulate data transfer by two different methods and to emulate requesting services from the TDRSS communications facilities in real-time. These sub-experiments are

1. Low-power data transmission through the TDRSS using fixed antenna pointing
2. Demand assignment service requests through TDRSS
3. Passive telemetry transmission using laser communications and a ground-based laser transmitter and receiver.

The center of the payload will be a microcontroller-based computer system. This system will have pre-loaded files in it to be used for all three payload sub-experiments. The type of file to be transmitted will be determined by the crew-interface switch settings. The appropriate data file for each sub-experiment will be sent by the microcontroller to the corresponding data port where it will be routed for transmission. The first two sub-experiments require that the data be transmitted via a radio link to a TDRS for relay to the White Sands Complex for data capture and analysis. The RF modulator, amplifier, and patch antenna components are required to transmit the data from the payload to the TDRSS for relay to the ground. The third sub-experiment will use a ground-based laser to illuminate the payload for data transmission. As the laser illuminates the payload, the data will change the transmission characteristics of the filter placed in front of a corner-cube reflector. Both of these are mounted behind a clear aperture in the canister top.

When the payload is not involved with data transmission both the RF and laser components will be powered down. The only activity that is anticipated is the drawing of heater power to keep the components within thermal limits if necessary. Crew interface switches will be used to enable the payload and determine which sub-experiment is to be conducted.

The first two sub-experiments will require the scheduling of TDRSS resources both in the satellites and the WSC ground station to complete the experiment.

2.4 OPERATIONAL SCENARIO

2.4.1 OPERATIONS DESCRIPTION

Each of the three sub-experiments are designed to operate independently of the others. In fact, the RF and the laser communications experiments cannot be operated simultaneously since they require mutually-exclusive payload pointing configurations. Experiment times through TDRSS will need to be pre-scheduled according to normal procedures. The laser communications experiment will need to be coordinated with the White Sands Missile Range facility.

1. Fixed Antenna Access of TDRSS Experiment.

The low-power data transmission experiment will transmit a pre-loaded data file, similar to a telemetry data file or a sensor data set, from the LPCTE experiment through the TDRSS communications network to the White Sands Complex (WSC) for file acquisition and comparison with the original file. This experiment will need to be conducted when the payload is near (within 20°) a TDRSS subsatellite point and with the payload pointing towards the TDRS used for communications support. At this time, the crew will enable the payload transmission and the data will be transmitted using the patch antenna system that is located in the canister upper plate. When the payload is not near a TDRS subsatellite point, no transmission is attempted. The TDRSS transmissions will not require a forward link from the TDRS to be accomplished. Operation of the Fixed Antenna Access of TDRSS Experiment will require a Shuttle pointing attitude of +LV (Bay to Space). The orbits that can be used for the experiment depends upon the shuttle orbital inclination angle. Based on the possible orbital inclinations, orbital ascending or descending nodes falling within the following ranges will provide suitable experimental configurations:

Shuttle Orbital Inclination	Ascending/Descending nodes occurring between
28.5°	-64.0 ° and -18.0°
51.6°	-27.0 ° and -55.0°

These nodes will provide access of to TDRSS East and similar restrictions will be developed if operation is through TDRS West. Power to the payload onboard computer and RF equipment will be activated 45 minutes prior to the start of the experiment through ground control and CC systems. The HMDA is to be enabled and opened prior to commencing the experiment. The experiment is to be activated by the crew through a dedicated SSP switch. The payload onboard computer will contain a predetermined data set that will be autonomously repeated for the length of the experiment which is nominally expected to be 10 minutes. After the access time of TDRSS has elapsed, the experiment is to be deactivated through the SSP switch. The HMDA is to be closed and power to the computer and RF equipment deactivated after the experiment has terminated. It is expected that crew switch activation and deactivation will be coordinated using voice links with the ground to ensure proper timing and shuttle attitude. To assess the transmission capabilities, at least three runs of this type of experiment throughout the mission profile are expected to be scheduled.

2. Demand Access Service Request Experiment.

The demand assignment requests will transmit a short, pre-loaded data request for a service request from the LPCTE experiment through the TDRSS communications network to the White Sands Complex where the tracking and receiving equipment will capture and record the data transmission. This experiment can be conducted from nearly any place in the shuttle's orbit as long as the payload is pointed out towards the geostationary arc where the TDRS satellites are located. It is desirable to have the test transmission sent from several places along the orbit to test the tracking and recovery capabilities at the WSC for these types of service requests. The start of the data transmission will be initiated by the crew setting at appropriate switch after the payload is enabled. Once the transmissions have begun, they will be repeated on a periodic basis as controlled by the on-board computer until the crew disables the experiment via the switch. Operation of the Demand Access Service Request Experiment will require a Shuttle pointing attitude of +LV (Bay to Space). For mission planning purposes, we propose selecting an orbit having an ascending or descending node falling in the following ranges:

Shuttle Orbital Inclination	Ascending/Descending nodes occurring between
28.5°	-70.0 ° and -14.0°
51.6°	-33.5 ° and -50.0°

These nodes will provide access to TDRSS East. Similar restrictions can be developed for testing through TDRS West. Power to the payload onboard computer and RF equipment will be activated 45 minutes prior to the start of the experiment through ground control and CC systems. The HMDA is to be enabled and opened prior to commencing the experiment. The experiment is to be activated by the crew through a dedicated SSP switch. The payload onboard computer will contain a predetermined data set that will be autonomously repeated for the length of the experiment. After the access time of TDRSS has elapsed, the experiment is to be deactivated through the SSP switch. The HMDA is to be closed and power to the computer and RF equipment deactivated after the experiment has terminated.

3. LASER Passive Telemetry Experiment

The LASER Passive Telemetry Experiment will transmit a pre-loaded data file, similar to a telemetry data file or a sensor data set, from the LPCTE experiment to a ground facility at the White Sands Missile Range (WSMR) for file acquisition and comparison with the original file. This experiment will need to be conducted when the shuttle is above the horizon as seen from WSMR and with the payload pointing towards the ground for communications support. At this time, the crew will enable the payload transmission and the data will be transmitted using the optical modulator and corner-cube reflector system that is located in the canister upper plate. When the payload is not above the WSMR horizon, no transmission is attempted. The laser transmissions will require a tracking laser source at WSMR for the transmission to be accomplished. Operation of the LASER Passive Telemetry Experiment will require a Shuttle pointing attitude of +LV (Bay to Space). The orbits that can be used for the experiment depends upon the shuttle orbital inclination angle. Based on the possible orbital inclinations, orbital ascending or descending nodes falling within the following ranges will provide suitable experimental configurations:

Shuttle Orbital Inclination	Ascending/Descending nodes occurring between
28.5°	Ascending nodes between 131 ° and -152°
51.6°	Ascending nodes between 104 ° and 128° Descending nodes between -146 ° and -123°

These nodes will provide viewing of the Shuttle from the White Sands Missile Range (WSMR). Power to the payload will be activated 1 hour prior to the start of the experiment through ground control and CC systems. The HMDA is to be enabled and opened prior to commencing the experiment. The experiment is to be activated by the crew through a dedicated SSP switch. The payload onboard computer will contain a predetermined data set that will modulate the LCD's in front of the corner cube reflectors and be autonomously repeated for the length of the experiment. After the access time of WSMR has elapsed, the experiment is to be deactivated through the SSP switch. Power to the payload will be deactivated after the experiment has terminated. The HMDA is to be closed after the completion of the experiment.

2.4.2 CRITICAL PROCEDURES

The following critical procedures have been identified for the LPCTE payload:

1. The payload must be pointed away from the center of the earth when the payload is near the designated TDRS subsatellite point for the data transmission testing and the crew must enable the data transmission via the associated switch.
2. The payload must be pointed away from the center of the earth for the demand assignment service request testing and the crew must enable the data transmission via the associated switch.
3. The payload must be pointed towards the center of the earth when the payload is near the White Sands Missile Range point for the laser passive data transmission testing and the crew must enable the data transmission via the associated switch.

If the pointing is not properly done, then the communications experiments will most likely not work since they have a preferred orientation to accomplish the data transmissions. If the crew does not set the switches properly, then either the desired test will not be run or no test will be run.

3. PAYLOAD REQUIREMENTS FOR CARRIER STANDARD SERVICES

3.1 CARRIER TO PAYLOAD ELECTRICAL INTERFACES

The payload will meet the standard electrical interface requirements (including connectors, pin assignments, impedances, signals, levels, etc.), specified in the CARS. This payload will require 1 of the standard signal interface connections or "ports" and 1 of the standard power interface connections or "ports". For each of the ports, a copy of Table E.3.1.1 must be filled in to show which of the standard electrical services will be required by the payload. Unused services will be left open circuited in the payload unless other termination is required by GSFC.

TABLE E-3.1.1
STANDARD AVIONICS PORT REQUIREMENTS
(HH CUSTOMERS)

PORT NUMBER:	1	
SIGNAL INTERFACE CONNECTION		
NUMBER OF BILEVEL COMMANDS (4 MAX) (2.4.2):	0	
NUMBER OF THERMISTORS (3 MAX) (2.4.7.2):	2	
ASYNCHRONOUS UPLINK (2.4.4):	N/A	CPS
ASYNCHRONOUS DOWNLINK (2.4.5):	N/A	CPS
MEDIUM RATE KU-BAND DATA RATE (2.4.6):	N/A	KB/S
ANALOG DATA (2.4.7.1):	N/A	
IRIG-B GMT (2.4.8):	N/A	
GMTMIN (2.4.8):	N/A	
CREW PANEL SWITCHES (2.4.10):	4	
ORBITER CCTV INTERFACE (2.4.12):	N/A	
PORT TO PORT INTERCONNECT REQUIRED (2.4.11):	N/A	
POWER INTERFACE CONNECTION		
POWER CIRCUIT A - AMPS MAX:	4	AMPS
POWER CIRCUIT B - AMPS MAX:	3	AMPS
POWER CIRCUIT HTR-AMPS MAX:	0.5	AMPS
TOTAL ENERGY REQUIRED A&B:.	0.5	KWH
OTHER (DEFINE):	None	

3.2 CARRIER TO PAYLOAD MECHANICAL INTERFACES

The payload will meet the standard mechanical interface requirements specified in the CARS. Mechanical drawings and other documentation will be supplied in sufficient detail for GSFC to perform user accommodation studies and ultimately draft the MICD. Section 2 of CARS addresses most of the information required for accommodation studies. The MICD Requirement Information List in Section 3.1.1.3.2 of the CARS lists the data required for inclusion on the MICD.

3.3 CARRIER TO PAYLOAD THERMAL INTERFACES

The customer will meet the standard thermal interface requirements specified in Section 2.2 of the CARS. A description of the thermal design concept for the payload follows:

The payload will be designed so that thermal control is achieved by

1. Only operating the RF amplifier when the RF tests are either on-going or in the short duration prior to the test for the amplifiers to power up and become stable. During times of inactivity, the RF amplifiers will be powered down. When the RF experiments are completed, the RF portion of the payload can be turned off for the remaining duration of the mission.
2. The optical modulator filters will need thermal control. Active thermal control using heating tape to keep the components within their specified range will be required. This will require minimal power to the payload at all times to keep the optical components in their range prior to experimentation. After the optical experiments are completed, the thermal control is not required.
3. The payload will need insulation to prevent large hot and cold thermal swings during times prior to the commencement of the experiments on-orbit.

During operations, we will utilize short operational windows and allow radiative cooling to keep the payload within temperature specifications.

3.4 GROUND OPERATIONS REQUIREMENTS

Table E.4 defines the handling and ground services required by the payload.

TABLE E.4

GROUND OPERATIONS REQUIREMENTS

a. MAXIMUM AND MINIMUM ALLOWED STORAGE TEMPERATURES: . . . 0 - 50°C

b. MAXIMUM AND MINIMUM ALLOWED RELATIVE HUMIDITY: . . . . 5% - 95%

c. CLEANLINESS REQUIREMENT FOR PAYLOAD INTEGRATION & TESTING: . . TBD

d. CUSTOMER SUPPLIED GROUND SUPPORT EQUIPMENT REQUIRED TO SERVICE PAYLOAD. (EXCLUDING CGSE IN SECTION 3.4): . . . . None

e. REQUIREMENTS FOR GASES OR LIQUIDS: . . . . dry N2 for canister; GSFC purge, seal, and leak check

f. REQUIREMENTS FOR PAYLOAD SERVICING AT GSFC: . . . . support for all lifting operations; integration, functional test, and interface verification

AT KSC: . . . . None

g. REQUIREMENTS FOR ACCESS DURING ORBITER INTEGRATION: . . . . . None

h. REQUIREMENTS FOR ACCESS ON LAUNCH PAD: . . . . None

i. REQUIREMENTS FOR POST-LANDING ACCESS: . . . . None

j. ANY OTHER SPECIAL REQUIREMENTS FOR HANDLING AT INTEGRATION AND TEST OR LAUNCH SITE: . . . . None

k. SIZES AND WEIGHTS OF ITEMS REQUIRED FOR SHIPMENT TO INTEGRATION OR LAUNCH SITES (EXCLUDING CGSE OF Table E.14): . . . . ______

ITEM	SIZE	WEIGHT
Payload		TBD

3.5 SAFETY

Table E.5 requires a "no" or "yes" answer to items related to payload safety. Details of items identified "yes" are also given.

TABLE E.5
PAYLOAD SAFETY RELATED ITEMS

a.	CONTAINS PRESSURIZED VOLUME(S):	yes
b.	CONTAINS RADIOACTIVE MATERIAL:	no
c.	CONTAINS LIGHT OR RF SOURCE:	yes
d.	EXTERNAL ELECTRIC OR MAGNETIC FIELDS:	no
e.	EXTERNAL ELECTRICALLY CHARGED SURFACE:	no
f.	EXTERNAL HOT OR SHARP SURFACE:	no
g.	CONTAINS TOXIC MATERIAL (E.G., HG, BE):	no
h.	CONTAINS OUTGASSING MATERIAL:	no
i.	VENTS FLUIDS OR GASES:	no
j.	CONTAINS CRYOGENS:	no
k.	HAS MOVING EXTERNAL PARTS:	no
l.	CONTAINS EXPLOSIVE DEVICES:	no
m.	CONTAINS OR GENERATES EXPLOSIVE OR FLAMMABLE MATERIAL OR GAS:	no
n.	CUSTOMER SUPPLIED GSE CONTAINS RADIOACTIVE MATERIAL, LIGHT OR RF SOURCES, PRESSURIZED VOLUME:	no
o.	ANY OTHER HAZARD:	yes

DESCRIPTION OF IDENTIFIED HAZARD(S):

1. The payload will nominally be pressurized to one atmosphere; the payload will not be over pressurized above one atmosphere.
2. The payload will be an RF emitter at S-Band for periods of the experiments (no continuous radiation).
3. A ground station will emit a laser non-continuous laser pulse train towards the shuttle payload and the payload will return the beacon using a retroreflector and a modulator to carry the data back to the ground station.

3.5.1 SAFETY MATRIX

The Payload Safety Matrix and Descriptive Data Form contained in Appendix A, figures A.4, A.5, A.6 and A.7 should be used to provide an estimate of payload safety hazards. The intent of the forms is to assist in tabulating identified hazards associated with payloads and GSE. Directions for preparing these forms are given in Appendix A, page A-10 for the Payload Safety Matrix and A-13 for the Descriptive Data Form.

4. MISSION OPERATIONS REQUIREMENTS

4.1 OPERATIONAL SCENARIO

4.1.1 Fixed Antenna Testing

The purpose of this set of experiments is to demonstrate the ability of a fixed-pointed antenna system to transmit data through the TDRS to the ground data collection facilities. To accomplish this test, the data transmission needs to occur on an orbit with an ascending or descending node near a TDRS subsatellite point as shown in Figure 4.1. The contact occurs during the highlighted region along the orbiter ground track centered around -41° longitude. It is also required that the payload in the orbiter cargo bay is oriented pointing out away from the center of the earth. An orbiter local attitude of (0,0,0) would be expected for the orbiter for these tests.

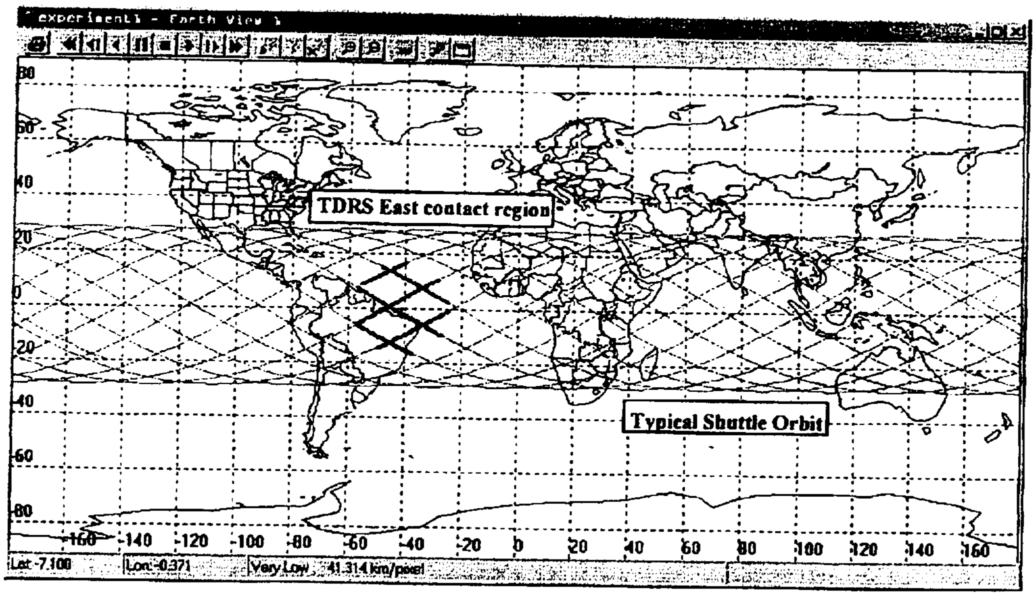


Figure 4.1 - Orbital configuration for fixed antenna pointing experiment. Shaded region along the orbit is the contact region.

The exact orbit for the test is not critical nor is the orbital inclination angle and can be selected based on other mission requirements as long as the ascending node/descending node requirement is met. It is desired that the ascending or descending node be in the range of -60°W through -20°W with a pass as close to -41°W as possible be chosen if the experiment is to be run through TDRS East. Similar orbital constraints exist for using TDRS West. There is no sun constraint on the pointing and the test can be run either during daylight or nighttime hours. The experiment time line would be as follows:

1. Crew activate the payload and select the experiment using the select switches. This will need

to be done approximately 15 minutes prior to the orbiter's closest approach to the TDRS subsatellite point. This will give approximately 5 minutes for the electronics to come on, power and amplifiers to stabilize, and the payload computer to verify correct status of all components. At this time, the access door to the payload will also need to be opened.

2. The computer in the payload will autosequence to begin transmitting data for a total of 10 minutes centered on the closest approach to the TDRS subsatellite point. This is based on the payload activation at the proper time.
3. After the 10 minute data transmission, the payload can be deactivated by the crew using the select switches. At this time, the access door to the payload can be closed.
4. The payload can remain dormant until the next scheduled activity.

For proper testing, we would request that this experiment be run on a minimum of 5 orbits throughout the total mission duration. It is desirable to have some passes within 5° of the TDRS subsatellite point and some passes at least 10° from the TDRS subsatellite point. One desirable pass configuration would be to have the first pass on TDRS East and the next pass on TDRS West at the next possible orbit where the ascending/descending node requirement is met.

4.1.2 DAMA Testing

The purpose of this set of experiments is to demonstrate the ability of a low-power, relatively omni-directional communications system to transmit a request for services through the TDRS to the ground data processing facilities. To accomplish this test, the orbiter needs to be within the field of view of a TDRS satellite as shown in Figure 4.2. It is also required that the payload in the orbiter cargo bay is oriented pointing out away from the center of the earth. An orbiter local attitude of (0,0,0) would be expected for the orbiter for these tests.

The exact orbit for the test is not critical nor is the orbital inclination angle and can be selected based on other mission requirements. The communications do not need to be started at any position relative to the TDRS ascending node as is done with the fixed antenna pointing. There is no sun constraint on the pointing and the test can be run either during daylight or nighttime hours. The experiment time line would be as follows:

1. The computer in the payload will autosequence to begin transmitting data for a total of 10 minutes centered on the closest approach to the TDRS subsatellite point. This is based on the payload activation at the proper time.

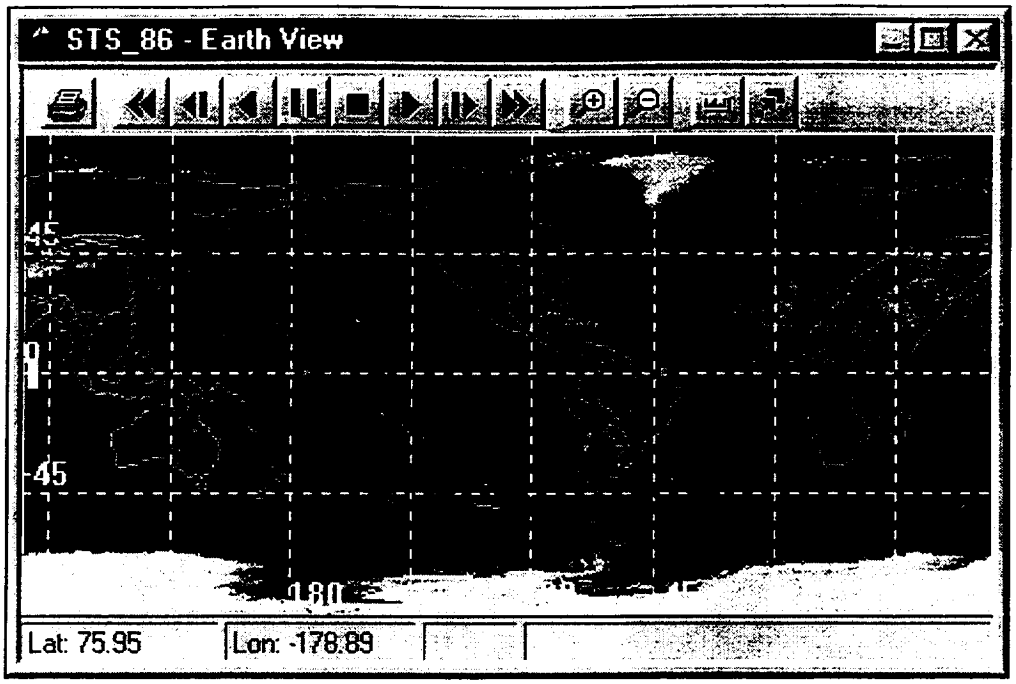


Figure 4.2. - Potential access regions along a typical shuttle orbit for DAMA requests through TDRS East and TDRS West.

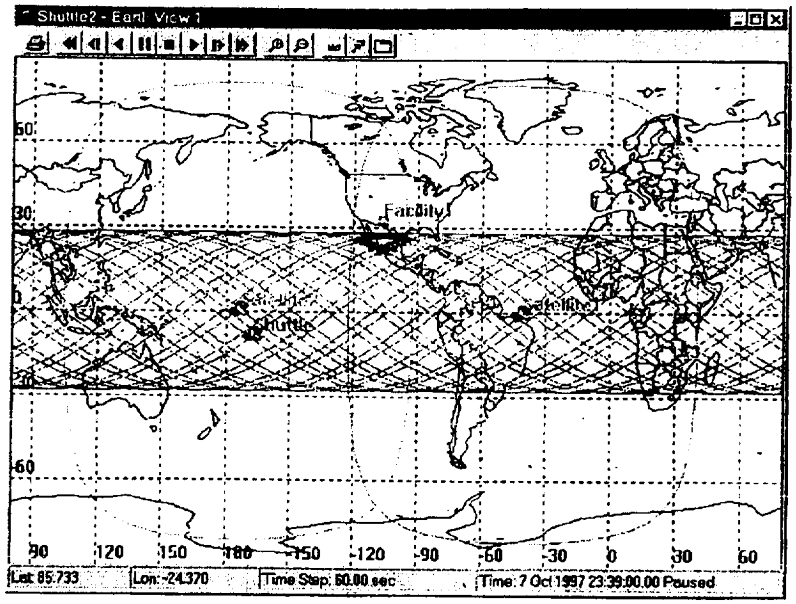
2. After the 10 minute data transmission, the payload can be deactivated by the crew using the select switches. At this time, the access door to the payload can be closed.

3. The payload can remain dormant until the next scheduled activity.

For proper testing, we would request that this experiment be run on a minimum of 5 orbits throughout the total mission duration. It is desirable to have some passes within 5° of the TDRS subsatellite point and some passes at least 10° from the TDRS subsatellite point. One desirable pass configuration would be to have the first pass on TDRS East and the next pass on TDRS West at the next possible orbit where the ascending/descending node requirement is met.

4.1.3 Passive Telemetry Testing

The purpose of this set of experiments is to demonstrate the ability of a ground-based laser system to extract data from a low-earth-orbit satellite by having the satellite modulate the data using a filter and then return the laser beam to the ground station using a retroreflector. To accomplish this test, the data transmission needs to occur when the orbiter is above the horizon as seen from the White Sands Missile Range as shown by the highlighted orbital period under the "Facility" in Figure 4.3. It is also required that the payload in the orbiter cargo bay is oriented towards the center of the earth. An orbiter local attitude of (0,0,-180) would be expected for the orbiter for these tests.



Experiment Window: Ascending nodes occurring between 131.3 and -152.0 degrees

Length of Access: 9 to 10 minutes

Figure 4.3 - Orbital configuration for laser-based passive telemetry testing.

The exact orbit for the test is not critical and can be selected based on other mission requirements as long as the ascending/descending node requirement is met. The orbital inclination angle will affect the duration of the testing. A 28° inclination will provide test time as illustrated in Figure 4.3, however, a 56° inclination would provide higher quality test passes. If a 28° orbital inclination is used, it is desired that the orbital ascending node be in the range of 131° through -152° with an ascending node as close to 180° as possible be chosen for the testing. If a 56° orbital inclination is used, it is desired that the orbital ascending node be in the range of 104° through 128° with an ascending node as close to 116° as possible be chosen for the testing. Alternatively, for a 56° inclination, orbits with descending nodes in the range of -156° through -123° can be chosen for testing. There is no sun constraint on the pointing and the test can be run either during daylight or nighttime hours. The experiment time line would be as follows:

1. Crew activate the payload and select the experiment using the select switches. This will need to be done approximately 15 minutes prior to the orbiter's closest approach to the White Sands Missile Range. This will give approximately 5 minutes for the electronics to come on, power to stabilize, and the payload computer to verify correct status of all components. At this time, the access door to the payload will also need to be opened.
2. The orbiter state vector will need to be updated and transmitted to the laser control at the White Sands Missile Range approximately 5 minutes prior to the start of the experiment pass.

The WSMR facility will need the position and down track velocity information at that time so that the optical transmitter can be directed to the payload in the orbiter cargo bay.

3. The computer in the payload will autosequence to begin the laser communications mode centered on the closest approach to White Sands. The payload will remain active in this mode for approximately 10 minutes. This is based on the payload activation at the proper time.
4. After the 10 minute data transmission, the payload can be deactivated by the crew using the select switches. At this time, the access door to the payload can be closed.
5. The payload can remain dormant until the next scheduled activity.

For proper testing, we would request that this experiment be run on a minimum of 5 orbits throughout the total mission duration. It is desirable to have some passes during daylight hours and some during night time hours to assess the solar rejection characteristics of the ground receiver filters.

4.2 EXPERIMENT POWER

TABLE E.6

EQUIPMENT POWER PROFILE

Phase	Idle	Nominal	Peak	Comment/Duration/ Attitude
Standby	0	20	40	Heaters
Experiment 1	100	110	150	operation ~ 5 - 10 min.
Experiment 2	100	110	150	operation ~ 5 - 10 min.
Experiment 3	50	50	70	operation ~ 5 - 10 min.
Voltage Regulator	10	20	30	
Laser Reflector Modulator	0	5	5	
Computer/Controller	2	3	3	
Heaters	1	1	1	
Communications Amplifiers	0	50	70	

SEE FORM TOOL

4.3 THERMAL OPERATIONS

Describe the thermal operations of your experiment, i.e. do you have heaters? Are they commandable or thermostatically controlled? Describe your thermal constraints in Table E.7 below:

TABLE E.7
THERMAL CONSTRAINTS

THERMOSTATIC EQUIPMENT	DUTY CYCLE (PERCENT)	POWER (watts)	COMMENTS/DURATION/ ATTITUDE
Heater	----------	----------	Bay-to-Sun (Hot)
Heater	50%	60	Bay-to-Earth (Nominal
Heater	80%	80 - 150	Bay-to-Space (Cold)

PAYLOAD with heaters OFF:

ATTITUDE	MAXIMUM DURATION	RECOVERY TIME	EFFECT IF VIOLATED
Bay-to-Sun	unlimited	----------	none
Bay-to-Earth	48 hours	1 hour	increase time needed to achieve operating temperature
Bay-to-Space	24 hours (HMDA closed)	2 - 3 hours	increase time needed to achieve operating temperature

PAYLOAD with heaters ON:

ATTITUDE	MAXIMUM DURATION	RECOVERY TIME	EFFECT IF VIOLATED
Bay-to-Sun	unlimited	30 minute cool down by opening HMDA	high internal temperature may affect electrical components
Bay-to-Earth	unlimited	0	none
Bay-to-Space	unlimited	0	none

4.4 EXPERIMENT COMMANDING

The payload will be designed with crew-activated switches to enable the payload operation and select the experiment to be performed. It is not anticipated that ground-based commanding through the orbiter will be required unless NASA requests such capability. The laser experiment will be receiving commands via the ground-based laser system.

4.5 EXPERIMENT TELEMETRY

It is expected that payload telemetry generated in the payload will be transmitted via downlink during the experiment times. No independent downlink is anticipated at this time unless NASA requires it for payload operational checkout.

4.6 CREW INVOLVEMENT

Only crew involvement anticipated is actuation of control switches at the designated time in the mission.

4.7 ORBITER POINTING

Orbiter pointing and attitude have been identified earlier for each experiment phase. Additional constraints beyond those previously identified are indicated below in Table E.12.

TABLE E.12
ORBITER POINTING RESTRICTIONS

RESTRICTION	DURATION	ANGLE	EFFECT IF VIOLATED
RAM	unlimited		none
Sun	unlimited		none
Moon	unlimited		none
Earth	unlimited		none
Earthlimb	unlimited		none
Umbra	unlimited		none

4.8 INSTRUMENT FIELD OF VIEW

The communications devices (antennas and laser reflectors) are anticipated to be surface-mounted on the payload and will be oriented normal to the payload container surface. The laser retroreflectors will have a field of view of ±60° relative to the payload zenith pointing direction. The RF antennas will have fields of view of ±20° and ±80° relative to the zenith pointing direction. It is expected that the payload will be vertically mounted and pointing out of the cargo bay.

4.9 CONTAMINATION CONSTRAINTS

TABLE E.13
CONTAMINATION CONSTRAINTS

CONTAMINANT	DURATION OF EXPOSURE	TIME UNTIL OPERATIONS RESUME	EFFECT IF VIOLATED
Payload bay lights on	unlimited	N/A	none
Flash Evaporator System (FES) operations	not during laser experiments	TBD	potential loss of data
Fuel Cell Purge (FCP) operations	unlimited	N/A	none
Vernier Reaction Control System (VRCS) burns	not during laser experiments	TBD	potential loss of data
Primary Reaction Control System (PRCS) burns	not during laser experiments	TBD	potential loss of data
Orbital Maneuvering System (OMS) burns	not during laser experiments	TBD	potential loss of data
Electron Contamination Regions (ECR)	unlimited	N/A	none
Water Dumps	not during laser experiments	TBD	potential loss of data
South Atlantic Anomaly (SAA)	unlimited	N/A	none

4.10 CUSTOMER SUPPLIED GROUND SUPPORT EQUIPMENT (CGSE)

4.10.1 HITCHHIKER CUSTOMERS

The payload will require two customer-supplied and operated CGSEs. One (the operations system) will provide control and display during integration and test activities of the payload to carrier, system tests, end-to-end tests, Joint Integration Simulations, and flight operations at GSFC. The other (the test system) will support the functional tests, CITE tests, and Orbiter IVT test at KSC. Table E.14 provides information about the CGSEs. Diagram E.1 indicates the configuration of the CGSE and the CCGSE/ACCESS both for testing and for operations.

TABLE E.14

CUSTOMER GROUND SUPPORT EQUIPMENT (CGSE)
(Not required for HH-J)

TEST SYSTEM

TYPE/MAKE OF UNIT	WEIGHT	POWER (Voltage/Current)

Will the CGSE transmit commands? ____________
Will the CGSE receive low rate data? ____________
Will the CGSE receive medium rate data? ____________
Number of standard 115 VAC outlets required: ____________
Floor space required: ____________ Sq.Ft.

OPERATIONAL SYSTEM

If there will be a backup system, describe that separately (i.e., equipment available but not set up, not backup, etc.)

TYPE/MAKE OF UNIT	PURPOSE	WEIGHT	POWER (Voltage/Current)
No backup required			

DIAGRAM E.1

CGSE/CCGSE/ACCESS CONFIGURATION

(Not required for HH-J)

TEST:

OPERATIONS:

4.11 PAYLOAD OPERATIONS CONTROL CENTER (POCC) REQUIREMENTS

4.11.1 HITCHHIKER CUSTOMERS

Approximately how many people/positions do you intend to have in the POCC during the mission? Identify the positions.

At most, two persons: Payload Manager and an Assistant Payload Manager.

How many customer space units will you require? One customer space unit.

One customer space unit includes:

- 1 3' x 5' table
- 2 standard outlets
- 1 video outlet port
- 1 data phone
- 1 call director (2 people can talk/listen)
- 1 color display unit

Identify any additional requirements not listed above.

None

Will you need additional space for non-operations personnel that will be monitoring the mission?

None.

4.12 POST-MISSION DATA PRODUCTS

4.12.1 HITCHHIKER CUSTOMERS

Do you desire Calibrated Ancillary System (CAS) parameter data? No

Do you desire to receive post-mission products of your telemetry data? No

5. PAYLOAD REQUIREMENTS FOR OPTIONAL SERVICES

We anticipate the capture of data at the White Sands Complex during the fixed antenna and DAMA experiment periods. We request permission to capture the data at the WSC and to bring in up to three engineering team members to monitor the data capture and experiment results. NMSU will supply the computers for data collection if this request is granted.

The Laser Communications experiment will require separate personnel at the White Sands Missile Range laser facility. They will need to interface with shuttle operations for orbital state vector updates to allow for ground segment laser pointing and tracking.

6. TBDs AND DUE DATES

At present, NMSU requests assistance in completing the items for Section 3.5.1 and 4.10.1. It is expected that these can be completed quickly with the assistance of NASA.

TABLE E.15

TO BE DETERMINED ITEMS

SECTION	DESCRIPTION	DUE DATE
Table E.1	Personnel Identification	60 days after being given approval to proceed
3.5.1	Safety Matrix	
4.10.1	CGSE Requirements	