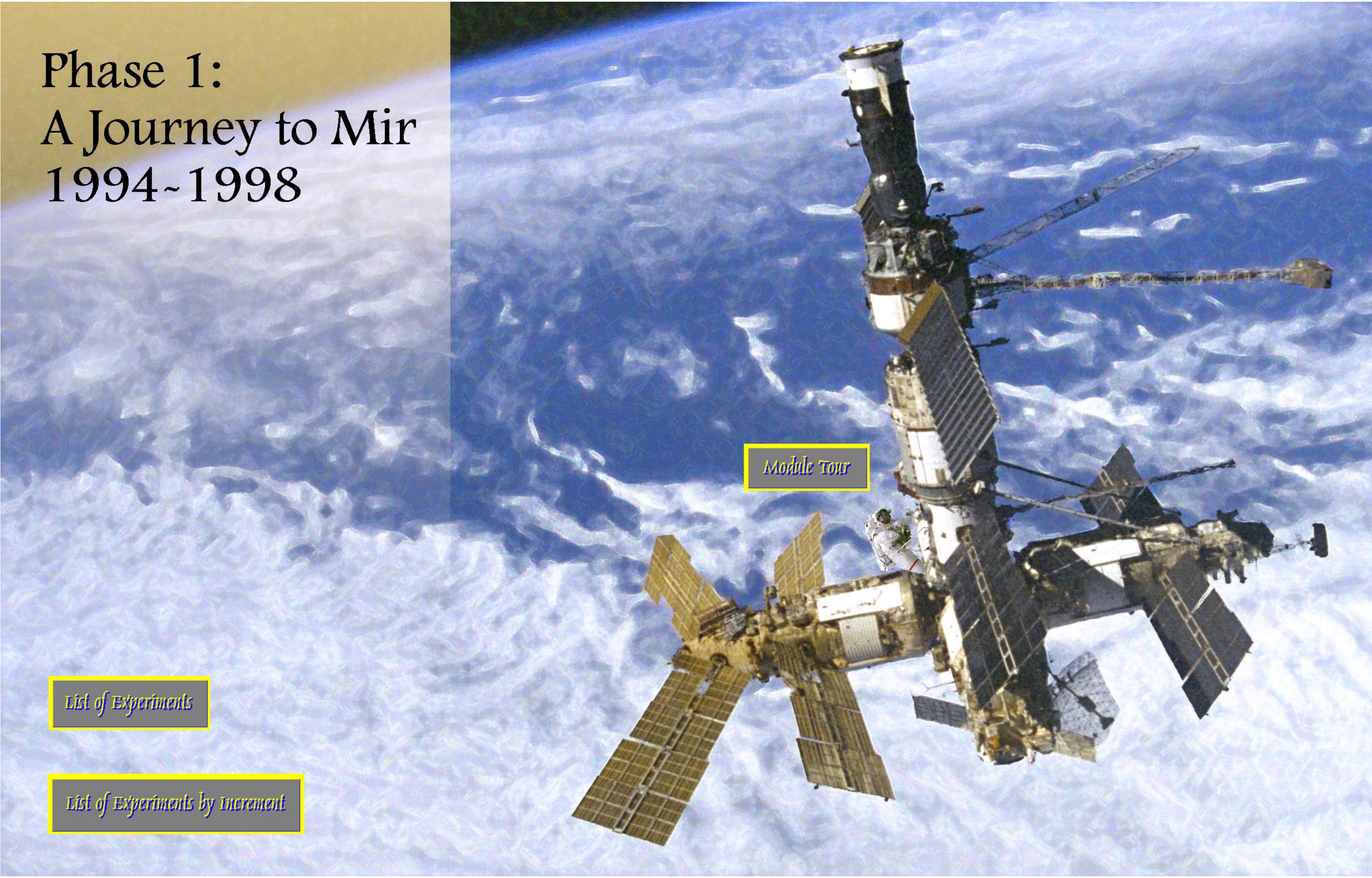
# Phase 1: A Journey to Mir 1994~1998



# Active Dosimetry of Charged Particles

## EXPERIMENT DESCRIPTION

The experiment measures angular distributions of charged particles with high local resolution in a telescopic arrangement of charge coupled devices (CCDs) for particle detection and atomic discrimination. The Particle Telescope Head is designed for radiobiological investigations with single heavy ions. The data obtained from this experiment will yield on-line data for particle fluxes for time resolved radiation monitoring and warning purposes.

## SCIENCE OBJECTIVES

1. To measure angular distributions of charged particles with high local resolution.

2. To yield on-line data for particle fluxes for time resolved radiation monitoring and warning purposes

## ASSOCIATED HARDWARE

Particle Telescope Head
CHAPAT Experimental Computer
Mir Interface to Payload Systems-2 (MIPS-2)
Data Storage System
Tape Storage and Transport Bags

## HARDWARE DESCRIPTION

The experiment consists of a particle telescope head (PTH) and CHAPAT Experiment Computer (CEC).

## PARTICLE TELESCOPE HEAD (PTH)

The PTH is a stand alone hardware item which contains three Charge Coupled Devices (CCDs) in telescopic arrangement, two Passivated Implanted Planar Silicon Detectors (PIPSs) on top of the CCDs, electronic boards for the processing of three TV signals, electronic boards for reading and digitizing of PIPS data, temperature monitoring electronics, and a fan for air cooling. Velcro is used to attach the PTH to surfaces in Mir.

The telescopic radiation sensor device housed in the PTH consists of three CCDs and two PIPSs together with electronics for signal conditioning. The signals of the frame transfer CCDs of type FT800 (Philips) are converted into CCIR standard TV format in three image sensor modules of type

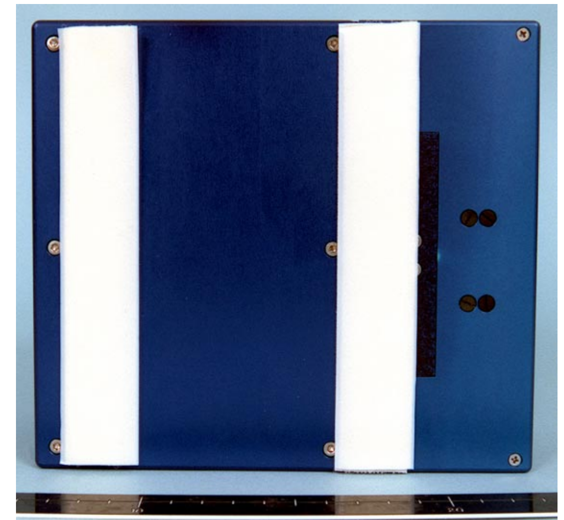


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Figure FB-2
Particle Telescope Head Bottom

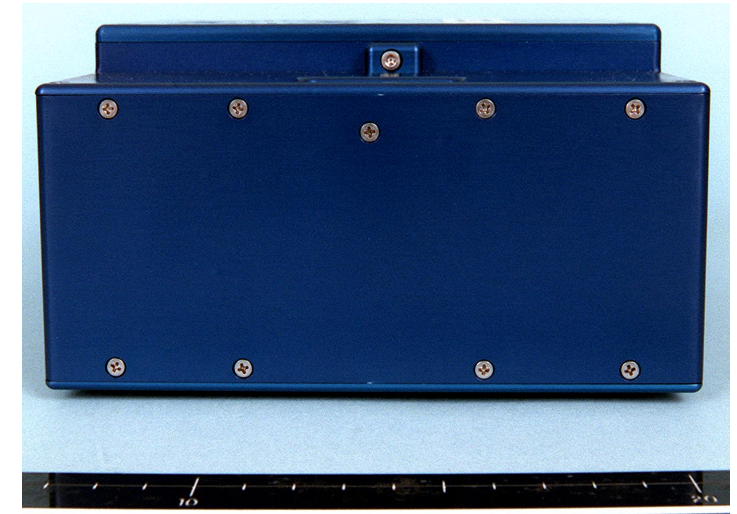

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Figure FB-3 Back View of PTH

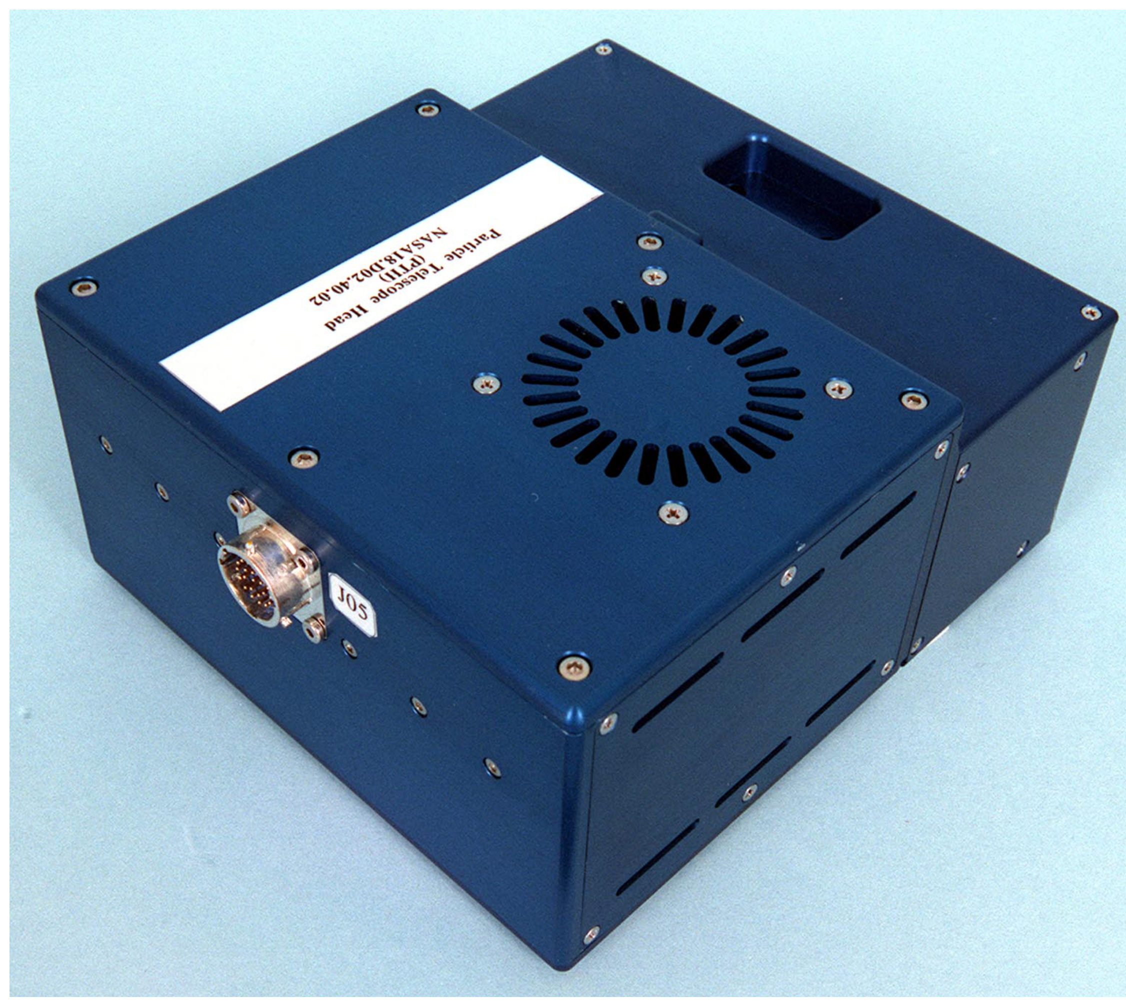


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Figure FB-1 Particle Telescope Head


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Figure FB-4 Front View of PTH

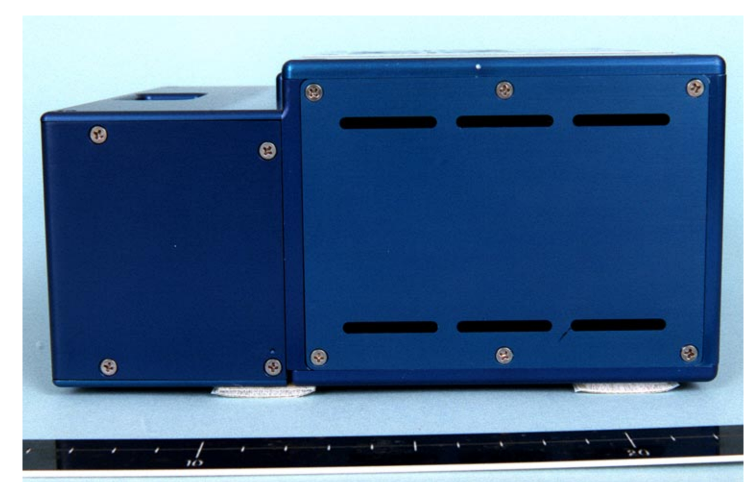

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Figure FB-5 Side View of PTH

D.I.D

Active Dosimetry of Charged Particles

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DLR, Institute for Aerospace Medicine
49-2203-6013-140

**ADCP**

Power Consumption:
100 ± 10 W
Start-Up Current:
19 amps, 0.2 sec.
Onboard Electrical Supply:
28 Vdc
Insulation Resistance:
Same
Operational Life:
10000 hrs.
Shelf Life:
5 years

**PARTICLE TELESCOPE HEAD**

P/N: NASA.18D02.40.02
Qty: 1
Mass: 2.5 kg
Power: 101 W
x,y,z: 18 x 16 x 9 cm

FTM800 (Philips). The modules are operated with manual gain control and black level setting via the CEC. The temperature conditions for operational mode are -10 to +55 °C. A sensor measures the temperature at the site of the CCDs. Its data is used for monitoring (correction of dark current effects) and for automatic power switching of the FTM800 modules in case of overheating. The signals from the PIPSs are conditioned and digitized on an electronic board adjacent to the sensors. The data is made available for transmission to CEC via a RS232 bus.

The PTH has no switch for power. It is active whenever it is connected by cable to the CEC and the status of the CEC is 'ON'.

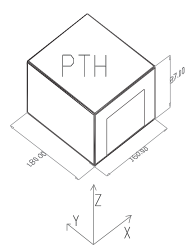


Figure FB-6 Particle Telescope Head

## CHAPAT EXPERIMENT COMPUTER (CEC)

The CHAPAT Experiment Computer (CEC) is designed as a stand alone hardware item. It contains Mir power switching and fusing, electrical filters, power conversion for CEC and PTH, fans for air cooling, status control elements, and PC components. Crew interfaces provided by the front panel during experiment operation are status indication, LCD display, alphanumeric keyboard, floppy drive, and DAT recorder.

The left side panel gives access to the power interface to Mir, the power switch for experiment operation, the fuses and the electrical interfaces to the PTH.

Soft handles are attached at both side panels for transportation. All other panels can be used as bottom base for storage purposes. Velcro hook bands are attached for affixing the CEC to Mir surfaces.

Cooling of the interior of the CEC is provided by a fan in the front panel. Air outlets are in the side panel close to the electrical interfaces.

The CEC is the central item of the ADCP. It is assembled from commercial PC boards together with an image analyzing system for online frame operations and an I/O board for the PIPS data reading and PTH operation. The I/O and image analyzing boards of the CEC are mechanically secured with a frame system alternate to the plug-ins to the bus sockets. The main components of the CEC are shown in the ADCP electronic block diagram.

A board inside the CEC carries three power converters (the 50 and 75 watt type on a passive cooling plate) and an electronic device for the generation of the power good signal for the motherboard. A filter between Mir power and the power converters is attached at the rear panel close to the power connector J01. The fuse for primary power is located beside the power switch.

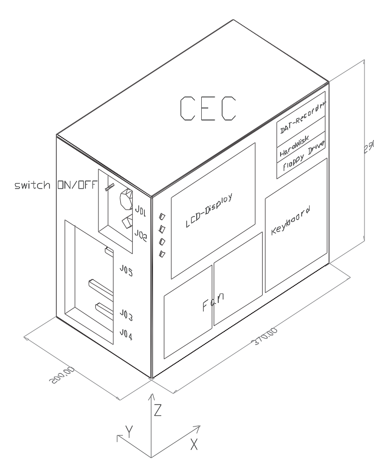


Figure FB-7 CHAPAT Experiment Computer

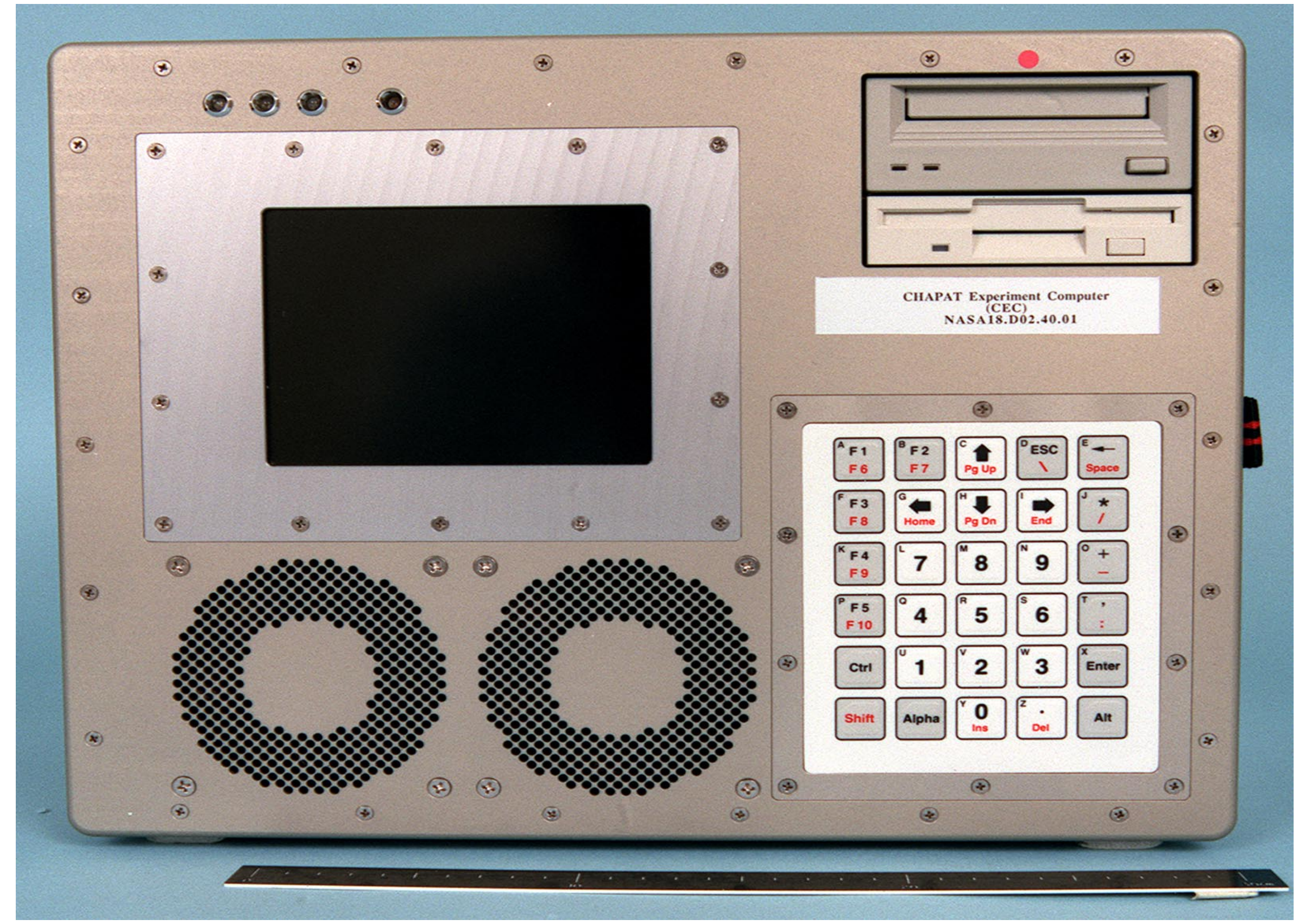


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Figure FB-8 CHAPAT Experiment Computer Face

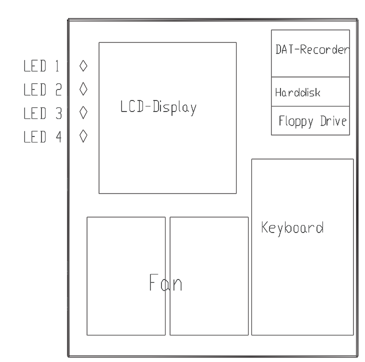


Figure FB-9 CHAPAT Experiment Computer - Front Panel with Status Indicators

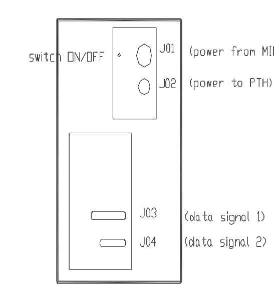


Figure FB-10 CHAPAT Experiment Computer - Side Panel with Electrical Interfaces

**CHAPAT EXPERIMENT COMPUTER**

P/N: ESA.18D02.40.CHA1
Qty: 1
Mass: 10.8 kg
Power: 101 W
x.y,z: 41 x 33 x 24 cm

The CPU uses a 90 Mhz Pentium processor in an extended EISA/PCI bus structure. A floppy disk of DOS 1.44 MB format is used for loading of experiment software and for the storage of samples of experiment data and experiment status information for downloading. A DAT recorder type HP354480 provides the storage of eight experiment data packages of a size of 250 MB on a single tape for recovery and post-mission evaluation on the ground. The hard disk is used for the operation system and intermediate storage of accumulated data.

For the online analysis of the incoming three frames of the FTM800 modules (R, G, and B channels), a frame grabber type AFP with a 6 MB memory is used together with a PRIMA SPEED board (both being produced by LEUTRON, Glattbrugg, Switzerland). The PRIMA SPEED allows discrimination of information from particle events in single CCDs against artifacts, such as the potential occurrence of permanent radiation damage in single pixels caused by the passage of single heavy ions of the orbital radiation field, or by nuclear interactions in the substrate. The I/O board of Keithley type DAS-1601 controls the operation of the PTH, power switching, setting of the FTM800 parameters 'Gain' (REMG) and 'Black level' (BLACK), and reading of the experiment data of the PIPSs and the ambient temperature. The provision of power for all components of the ADCP is performed in the CEC. All secondary power circuits are galvanically isolated from primary Mir power. Table FB.1 shows the converters used.

TABLE FB.1
POWER CONVERTERS

| I.D. No. | Manufacturer | Type Voltage/ Polarity | Power (Watts) |
|---|---|---|---|
| 1 | Powertrade | IP3-36-5-75 | +575 |
| 2 | Powertrade | IP3-36-12-50 | +1250 |
| 3 | Melcher | 24IPS3-05-12-T-5-12 | 1.25-1.25 |

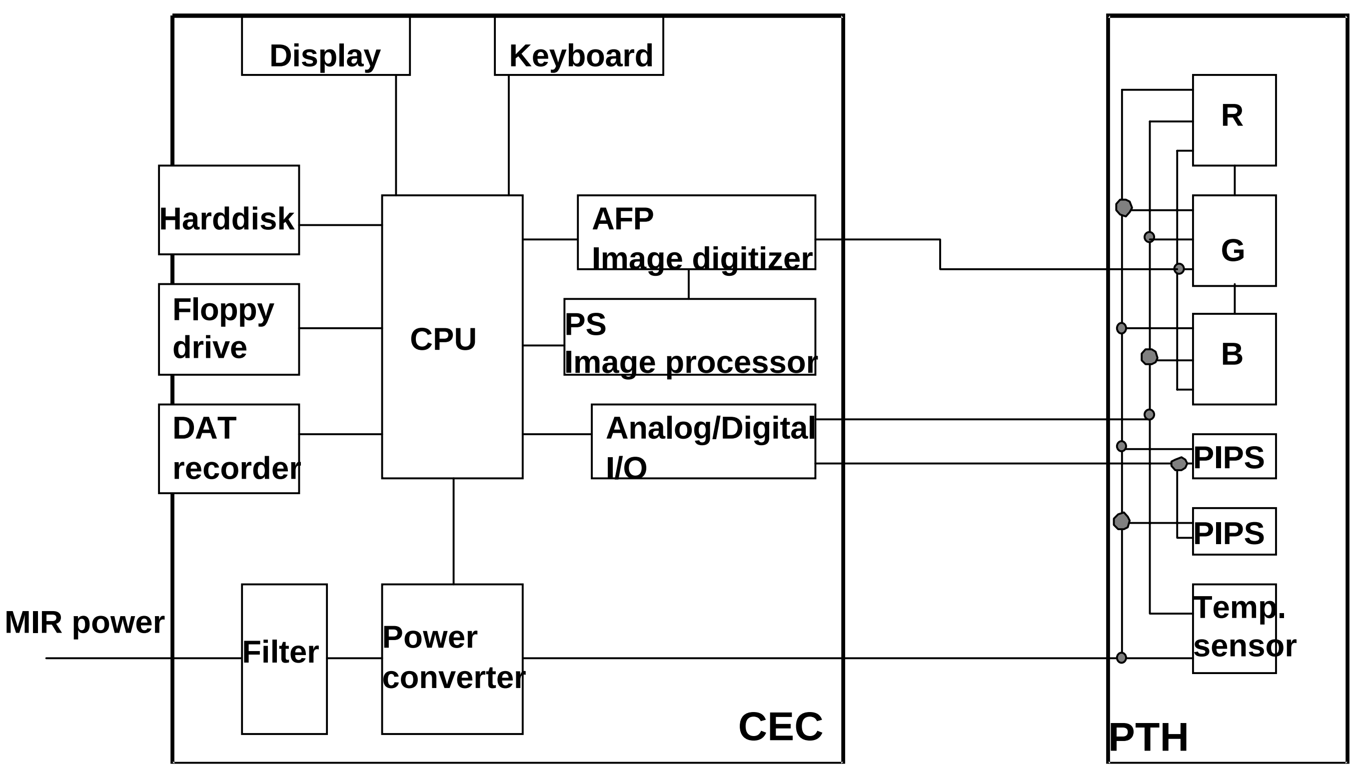


Figure FB-11 ADCP - Electronic Block Diagram

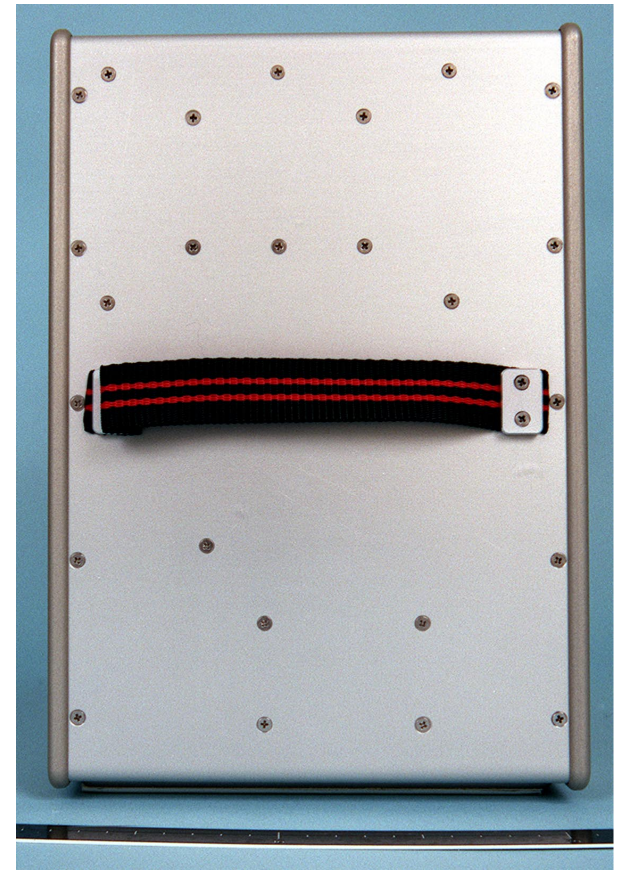

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Figure FB-12 Right Side of CHAPAT

The +5 Volts are used for computer components and for the electronics of the PIPS in the PTH; -5 Volts are used for the mother board of the computer only. The +12 Volt line powers computer components and the fan within the CEC, and the electronics for CCD read out, PIPS operation, and the fan in the PTH. The -12 Volts are connected to PIPS electronics. The +5 Volt and the +12 Volt power lines from the CEC to PTH are fused. Table FB.2 shows the fusing of secondary power for the PTH.

All power lines use PTFE isolated cables.

TABLE FB.2
EXPERIMENT FLIGHT HARDWARE

| Hardware | Title | Qty |
|---|---|---|
| Particle Telescope Head | (PTH) | 1 |
| CHAPAT Experiment Computer | (CEC) | 1 |
| Data Storage System | (DSS) | 24 |
| Tape Storage and Transport Bags | (TSTB) | |
| Harness Power | (W1P) | |
| Harness Data | (W1D) | 1 |

TABLE FB.3
POWER PROVISION AND FUSING FOR THE PTH INSIDE CEC

| Power (Volts) | Wire Gauge | Fuse No. | Electrical Parameters | Dest | Function Remarks |
|---|---|---|---|---|---|
| +5 | AWG20 | 3 | 1 A | PTH | PIPS operation |
| +12 | AWG20 | 4 | 2 A | PTH | CCD operation |
| | | | | | PIPS operation |
| | | | | | Temp. sensing |
| | | | | | Fan operation |
| -12 | AWG20 | NO | | PTH | PIPS operation |

1.5 Watts output, continuous short circuit proof

## TAPE STORAGE AND TRANSPORT BAG (TSTB)

The TSTB is a Nomex bag for DAT cartridges and floppy disks (DSS). Each bag is folded once and closed by a Velcro tape. Two of the three bags contain eight SONY DG90MA cartridges, and the third bag contains six of these cartridges and two floppy disks. The floppy disks are used to load ADCP software into the computer and to transfer small increments of experiment data to the MIPS system for downloading. The DAT cartridges are used for storage and recovery of experiment data.

## DATA STORAGE SYSTEM (DSS)

The DSS uses floppy disks and DAT cartridges for storage of experiment software for operation of the PTH and data acquisition, transfer of experiment data to the MIPS-2, and storage of experiment data for recovery. Table FB.4 shows the components of the DSS. Refer to Table FB.5 for data formats of DSS items.

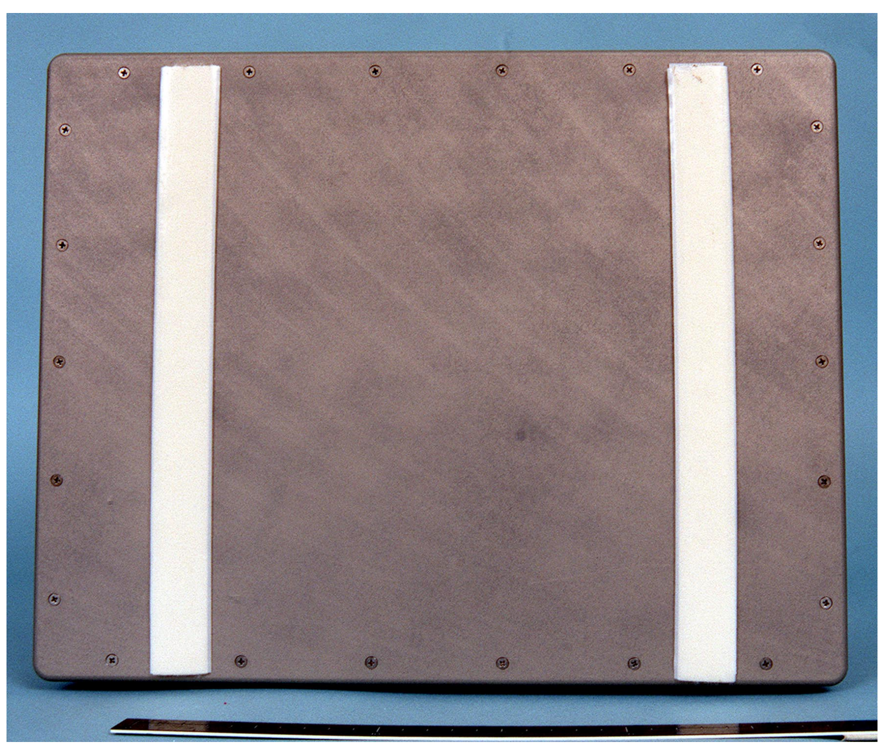

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Figure FB-13 Back of CHAPAT


S97-05365

Figure FB-14 Left Side of CHAPAT

## HARNESS POWER (W1P)

The W1P is a 3 m long skeined cable with two twisted wires, used to connect J01 of the CEC to the Mir power system. For transportation, the W1P is stored in a Nomex bag with the harness for the connection of CEC to PTH. The electrical characteristics of the W1P are shown in Table FB.6.

## HARNESS DATA (W1D)

The W1D is a 3 m skeined cable connecting the CEC with the PTH. At the site of the PTH it is equipped with the connector type MS27473T-12F35S, fitting into J05 on the back panel of the PTH. At the EC site, it is split into three cables with connector type MS3476L10-6 fitting EC power (J02) and two data connectors type UHM37, FCT433 FU37S7-K147 and FMH3, FCT364 FU25S7-K147 fitting the AD/DA-I/O slotcard (J03) and the AFP slotcard (J04). The electrical characteristics of the W1D are shown in Table FB.7. For transportation, the W1D is stored in a Nomex bag with the W1P. ☀

TABLE FB.4
MECHANICAL CHARACTERISTICS OF DSS

| Item | Qty | Manufacturer | Type |
|---|---|---|---|
| Floppy diskette | 2 | 3M | HD 3.5" |
| DAT cartridge | 22 | SONY | DG90MA |

TABLE FB.5
DATA FORMATS OF DSS ITEMS

| Item | Format | Capability | Size of single files |
|---|---|---|---|
| Floppy diskette | DOS | 1.44 MB | 250 KB |
| DAT cartridge | DOS | 2 GB | 250 MB |

TABLE FB.6
ELECTRICAL CHARACTERISTICS OF W1P

| I.D. No. | Connector for Mir Power | Pin No. | Wire Gauge | Connector for EC | Pin No. | Remarks |
|---|---|---|---|---|---|---|
| 1 | TBD | TBD | AWG 16 | MS3476L8-33S | A | +28 Volts |
| 2 | | TBD | AWG 16 | | B | RTN |

**POWER HARNESS**

P/N: NASA18.D02.40.04.01
Qty: 1
Mass: 0.25 kg
Power: 0
x, y, z: 90 x 0 x 2.52 cm

**DATA HARNESS**

P/N: NASA18.D02.40.04.02
Qty: 1
Mass: 0.25 kg
Power: 0
x, y, z: 90 x 0 x 2.5 cm


S97-05366

Figure FB-15 CHAPAT

TABLE FB.7
ELECTRICAL CHARACTERISTICS OF W1D

| Connector pin | Wire # | AWG | Signal/ Power | Twisted to wire # | Connector pin |
|---|---|---|---|---|---|
| J05 / 1 | 1 | 20 | + 12 V | 2 | J02 / A |
| J05 / 2 | 2 | 20 | RTN | 1 | J02 / B |
| J05 / 21 | 3 | 20 | RTN | 4 | J02 / C |
| J05 / 20 | 4 | 20 | + 5 V | 3 | J02 / D |
| J05 / 18 | 5 | 24 | - 12 V | 10 | J03 / 37 |
| J05 / 19 | 6 | 24 | RTN | 9 | J03 / 18 |
| J05 / 16 | 7 | 24 | AO 1 / BLACK | 6 | J03 / 9 |
| J05 / 15 | 8 | 24 | DI 1 / SAA | 5 | J03 / 29 |
| J05 / 17 | 9 | 24 | AO 2 / REMG | 8 | J03 / 27 |
| J05 / 22 | 10 | 24 | AI 1 / Temp. | 7 | J03 / 28 |
| J05 / 5 | 11 | 24 | AI 2 / Let | 12 | J03 / 36 |
| J05 / 6 | 12 | 24 | RTN / AD-Sig. | 11 | J03 / 17 |
| J05 / 7 | 13 | 24 | DO 1 / Relais | | J03 / 23 |
| J05 / 10 | 14 | 24 | RS232/Trans. | | J03 / 4 |
| J05 / 11 | 15 | 24 | RS232/Recei. | | J03 / 22 |
| J05 / 12 | 16 | 24 | RS232/ GND | | J03 / 3 |
| J05 / 3 | 17 | Coax | VIDEO R | | J04 / 13 |
| J05 / 4 | 18 | Coax-RTN | VIDEO R | | J04 / 11 |
| J05 / 8 | 19 | Coax | VIDEO G | | J04 / 12 |
| J05 / 9 | 20 | Coax-RTN | VIDEO G | | J04 / 11 |
| J05 / 13 | 21 | Coax | VIDEO B | | J04 / 10 |
| J05 / 14 | 22 | Coax-RTN | VIDEO B | | J04 / 11 |

S97-05368

Figure FB-16 CHAPAT Flight Bags

**TAPE STORAGE AND TRANSPORT BAGS**

P/N: NASA.18D02.40.03.01
Qty: 1
Mass: 1 kg
Power: 0
x, y, z: 15 x 12 x 6 cm

D.I.D

Beetle Kit

# Effects of Gravity on Insect Circadian Rhythmicity

## BEETLE KIT ASSEMBLY

### BEETLE KIT

The Beetle Kit is self-contained within a Zero box container, which provides the third level of containment for these biological specimens. The bottom of the kit houses batteries to power the data loggers and the lighting timer systems. The Beetle Activity Modules will be supported above the batteries, and the upper lid of the kit will hold the kit electronics, the light timers and dataloggers. The kit will be configured so that the beetles are oriented with their feet downward (toward aft of orbiter) during launch.

### Beetle Activity Module (Treadmill and Living Space)

The BAM design is an adaptation of an existing item of Russian research hardware. The individual BAMs will be stacked within a chassis 8 in a row, top to bottom, with the wiring and tubing of the grouped BAMs collected in an umbilical. This chassis provides light insulation between each of the BAM groups and ensures a second biological level of containment.

The treadmill portion of the BAM is divided into four sections by a rotor, and each beetle will reside in one section. The rotor height is adjustable, and will be custom-fitted to the height of the individual beetle, such that the BAM roof will prevent the beetle from turning over in microgravity.

Movement of a beetle on the treadmill generates movement of a paddle wheel located beneath the floor of the beetle enclosure. An infrared sensor placed at one location under the wheel both emits light and senses its reflection, and it will give a measurement of the beetle's activity as a function of the difference between light reflected back from the opaque paddles and light passing through the clear space between paddles.

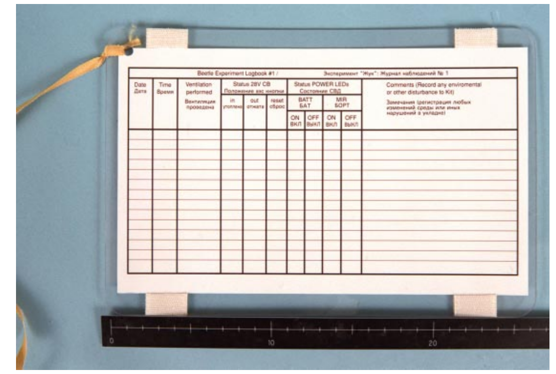
### Dataloggers

Eight 4-channel dataloggers will be used to record BAM activity. An event marker can be placed in the data stream by pushing a pushbutton on the Kit's control panel (Reference next section).

Figure FB-17 Beetle Kit Assembly S96-18511

### Ambient Temperature Recorder

In addition, and Ambient Temperature Recorder will be enclosed within each of the kits adjacent to the BAMs to measure kit temperature throughout the mission's duration. Optimal temperature range for the beetles is 24-28 °C, and maximum allowable range is 20-35 °C. There will be no active temperature control of the kits, and no active display of the kit temperature. To help dissipation of heat from the kit's electronics, the rear panels of the Priroda locker will be removed prior to installation of the kits.



S96-18508

Figure FB-18 Logbook

S96-18507

Figure FB-19 Beetle Cable

### Front Panel (Crew Interfaces)

The front panel controls and connections will be accessible to the crew through the cutouts in the modified middeck locker front door.

The following functions are provided:

*28 Vdc:* A connection for 28V power cable from Priroda.

*TIMER INIT:* A pushbutton switch to activate time control of lighting, providing switching of LEDs on and off automatically per the experiment protocol.

*28 V:* A circuit breaker/ switch that provides power to LEDs.

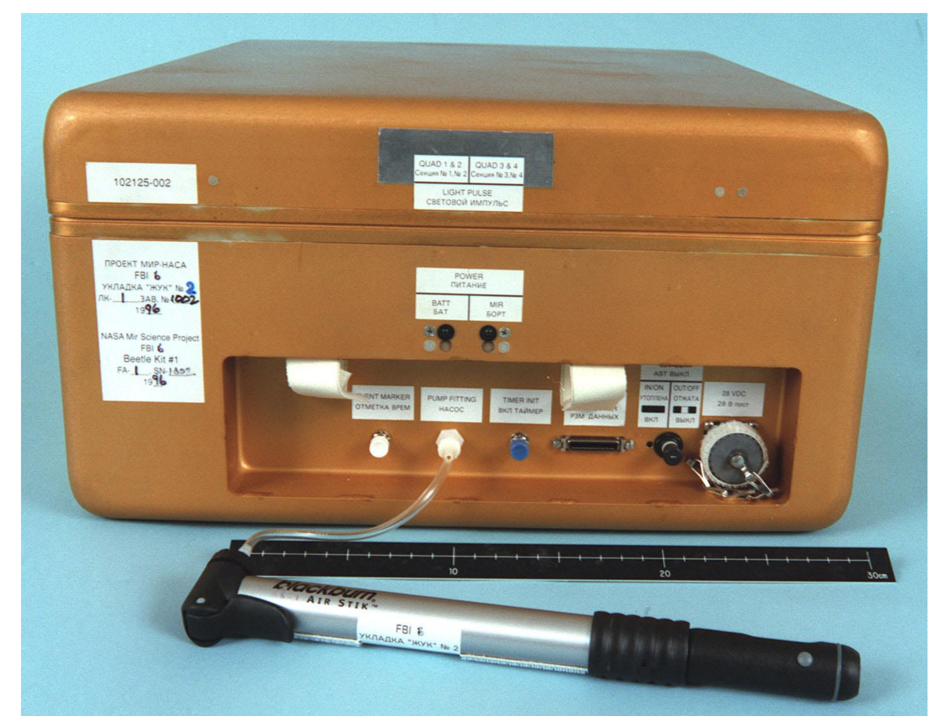
When the circuit breaker is tripped (out), a white band will be visible on the pushbutton switch. Circuit breaker status will be monitored once a week and immediately prior to scheduled light pulses.

*EVENT MARKER:* A pushbutton switch that places a marker in the data stream. It will be used to mark the weekly ventilation operation, as well as off-nominal events, such as a disturbance to the kits or a finding of a power-off condition of the circuit breaker.

*PUMP:* A QD connector for the bicycle pump used to replenish air in the beetle modules.

### Electrical Interface

28 V power is supplied to the Beetle Kits by cable from the Priroda Payload Utility Panel (PUP). The nominal power draw is 14 Watts. ✳



S96-18510

Figure FB-20 Beetle Pump

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# Cellular Mechanism of Spaceflight-Specific Stress to Plants (BRIC)

## EXPERIMENT DESCRIPTION

Embryogenically competent Daylilly (Hemerocallis cultivar. Autumn Blaze) cell cultures are grown in standard, 100 mm petri plates. There are four petri plates in each BRIC-100 canister and nine canisters were flown in support of this experiment for a total of 36 petri plates. Use of somatic embryos at different stages of development on semi-solid nutrient medium which has various degrees of free water tested whether the water relations of cells in relationship to the prevalence of free water in their immediate vicinity affects the nuclear responses. No inflight manipulation of this payload was required. Living cells and somatic embryos were returned for post-flight analysis and continued development. Post-flight analysis concentrated on general cellular morphology, light and scanning electron microscopy of the embryogenic cells, and chromosome analysis and karyotype determination.

### EXPERIMENT OBJECTIVES

- To test and profile critical stages in plant embryogenesis using embryogenic cultured cells grown in microgravity. Emphasis is on the capability to produce polarized organs and to maintain nuclear states and chromosome fidelity in microgravity. This experiment will validate and extend previous flight findings using embryogenic plant cells as a model.
- To test the primary question “How does the space environment bring about chromosomal and nuclear perturbations in plant cells?” The hypothesis to be tested is: Microgravity alters the water and gaseous relations of cells that are plated on substrates in space because the behavior of fluids in microgravity is significantly different from that on earth. Excess water and the accumulation of respiratory gases like $CO_2$ perturb cell water relations and metabolism in stressful ways and this is reflected in aberrant nuclear responses in the cell cycle.

### EXPERIMENT IMPORTANCE

Current efforts to exploit developing plant cells for use in biotechnologies are dependent on the ability to use and manipulate such systems in space. Obviously, cells must be able to divide normally and partition their genetic information (via chromosomes) with high fidelity if sustained and efficient plant growth is to occur in space. In short, dividing and developing plant cells need to get their signals straight and to process them accurately. The extent to which such development will occur in microgravity is a key concern for using modern plant biotechnologies in space.

## HARDWARE DESCRIPTIONS

### BRIC-M KIT

The kit consists of a foam padded Nomex bag holding a foam block and 9 (nine) BRIC-M Canisters.

The kit takes up the volume of one middeck locker. The Nomex bag provides Velcro attach points for securing the BRIC-M Kit to the stowed location aboard the Mir Station. Additionally, the kit may be secured using elastic cords or other straps through loops provided on the bag. A label is attached on the top cover of the kit. The dimensions of this bag are 508 x 254 x 420 ± 10 mm. The mass is not greater than 15 kg.

### BRIC-VC CANISTER

#### Mechanical Characteristics

The BRIC-VC canister is an anodized-aluminum cylinder with 3.125 mm thick walls. The outside dimensions of the BRIC-VC canisters are 114.3 mm OD x 158.75 mm long. One end of the cylinder is sealed while the other end supports a removable, pressure tight lid. At either end of the canister are pressure-tight, quick-disconnect, fittings used for flushing the canisters with gases of known composition.

The size of the BRIC-VC canister allows them to accommodate standard, laboratory, 100 mm petri plates. The BRIC-VC canisters are completely sealed to allow for a controlled experimental environment. The hardware inside the canister consists of four (4) polycarbonate 100 mm petri plates. Each petri plate contains semi-solid nutrient containing agar. On top of the solidified agar is a sheet of activated-charcoal impregnated filter paper. On top of this filter paper is a layer of dialysis membrane supporting the daylilly plant cell culture. The petri plates are held into place by means of a petri dish cage insert. The cage insert is manufactured from 304 stainless steel and contains guide rivets made from Acetal. In the bottom of each canister is housed small, commercially available temperature and relative humidity data loggers. These data loggers will store ambient condition data on EEPROM to be examined upon retrieval of the payload.

#### Electrical Characteristics

The BRIC-VC canisters do not require external electrical power.

The power for each of the Temp and RH Data Loggers is supplied by a Lithium Battery, Taradin TL-5186 (3.6V/370 mAH).

The continuous operation of the Temp and RH Data Loggers from a single Lithium Battery is not less than 1 year.

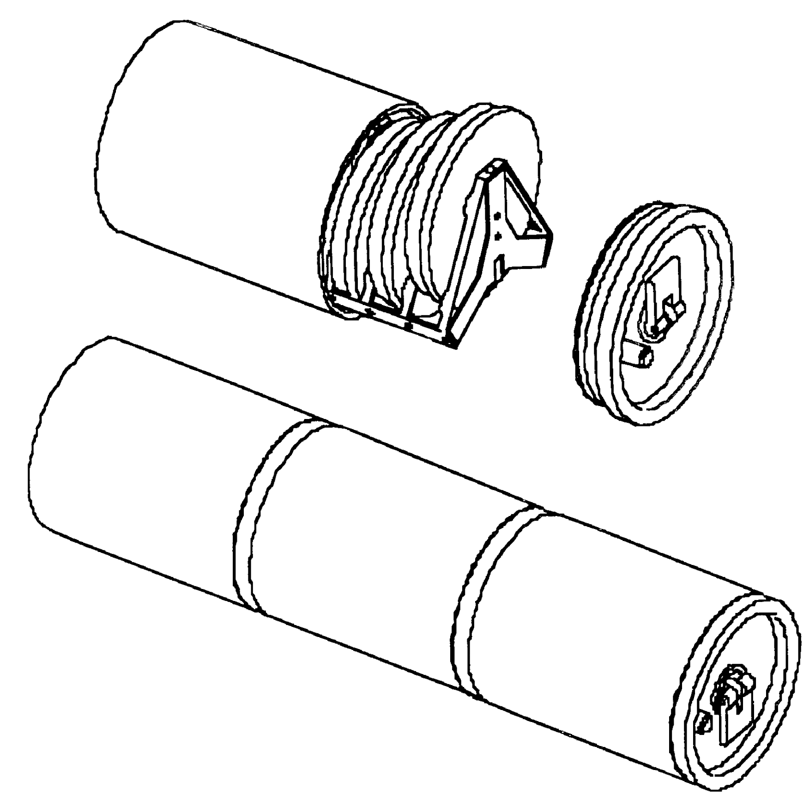

Figure FB-21 BRIC Canister Assembly

#### Data Interface Characteristics

The BRIC-VC canisters have no data interfaces.

#### Measured Environmental Parameters

The Temperature Data Loggers used are capable of recording temperatures ranging from -5 to + 37 °C ± 1 °C.

The relative humidity data loggers used are capable of measuring relative humidity from 0 - 100% + 5%.

## SYSTEM OPERATION DESCRIPTION

The BRIC-M payload is totally passive. No operation description is required. ⁂

**Principal Investigator:**
Abraham D. Krikorian
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**BRIC**

P/N: 1013-M-2000-00
Qty: 1
Mass: 13.60 kg
Power: N/A
x,y,z: 120.00 cm

# Integrated Quail Experiments on Mir (Incubator)

## EXPERIMENT DESCRIPTION

Experiments studying the effects of microgravity on embryo development in the Japanese quail (conducted in 1990 and 1992 on Mir) revealed that embryonic development and hatching is possible under spaceflight conditions. However, anomalies were detected during various phases of this development.

The presence of anomalies, as well as the decreased hatch ratio in comparison to a control group on Earth, provide some information of spaceflight effects on embryogenesis. The exact nature of these effects is still unclear, and it is uncertain whether its effects are direct or indirect.

The purpose of this investigation is to determine the nature of these effects and to explain more the precisely mechanisms by which they occur.

### SCIENCE OBJECTIVES

To study the effect of spaceflight conditions, including microgravity on embryogenesis of quail.

### FUNCTIONAL OBJECTIVES

The functional objectives of Incubator - Integrated Quail Experiment on Mir are:

- Egg Incubation
- Group Embryo Fixation
- Transfer Sessions

## FLIGHT HARDWARE DESCRIPTION

### RUSSIAN HARDWARE

#### Incubator-2 Assembly

This assembly is designed to incubate Japanese quail eggs in space, to raise hatchlings obtained from incubation, and to maintain adult birds. It is composed of three components: the Adult Habitat, or bird cage; the Incubator; and the Control Unit.

#### Incubator 1-M

The incubator has eight trays, with five sections per tray, for an optimal capacity of 40 eggs, or 80 eggs if two are incubated in each tray. It can be held at a temperature of 37.5 °C, with a humidity of 60 to 80 percent.

#### Adult Habitat

The cage for adult birds will hold 6 adult birds or 10 hatchlings and has two temperature ranges: the lower has a limit of 20 °C and the upper has a range of 32 to 37 °C.

#### The Control Unit

The Control Unit has following components: power switches and indicator lights for the subcomponents; a readout display for temperature in the Adult Habitat and for temperature and humidity in the Incubator; and control buttons to select temperature range and prime or backup pump.

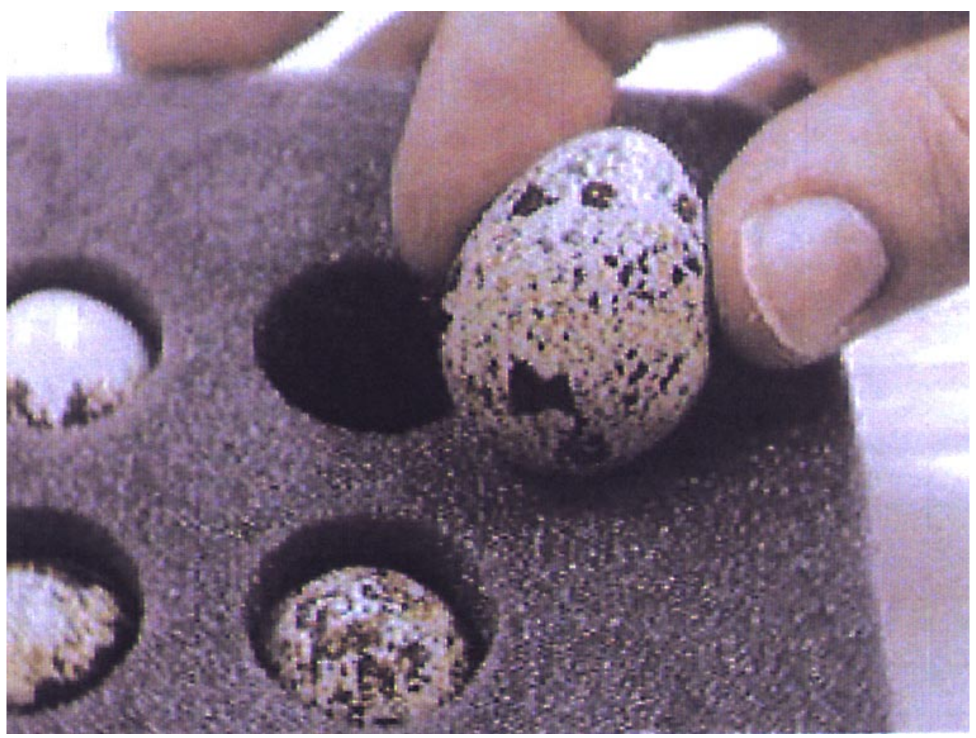


Figure FB-22 Quail Eggs

Figure FB-23 Incubator

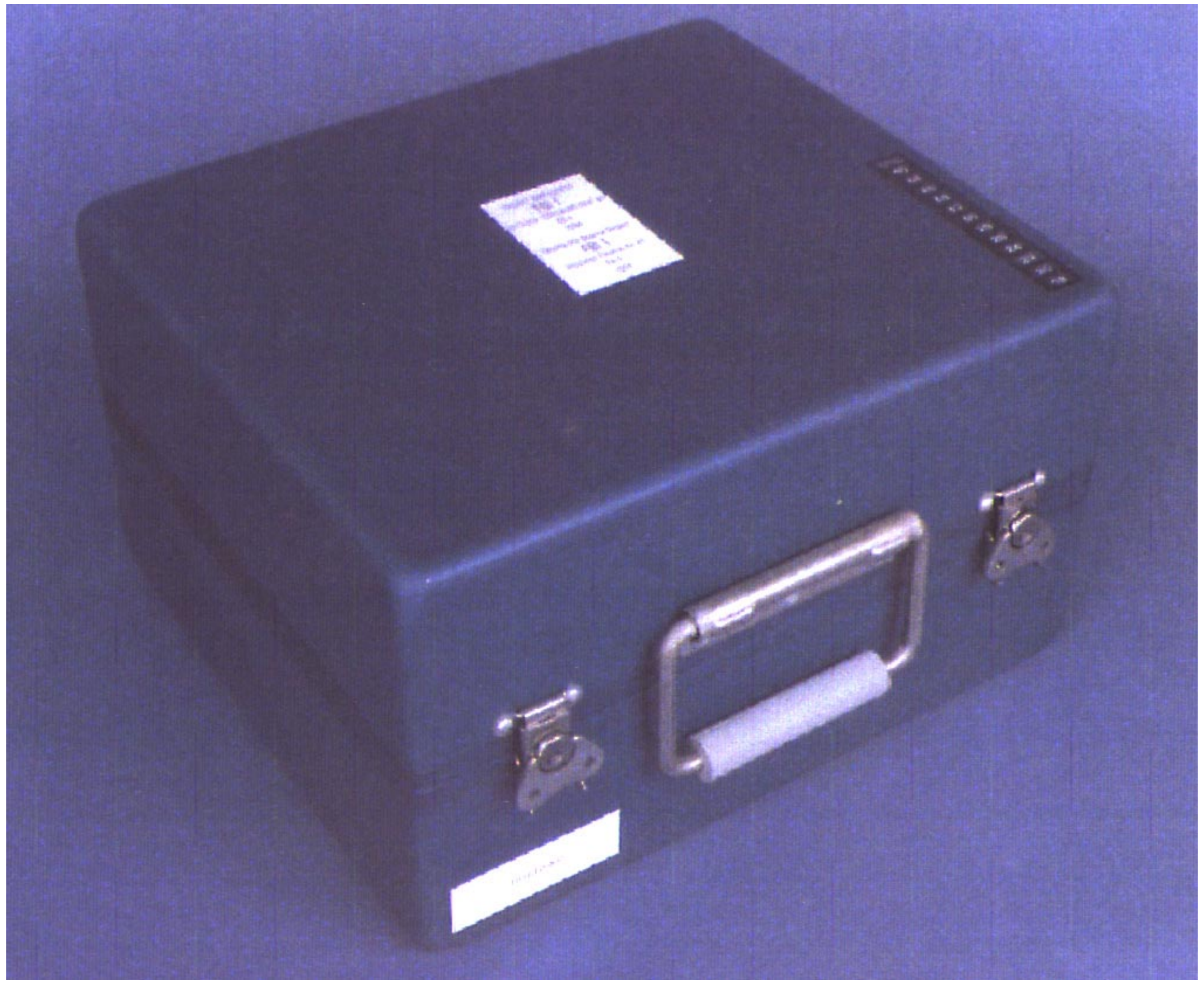


Figure FB-24 Incubator Fixative Kit

### Ovoscopy Kit

This kit has an ovoscope for examination of eggs prior to incubation and is located inside a Spare Parts Kit.

### Fixation Container for Eggs

This kit contains a fixation bag with an alcohol-glycerol fixative, larger than the U.S. fix bags, to be used for eggs remaining after fixation with the U.S. bags (one egg to a bag).

More complete information on the Russian-provided hardware is provided in Russian training materials.

U.S. HARDWARE

### Incubator Fixative Kits

This kit consists of an outer aluminum box containing four large mother-bag assemblies. These assemblies hold two-layer Fixative bags (16 per box) that provide triple containment for fixatives. Two clamps are used with each fixative bag to ensure containment. An additional clamp keeps the fixative solution in close contact with the specimen. A resupply kit is launched on STS-76. A kit containing samples is returned on STS-74.

### Glovebag Kit

This kit provides a glovebag for performing the fixation of egg samples. The glovebag maintains the third level of containment for fixative solutions and is sealed off by means of clamps in such a way that samples can be held in an airlock section and retrieved in the event of a spill of fixative in the working area of the bag. The kit contains items to be used for fixation of plants in another experiment and two items used in egg fixation:

- The Egg Transport Bag is used for transporting eggs from the Incubator to the workplace, and for use inside the glovebag.
- The Spill Kit is placed in the glovebag during fixations. It contains an absorbent towel to wipe up liquids in case of a fixative spill. The Kit itself is a containment bag which will hold the liquids cleaned up.

### Spare Glovebag Kit

This kit contains the glovebag and Egg Transport Bag, but does not have the other tools used for plant fixation.

### Filter Kit

This kit holds the equipment for deflation of the glovebag in the event of a spill. Air is pumped through the filter to remove fixative vapors. Containment bags are also provided in the kit for disposal of the contaminated glovebag. ⋇

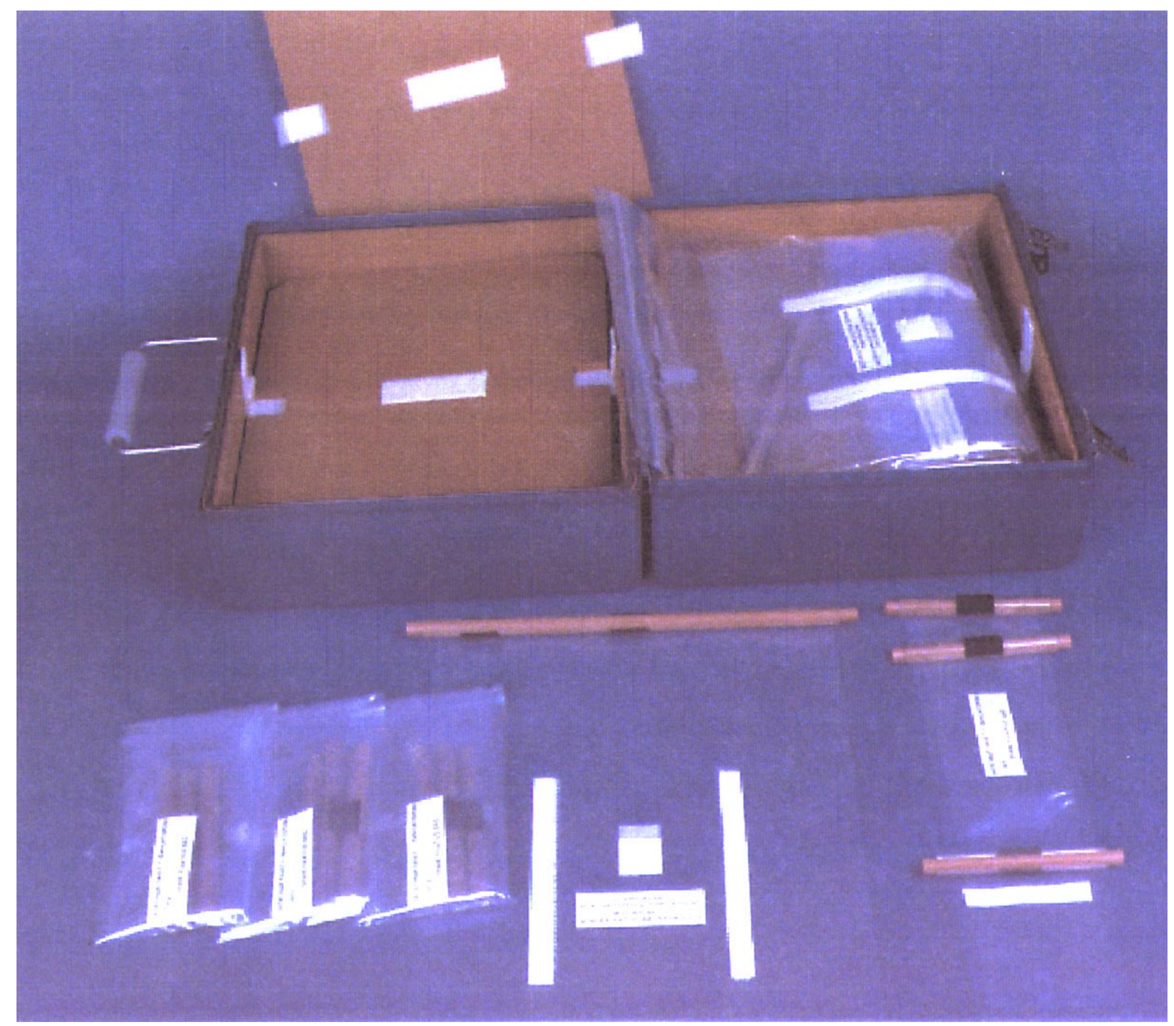


Figure FB-25 Incubator Fixative Kit Displayed

D.I.D

Incubator Fixation Kit No.1

D.I.D

Incubator Fixation Kit No. 2

# Developmental Analysis of Seeds Grown on Mir

Figure FB-27 Svet Cuvettes

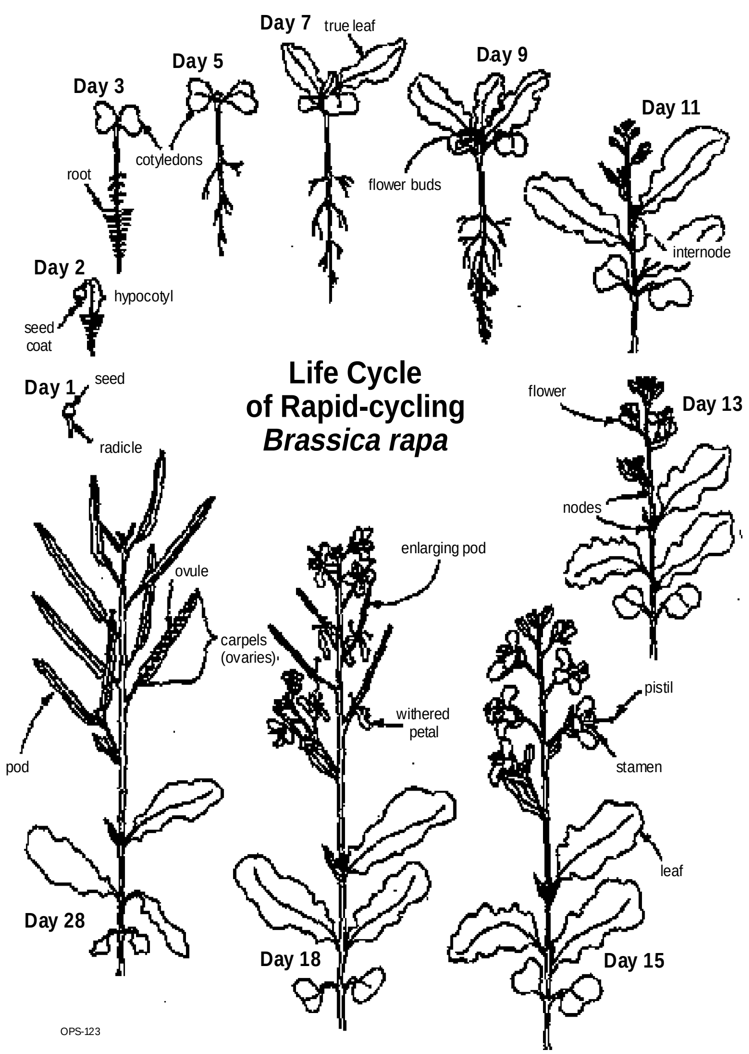
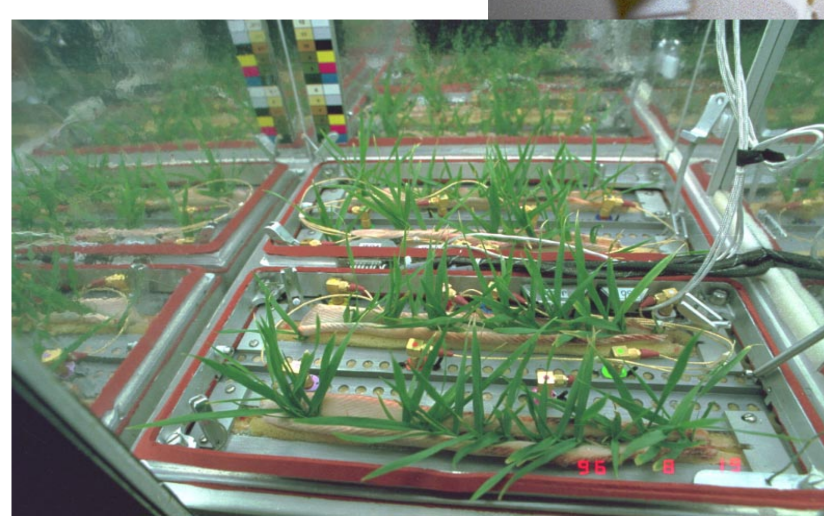



Figure FB-26 Life Cycle of Rapid-Cycling *Brassica rapa*



NM22-420-030

Figure FB-28 Interior showing the Root Module

STS79-347-022

Figure FB-29
Svet Greenhouse

## EXPERIMENT DESCRIPTION

The purpose of the Greenhouse Experiment is to determine the effects of spaceflight on the ontogenesis, reproductive function, metabolism, and productivity of higher plants. This study will provide information to answer critical questions involved in gravitational biology and development of advanced life support systems, which assume the use of green plants provide nutrition and recycle waste products.

A number of prior experiments conducted on Salyut and Mir have shown that the various stages of growth and development of higher plants are possible in microgravity. A number of anomalies were seen in the morphogenesis, anatomy of organs, tissues, and cells of plants grown under spaceflight conditions. The first experiment with the Svet greenhouse, on board Mir in 1990, revealed a significant retardation and decrease in net productivity in leafy cabbage and radish seedings. These facts demonstrate the negative effect of spaceflight conditions on plants.

A complete assessment of distinct ontogenetic stages in seedings (peas or wheat, for example) needs to be conducted under normal and varying water conditions. The results from the proposed experiment (such as gas exchange data, total biomass, and viable seed production) will provide essential information for the evaluation of potential crop plants to be used in the Controlled Environmental Life Support Systems (CELSS).

## SCIENCE OBJECTIVES

- Analyze microgravity effects on the processes controlling plant growth, development, and biomass (production and yield determination of crop plants).

  Measurements will include:

  - Percent germination, percent seeding maturation
  - Total and individual plant masses, mass partitioning between vegetative and reproductive organs
  - Analysis, including morphological study, of gross anatomical structure
  - Cytological analysis of tissues

- Analyze sexual reproductive competency of microgravity grown plants and determine the genetic state and reproductive capability of microgravity produced seed.

  - Analyze developmental phase, phase duration, and rate of development.

- Determine the chemical and biochemical composition and structural characteristics of plants grown in microgravity including:

  - Organic and inorganic composition
  - Cell wall formation: lignin and cellulose deposition
  - Leaf enzyme activity
  - Changes in gene expression

D.I.D

Gas Analyzer System

D.I.D

Glovebag Kit

D.I.D

Leaf Area Measurement Kit

D.I.D

Root Module Launch Kit

D.I.D

Root Module Return Kit

**Principal Investigators:**
Frank Salisbury, Ph.D.
Utah State University
Retired Professor

**AIR FILTRATION & INTEGRATION ASSY**

P/N: E3-1172-01
Qty.: 2
Mass: 1.59
Power: N/A
x, y, z: 23.80 x 23.80 x 7.00 cm
Loc: Kristall, Dep

- Measure plant gas exchange characteristics in microgravity.
    - Photosynthesis
    - Respiration
    - Transpiration
    - Stomatal conductance
    - Water use efficiency
- Measure changes in microflora of plants (specifically of the roots, leaves, and stems).
- Technological evaluations including:
    - Water dynamics, distribution, and consumption in the root module
    - Svet system and subsystems — operational characteristics
    - Trace gas evaluation

## HARDWARE DESCRIPTION

### FILTER/PUMP KIT

The Filter/Pump Kit is a foil pouch containing a filter, four containment bags, and four clamps to which a pump is attached by Velcro. In the event of a fixative spill during fixation procedures, the kit will enable deflation of the Glovebag air through the filter to remove any fixative vapors and also provide subsequent containment of the Glovebag inside two containment bags, thereby maintaining the required three levels of containment for toxic chemicals. The pump is attached by Velcro strap to the outside of the kit.

## SVET GREENHOUSE HARDWARE DESCRIPTION

Svet is a greenhouse designed jointly by the Institute for Biomedical Problems (IBMP) and the Space Research Institute of the Bulgarian Academy of Sciences for the study of plant growth in space. It is located in the Kristall Module of the Mir Space Station and has been used for three prior plant experiments on Mir: first in 1990, then in 1995 (Mir 19/20) and in 1996 (Mir-22/NASA-3) for growth of wheat (Mir-19/20). The Svet consists of four basic units: the plant growth chamber, vegetation module or root module, light unit, and control unit. Below is a brief description of each of these units.

### PLANT GROWTH CHAMBER

The plant growth chamber is a rectangular metal enclosure with windows on two of the chamber walls (front and right side) for inspections and performance of experimental manipulations. Mylar reflective film has been applied to the interior walls of the chamber to intensify illumination.

### ROOT MODULE

The vegetation or root module is inserted into the bottom of the growth chamber as a drawer and has two sections, or cuvettes, C1 and C2. It is filled with a granular ion-exchange nutrient substrate called Balkanin and has water and air supplied by a compressor, pump, and corresponding tubes and electromagnetic valves. Each cuvette has two rows for seed planting, with a wick material around the base of the plants, surrounded by a foam material, and secured with a metal plate.

### LIGHT UNIT

The light unit is inserted into the top of the growth chamber and can be set at three different positions, at distances of 20, 30, and 40 cm from the root module surface, to allow for maximum illumination during plant growth. It contains six units containing fluorescent bulbs and can provide lighting of up to 300 lumens.

### CONTROL UNIT

The control unit provides automatic measurement of SVET environmental parameters every 4 hours, generating data for display and telemetry. The unit can be programmed to operate in three different modes, or regimes. Program 1 performs a functional check of the unit, with error labels shown on the 7-digit display in the event of a malfunction. Program 2 initiates the watering of the substrate, and Program 3 puts into effect automatic control of the substrate moisture, with limits set by using the keyboard of the control panel.

S96-19002

Figure FB-30 Group Photo of all the FBI-1 Kit Hardware

## FUNDAMENTAL BIOLOGY INVESTIGATIONS (FBI)-1 KIT

The FBI-1 Kit hardware provides all supplies required to collect biological samples in support of the Greenhouse 3 Experiment: harvesting tools, equipment for fixing and drying plant samples, log book for data entry, and photography equipment. It also includes equipment for pollination and operations with seeds. A brief description of each hardware item and its application is listed below.

### PLANT FIXATIVE CANISTER ASSEMBLY

The Plant Fixative Canister Assembly contains fixative bags used to arrest development of plant specimens and secure them for postflight investigations. The kit consists of an aluminum cylinder containing a Mother Bag Assembly which contains 4 Fixative Bags.

The lowest bag clamp is removed to release fixative and immerse the plants in the fixative. The Fixative Bag is placed into the Mother Bag, and a new bag is removed for the next sample. These steps are repeated until all samples are fixed, whereupon the Mother Bag is restowed inside the Fixative Canister. Kits were returned to investigators on the following Space Shuttle.

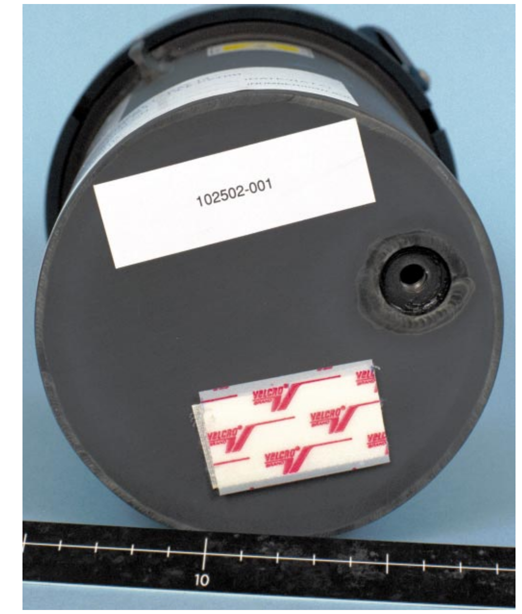
### PLANT DRY STOWAGE KIT

The Dry Stowage Kit #1 allows the return of dry plant samples by inhibiting the growth of organisms due to plant specimen residual moisture content. The kit is a foil pouch containing the Dry Stowage Bags, which are plastic bags containing silica gel desiccant. The bags are heat-sealed down the center to provide separate compartments for samples from the two different cuvettes of the growth chamber.

A Dry Stowage Bag is unstowed at the time of plant sampling from the Dry Stowage Kit and secured near the Greenhouse. Plant samples are placed inside a Dry Stowage Bag, which is then fastened tightly with one clamp. The Dry Stowage Bag is returned to the Dry Stowage Kit.

Figure FB-31  Plant Fixative Cannisters

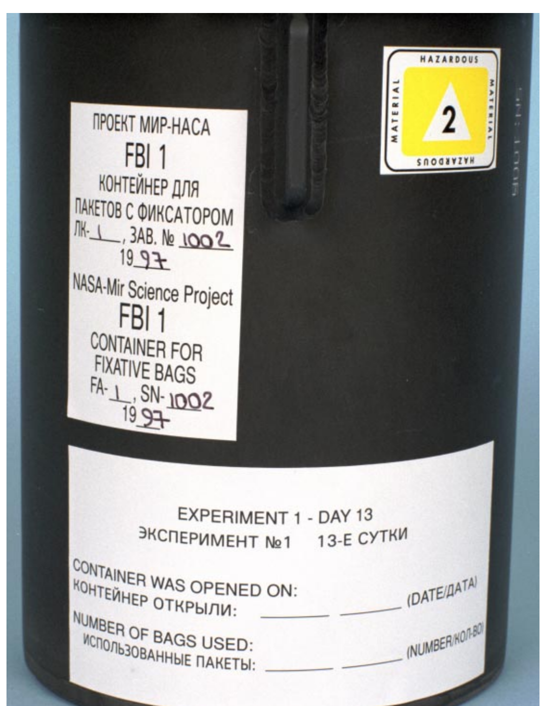
S97-04359




S97-04355

Figure FB-34  Canister Bottom

# Plant Fixative Canisters




S97-04362

Figure FB-32  Plant Fixative Canisters Labels

S97-04361

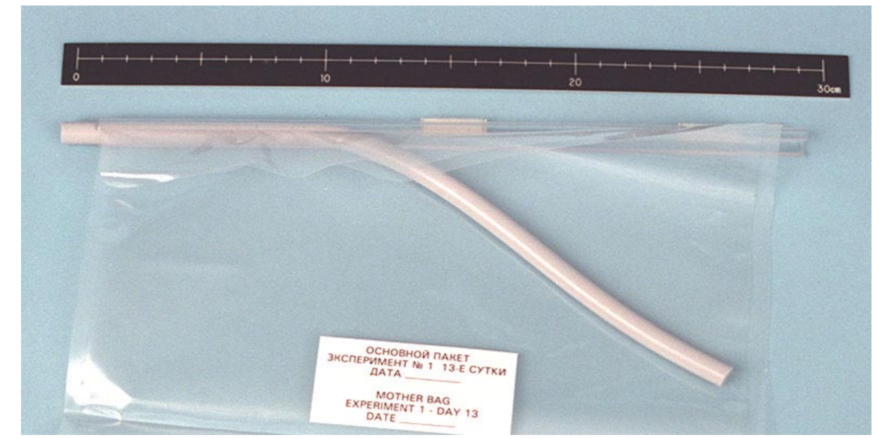
Figure FB-33  Plant Fixative Canister Interior

S97-04735

Figure FB-35  Plant Fixative Canister Contents

S96-19020

Figure FB-37
Unsealed Mother Bag




S96-18019

Figure FB-38  Half-Sealed Mother Bag

S96-18976

Figure FB-36  Plant Dry Stowage Kit


S96-18018

Figure FB-39  Sealed Mother Bag

S96-18966

Figure FB-40  Plant Harvest Kit

## PLANT HARVEST KIT

The Harvest Kit contains tools and containment bags used in obtaining plant samples from the SVET growth chamber: the Harvest Tools and Harvest Bags. The tools are:

Long scissors (2) — trigger-activated micro-scissors at the end of a 17-inch extension
Short scissors (2) — standard pointed/blunt scissors, 13 cm long
Long forceps — trigger-activated micro-forceps, also with a 17-inch extension
Short forceps — straight forceps with serrated 2mm tips, 13 cm long

Harvest Bags are polyethylene bags that provide transport for samples from the two cuvettes of the root module to the SIGB.

The kit has the Harvest Bags inside a small foil pouch on the front of the bag. The front pouch contains the short tools, and the long tools are inside the kit itself.

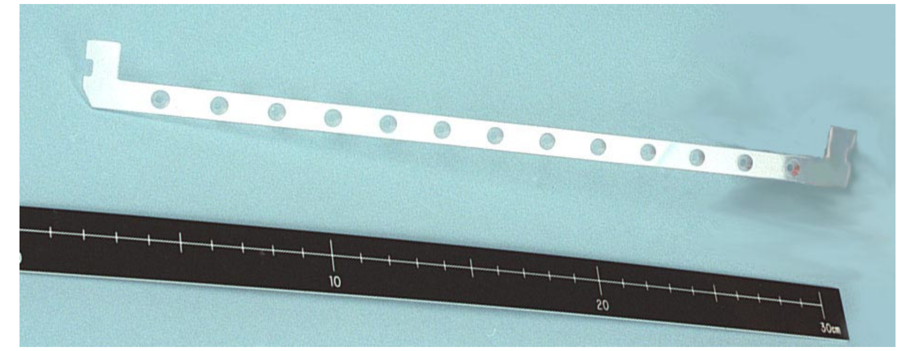
The Harvest Kit were unstowed and taken to the SVET Greenhouse during sampling operations. The Harvest Tools will be used to cut plants at the base of the stem from the root module in the growth chamber, or to remove siliques from plants. Plant samples will then be placed into the Harvest Bag to be used in subsequent operations.

## SEED OPERATIONS KIT

The Seed Operations Kit will provide a means of separating seeds from mature siliques and replanting them on orbit for subsequent generations. At the end of each planting, siliques will be collected from each plant type. The seeds within the siliques will be removed and fixed to the seed strips for use in the next experiment.

Hardware provided in the kit includes:

- Work-surface for support of the seed strip and other tools used in preparation of the seed strips.
- Seed strips with tape added to fasten seeds. Some strips will be loaded with seeds from the earth and others empty for use on orbit.
- Seed separator strips used to expose the seeds within the siliques.
- Forceps to transfer the seeds from seed separator strips to the seed strips.
- Silique harvest containers for storage of the siliques until used in seed strip preparation.
- Earth seeds for loading onto seed strips for 2nd and 3rd experiments. Seeds can also be used to repair seed strips prepared on ground that are missing a seed.
- Color stickers to identify location on plants where siliques were removed.
- Extra tape to repair seed strips.



S96-18980

Figure FB-42  Seed Strip

S96-18981

Figure FB-41  Seed Operations Kit

D.I.D.

Harvest Kit

**HARVEST KIT**

P/N: 101677-001
Qty.: 1
Mass: 0.50 Kg.
Power: None
x, y z: 49.00 x 20.00x 3.80 cm
Loc: PR, SIC2-I-1a

S96-18997

Figure FB-43 Pollination Kit

## POLLINATION KIT

The Pollination Kit provides the tools necessary to pollinate the plants during the three experiments. Vials containing a "beestick" are packaged so that one wand will be used for each type of plant per cuvette per day. A telescoping wand is included in the kit to assist in reaching the plants in cuvette 2. Each vial contains a one gram desiccant cartridge which will allow for analysis of pollen viability upon return to Earth.

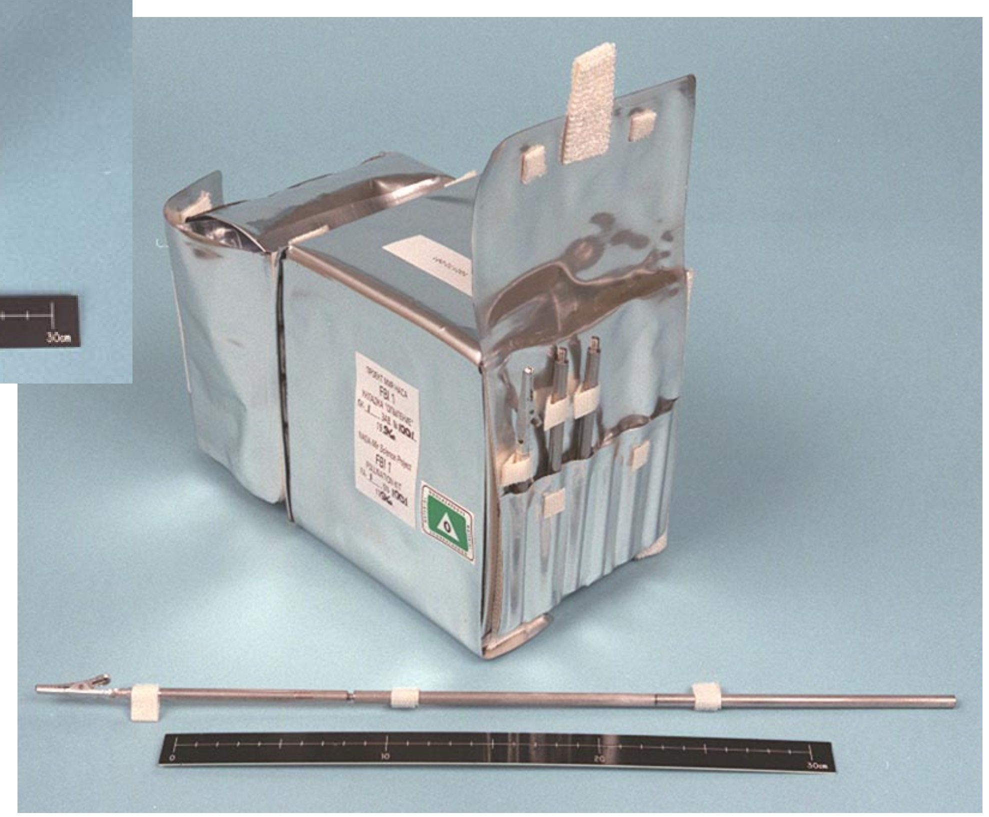
Pollination will take place for 7 days beginning at day 14 of the plant growth. Each day of the pollination phase, a beestick was obtained and gently brushed across the anthers and pistil of the flowers. By moving from one plant to another, the pollen will collect on the wand and be distributed all in one step.

## FBI LOG BOOK KIT

The Log Book Kit contains a log book for entry of experimental data for the Greenhouse 3 Experiment, as well as information to aid in conducting the experiment, such as diagrams for hardware assembly and sampling scenarios. The log book has Lexan covers and a clip with Velcro for securing it near the Greenhouse.

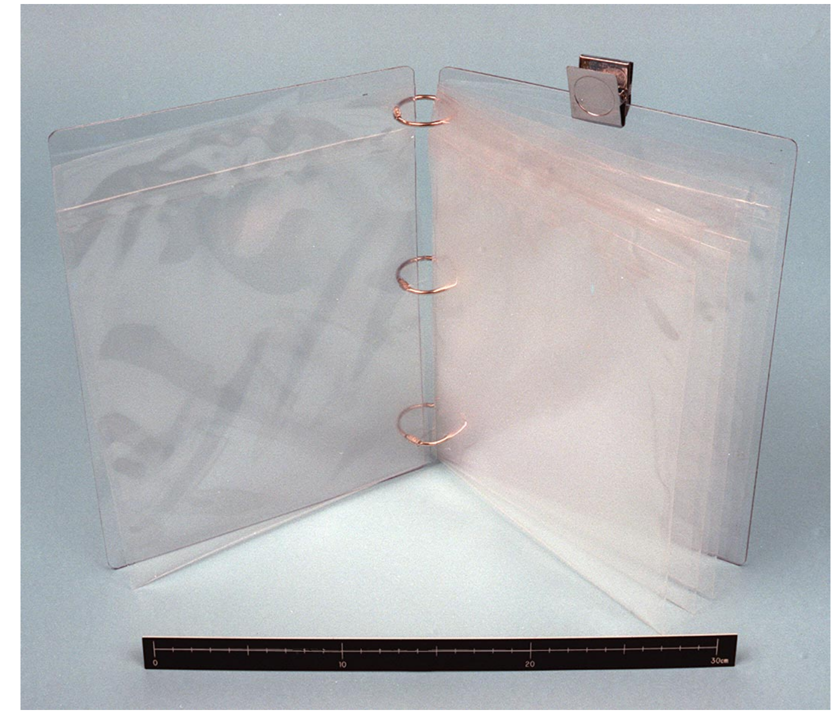
The text of the log book contains entries for:

- Daily hardware monitoring
- Data to be recorded during a given day's observation or fixation operation, such as number of seedlings germinated, height of plant canopy, etc.
- Parameters and notes relating to performance, calibration, or maintenance of hardware
- Record of malfunction occurrences and steps taken to remedy the problems



S96-18996

Figure FB-44 Tool Extension Kit



S96-18978

Figure FB-45 Logbook

Reference material will include:

- Diagram of sampling scenarios
- Drawings of plants at various stages of development
- Procedures and diagrams for assembly of the gas exchange hardware

## OBSERVATION KIT

The Observation Kit contains tools used for observation of plant growth: a bracket to hold the camera during plant photography, a ruler for measuring plant height, and a databack for the camera to imprint the date on photographs taken.

## **FBI-2 HARDWARE**

FBI-2 designates hardware included in the GEMS, which measures plant environmental parameters and gas exchange rates to enable the determination of plant photosynthesis, respiration, and transpiration. GEMS also provides the means to control airflow velocity through the individual leaf bag assemblies and will be designed to minimize the ventilation rate dependent on leaf — cabin air temperature difference and water vapor — density in the chamber.

The GEMS air conveyance system draws air from the Mir cabin into two Air Filtration and Integration Assemblies through air filters.

- Air Filtration and Integration Assembly:

  The Air Filtration and Integration Assembly supplies filtered and homogenous airflow to the plants, which are enclosed within the Leaf Bag Assemblies. Air from the cabin enters the Gas Analyzer System (GAS), where $CO_2$ and $H_2O$ concentrations are recorded and continues to the Leaf Bag Assemblies where gas exchanges occur. The outgoing air is drawn through the GAS units to obtain another set of $CO_2$ and $H_2O$ measurements. Comparisons of the two sets of measurements are used to derive photosynthesis rates.

- Leaf Bag Assemblies:

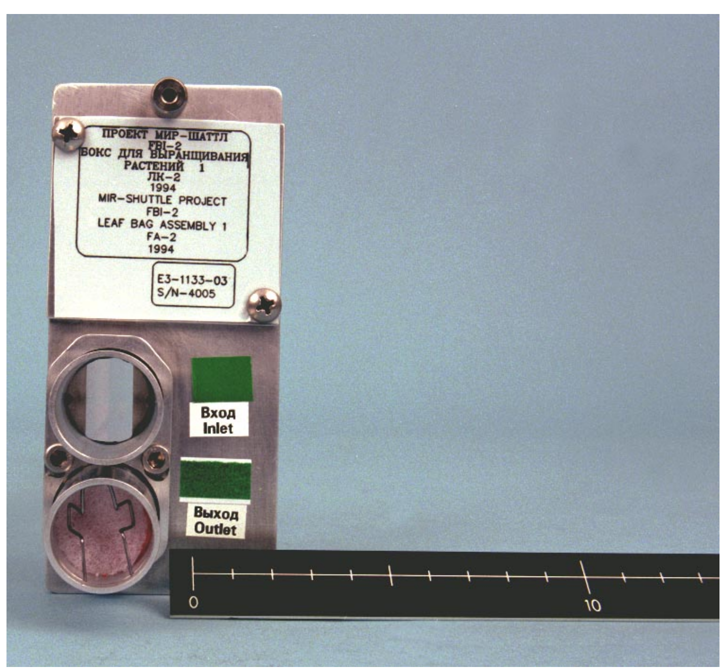
  Within the Leaf Bag Assemblies, sensors measure light intensity, air temperature, and leaf temperature. Within the root substrate, probes measure soil moisture.

- Environmental Data System (EDS):

  The EDS, an electronic data acquisition and control system, receives, encodes, and stores the measurements from all the sensors within the Leaf Bag Assembly and also from certain cabin environment sensors. It also controls fan speeds and soil moisture probe functions, and provides the capability to shut down communications from the sensors in an emergency.

- GAS:

  The GAS is an infrared gas analyzer with its own internal data acquisition and control system. It measures the infrared absorption of $CO_2$ and $H_2O$ in the air entering and exiting the Leaf Bag Assembly. It also measures the flow rate, temperature, and pressure in both the input and output air. It can be shut down and restarted when necessary to facilitate taking leaf area measurements and harvesting plant samples within the Leaf Bag Assemblies.



S96-18329

Figure FB-46 SIF showing inlet and outlet

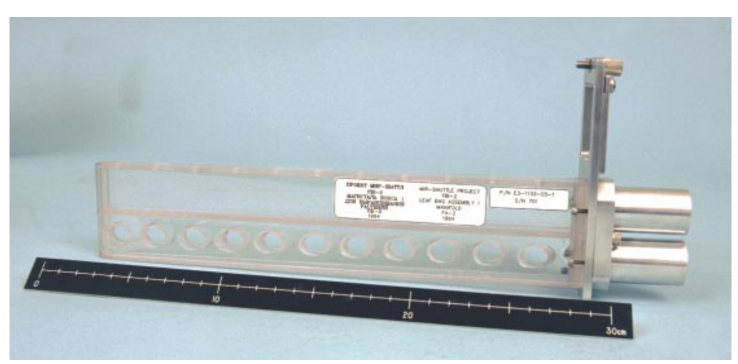

S96-18328

Figure FB-47 SIF side view

## EDS

The EDS measures these environmental parameters within the Leaf Bag Assemblies:
- Air temperature
- Leaf temperature
- Light level

Inside the root module, the EDS measures the following:
- Temperature of substrate
- Moisture of substrate

It also measures the following cabin environmental parameters at the entrance into the gas analyzer system:
- Oxygen concentration
- Absolute pressure
- Temperature
- Relative humidity

It has sensors for the following temperatures:
- EDS internal air temperature
- EDS internal circuit board temperature
- Power Distribution System internal temperature sensor

The EDS receives information from the sensors in an analog voltage form and then transforms the voltages to a digital form. The information is then stored in memory until requested by the Portable Computer.

The system consists of the following components:
- Electronics for processing sensor signals (circuit boards)
- Gas Analyzer Entrance Air Sensors
- Air Filter
- Fan
- Enclosure

Figure FB-48 EDS

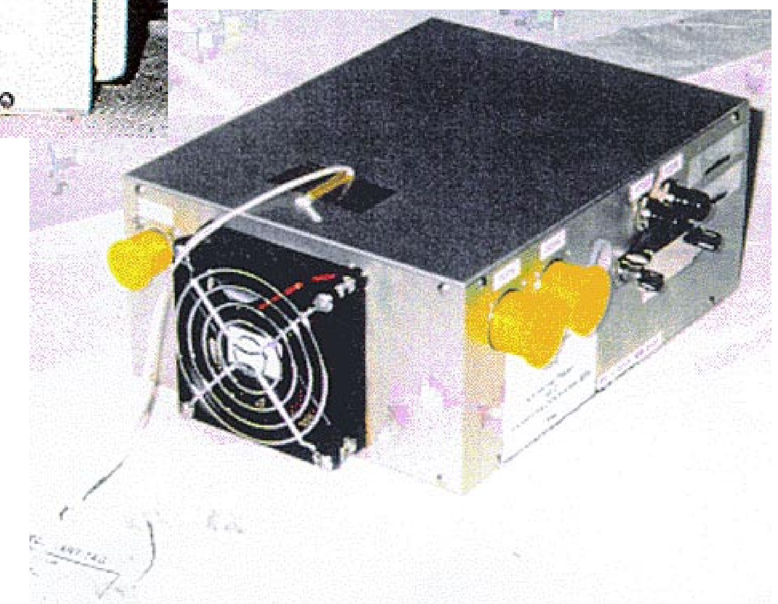


Figure FB-49 EDS Back

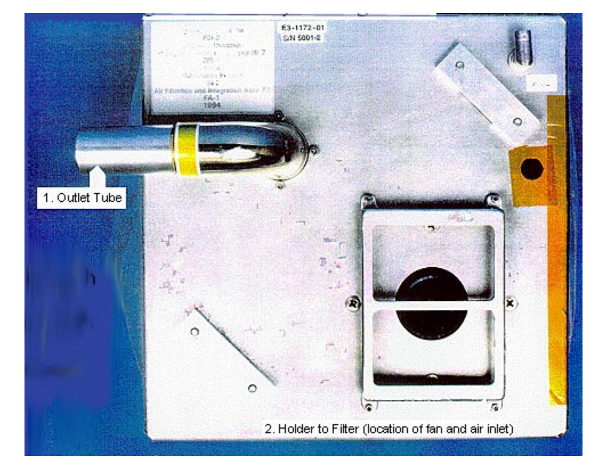


Figure FB-50 Air Filtration and Integration Assembly Base

D.I.D.

Dry Stowage Kit #1

D.I.D.

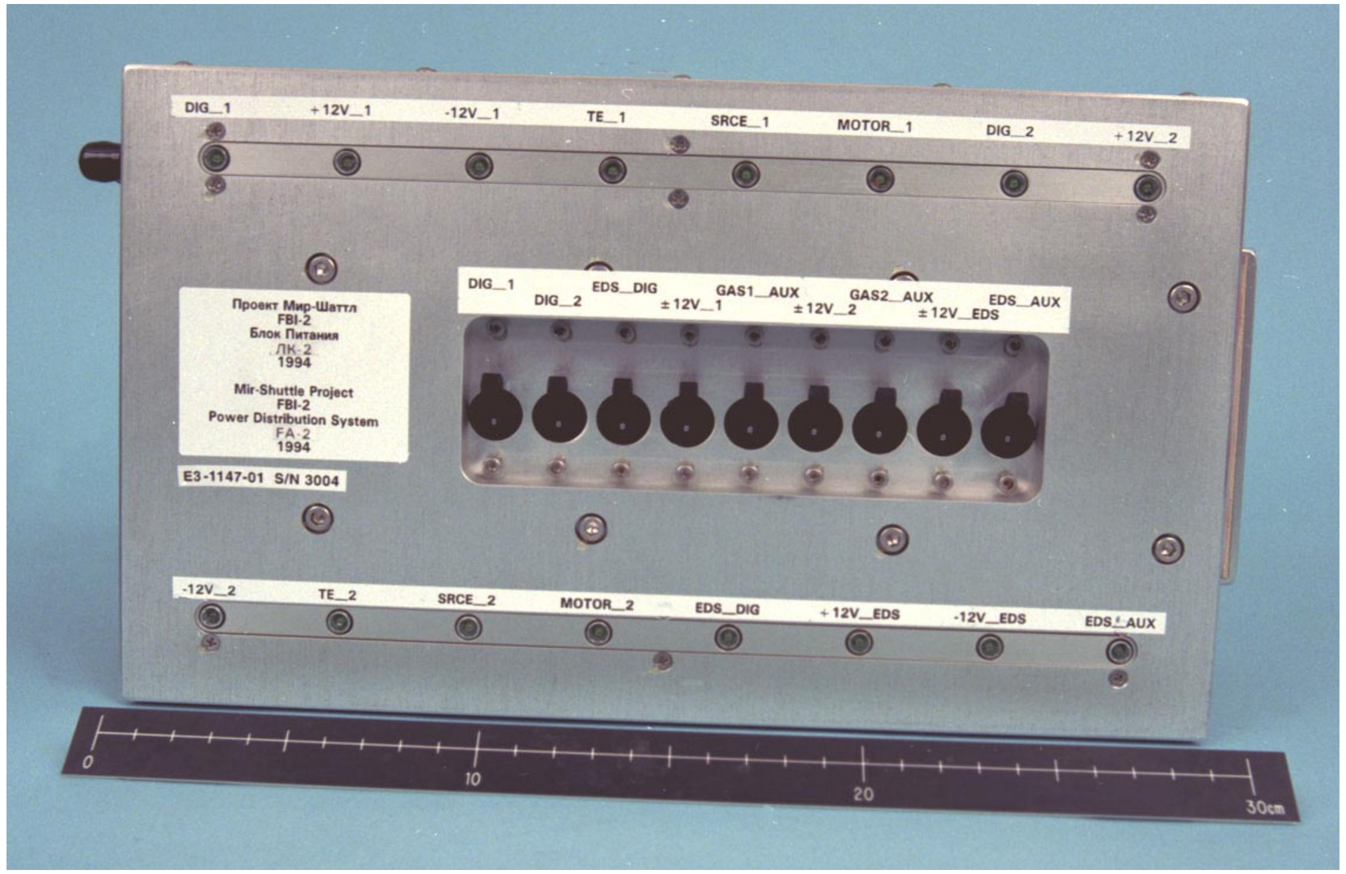
Logbook Kit

D.I.D.

Observation Kit

**LEAF AREA MEASUREMENT KIT**

P/N: 101674-001
Qty.: 1
Mass: 4.15 kg
Power: none
x, y, z: 45.20 x 36.10 x 6.60 cm
Loc: Spektr




S96-18326

Figure FB-51 Power Distribution System Front

## DATA ACQUISITION AND CONTROL COMPONENTS:

### TABLE FB.8
### BREAKER SWITCES

| System | Label | Description |
|---|---|---|
| GAS 1 | DIG_1 | Digital power for GAS 1 |
| GAS 2 | DIG_2 | Digital power for GAS 2 |
| EDS | EDS_DIG | Digital power for EDS |
| GAS 1 | ±12V_1 | Analog power for GAS 1 |
| GAS 1 | GAS1_AUX | Auxiliary power for coolers, sources, motor, etc. for GAS 1 |
| GAS 2 | ±12V_2 | Analog power for GAS 2 |
| GAS 2 | GAS2_AUX | Auxiliary power for coolers, sources, motor, etc. for GAS 2 |
| EDS | ±12V_EDS | Analog power for EDS |
| EDS | EDS_AUX | Auxiliary power for moisture probes, etc. for EDS |

## PDS

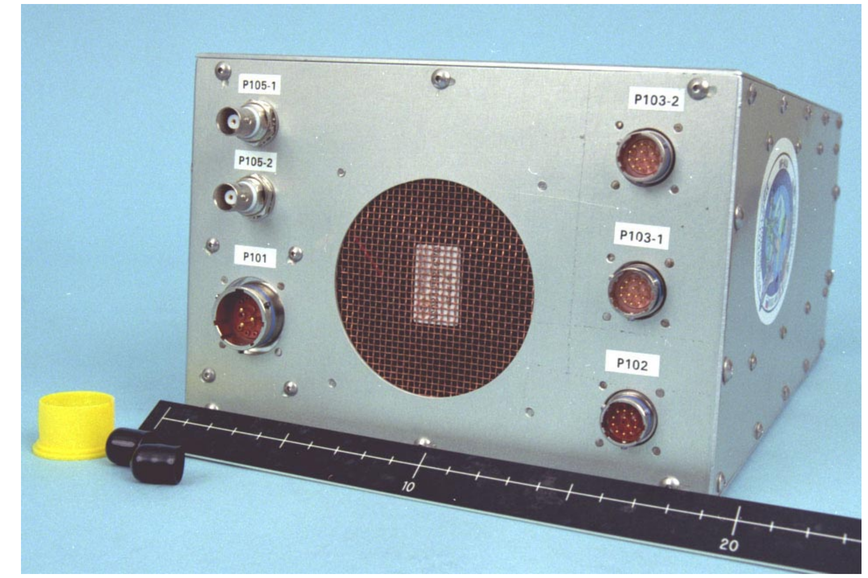
The PDS provides power to each module of the GEMS by transforming the 27V DC power supplied by Mir to the various voltages needed by the GEMS electronic units.

The PDS consists of the following components:

- Sixteen Voltage Converters
- Nine Switchable, resettable magnetic Circuit Breakers
- Air Filter
- Cooling Fan

A peculiarity of the system is that the OFF position of the circuit breakers is UP; the ON position is DOWN.

The left panel of the system contains the connections from the source and the output to these units: EDS, GAS 1, GAS 2, Calibrator Unit, Calibrator Unit Backup, and Power Input. The front panel contains the breaker switches and Light-Emitting Diode (LED) power indicators.




S96-18325

Figure FB-52 Power Distribution System Back

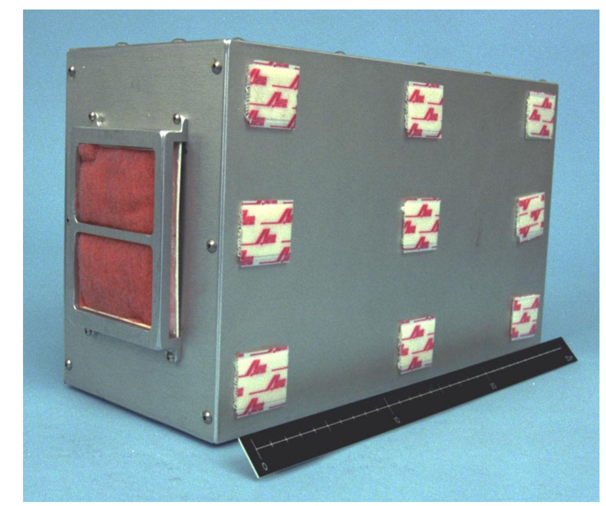
### TABLE FB.9
### LEDs

Top Row, Left to Right:

| System | Label | Description |
|---|---|---|
| GAS 1 | DIG_1 | Digital power for GAS 1 |
| GAS 1 | +12V_1 | Analog +12V for GAS 1 |
| GAS 1 | -12V_1 | Analog -12V for GAS 1 |
| GAS 1 | TE_1 | Thermal electric cooler power for GAS 1 |
| GAS 1 | SRCE_1 | Infrared Source Power for GAS 1 |
| GAS 1 | MOTOR_1 | Chopper Motor and Cooling Fan Power for GAS 1 |
| GAS 2 | DIG_2 | Digital Power for GAS 2 |
| GAS 2 | +12V_2 | Analog +12V for GAS 2 |

Bottom Row, Left to Right:

| System | Label | Description |
|---|---|---|
| GAS 2 | -12V_2 | Analog -12V for GAS 2 |
| GAS 2 | TE_2 | Thermal electric cooler power for GAS 2 |
| GAS 2 | SRCE_2 | Infrared source power for GAS 2 |
| GAS 2 | MOTOR_2 | Chopper motor and cooling fan power for GAS 2 |
| EDS | EDS_DIG | Digital power for EDS |
| EDS | +12V_EDS | Analog +12V for EDS |
| EDS | -12V_EDS | Analog -12V for EDS |
| EDS | EDS_AUX | Soil moisture probe heater and cooling fan power for EDS |



S96-18324

Figure FB-53 Power Distribution System Side

## LAPTOP COMPUTER

The Laptop Computer provides the means to display all collected data, control humidity levels in the Leaf Bag Assemblies, and initiate software routines. Data is stored in files that will be copied to computer diskettes. The files are then transferred to optical storage disks on the Mir Interface to Payload System (MIPS), and samples of the data are downlinked to ground control personnel.

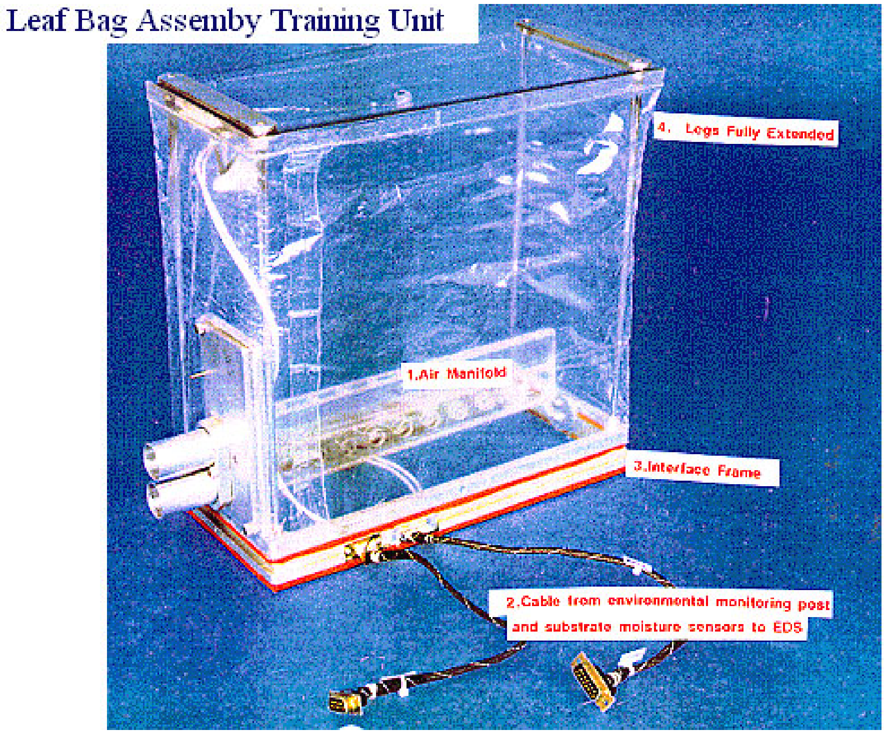



Figure FB-54 Leaf Bag Assembly Training Unit

## LEAF BAG ASSEMBLY 1, 2

The Leaf Bag Assemblies enclose the aerial part of the plants and the gaseous environment immediately around them, and thereby serve to isolate the plant's exchanged gases from the air used to cool the Greenhouse. The seal between the Nylon bag and the holding structure, provided by the Substrate Interface Frame (SIF), must be air tight to ensure accurate monitoring and control of gas exchange rates.

Each Leaf Bag Assembly consists of the following components:

- SIF
- Transparent bag on telescoping legs
- Exit Air Filter
- Air Distribution Manifold

### SIF

The bottom surface of the SIF adapts to the root module on top of a silicone rubber gasket. Four latches, one on each corner of the frame, secure it to the root module. Connectors on one side of each frame conduct wiring to the soil moisture sensors and leaf bag sensors.

### Leaf Bag Assembly

Each Leaf Bag is inserted into the Svet between the light unit and the root module. Leaf Bag Assemblies 1 and 2 are mounted on the top of cuvettes 1 and 2 of the root module, respectively. Each assembly consists of a biax Nylon bag with a hard polycarbonate top held to its base by telescoping aluminum legs. An aluminum Interface Frame provides a seal between the leaf bag and root module. The tops of the leaf bags are attached to the lower surface of the light unit with Velcro; this allows for the extension and compression of the telescopic legs as the light unit is raised or lowered. The bags are coupled to the SIF by a latch at the back and a latch (with spring) on the front. A tool is provided to turn the back latch from the side opening in the Svet.

### Leaf Environment Monitor

Sensors within the leaf bags for light levels and leaf and air temperature are assembled on a monitor post. The post is secured by Velcro to Velcro on the Leaf Bag Frame in such a way that the light sensors face the light unit and the leaf temperature sensor faces the center of the plant canopy. Leads are connected to a plug at the base of the Leaf Bag, which conducts signals to the EDS.

### Air Distribution Manifold

The Air Distribution Manifold is also connected to the Leaf Bag Assembly. It is described in the Air Supply Components section.

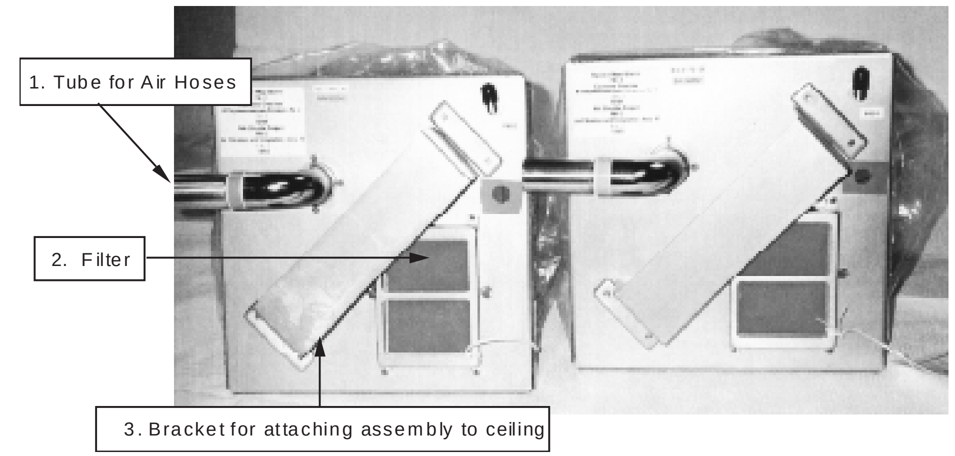
## AIR SUPPLY COMPONENTS

### Air Distribution Manifold

The Air Distribution Manifold provides a transparent air vent that distributes the incoming air uniformly in the Leaf Bag through holes on top of the tube. The outgoing air is also collected uniformly throughout the bag and conducted through a hose to the GAS. The manifold is secured to the Leaf Bag with two screws, one on the top center and one on the bottom corner (Direction of airflow).

### Air Filtration and Integration Assembly

The Air Filtration and Integration Assembly is an air mixing bag, which ensures that the concentration of gases in the air leading to the Leaf Bag is uniform. It consists of an aluminum top that holds the biax Nylon integration bag, an air filter, and a blower fan. The blower fan speed is used to control humidity levels in the bag by varying the airflow rate. The fan is controlled by the Portable Computer. The air is drawn into the integration assembly through the air filter and routed to the gas analyzer via the air hoses to be measured. From the analyzer, it flows into the leaf bag via the manifold, then returns to the analyzer for another measurement. It is then exhausted into the cabin.




S95-10617

Figure FB-55 Air Filtration and Integration Assembly, Flight Units

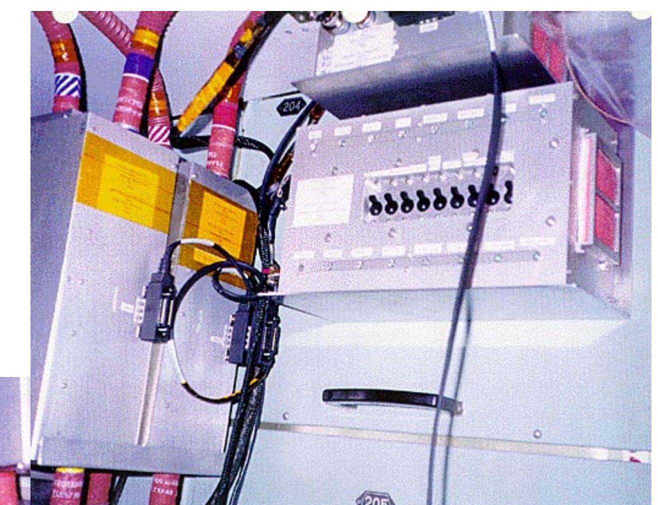


Figure FB-57 Mixed Gas Analyzers

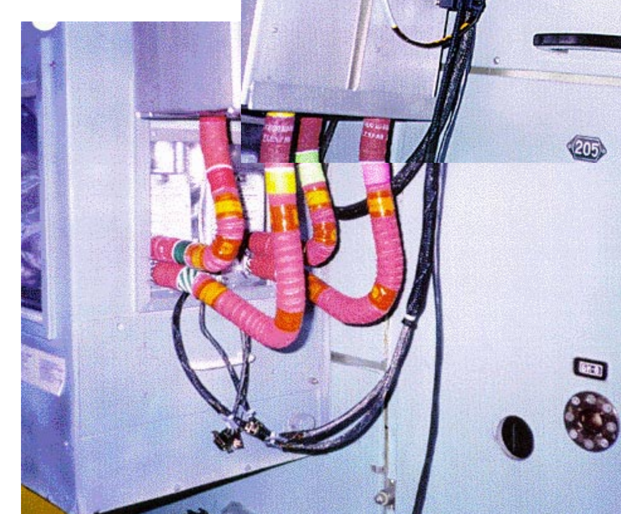


Figure FB-56 Mixed Gas Analyzers

D.I.D.

Environmental Data Systems

D.I.D.

Power Distribution System

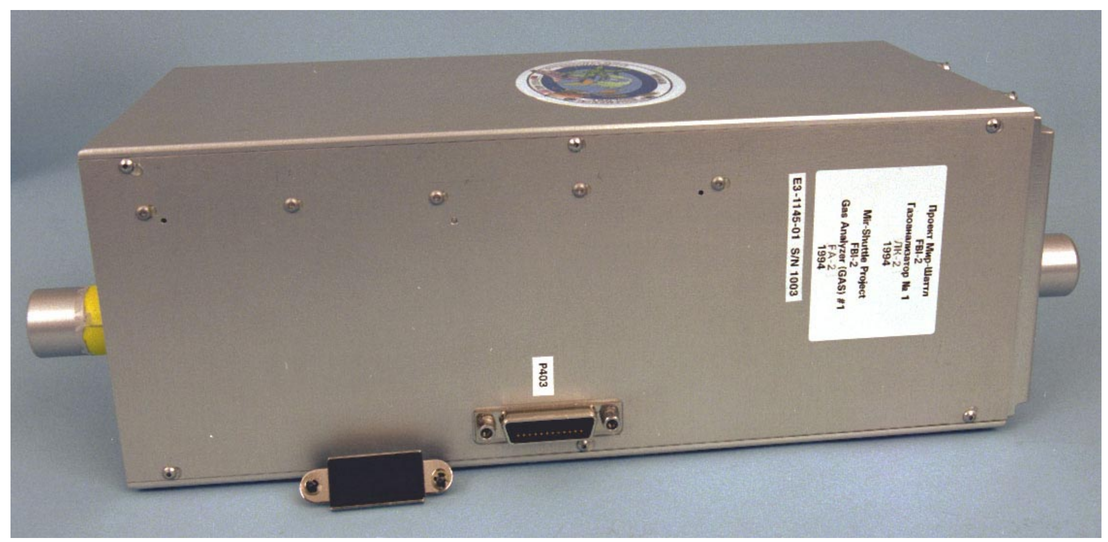
**CALIBRATION KIT (GAS)**

P/N: D3-4126-01
Qty: 1
Mass: 1.48 kg
Power: 4 W
x,y,z: 15.20 x 10.20 x 5.10 cm
DID#: D3-4126

S96-18285


S96-18332


S96-18331



S96-18333

Figure FB-58 (a, b, c, d)
Gas Exchange Measurement Unit (GEMS)

## CABLES/CABLE KIT

The cables installed on the GEMS were launched inside the Cable Kit, along with other support hardware: 12 leaf bag exit air filters, a leaf bag tool, and five 3.5-inch computer diskettes. A list of the cables is below. They are labeled with a circular label giving cable number and "FBI-2" and also by hardware designation.

Cable 1: Integration Container 1
Cable 2: Integration Container 2
Cable 3: GAS Power 1
Cable 4: GAS Power 2
Cable 5: EDS Power
Cable 6: General Purpose Interface Bus (GPIB) Cable 1
Cable 7: GPIB Cable 2
Cable 8: GPIB/Computer
Cable 9: Mir Power
Cable 10: Calibrator Power
Cable 11: EDS 1
Cable 12: EDS 2
Cable 13: Sensor Cable 1
Cable 14: Sensor Cable 2
Cable 15: Mir Power Computer Extension

NOTE: The Calibrator Power cable was used to repair a malfunctioning part of the Svet, and is no longer usable. Therefore it is not anticipated that the calibration procedure will be performed unless a replacement cable is provided.

## HOSES/HOSE KIT

The hoses that convey the air from the Integration Assembly to the GAS, from the GAS to the Leaf Bag, from the Leaf Bag back to the GAS, and from the GAS to exhaust were launched in the Hose Kit. They are color-coded with tape to match the tape marking the corresponding hardware location. The tape is either a solid color strip or a color strip with a white stripe on each end, with the name of the hardware location printed on it.

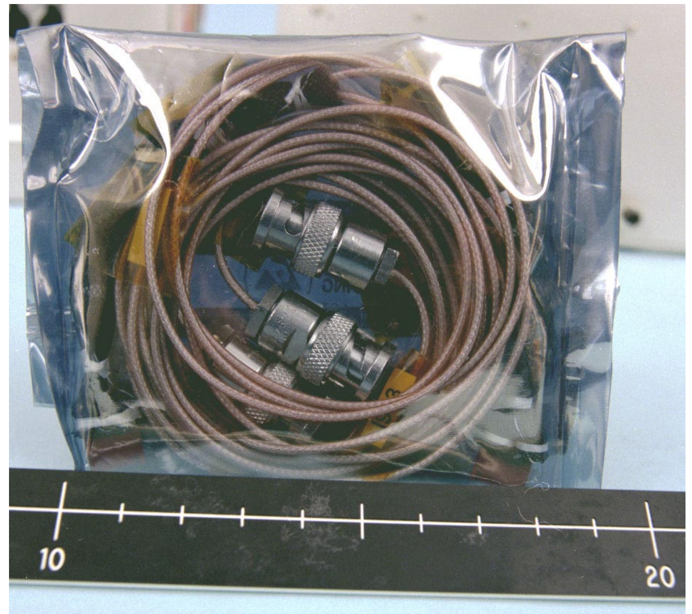
1 GAS 1/Manifold 1 Hose
2 GAS 2/Manifold 2 Hose
3 GAS 1/Exhaust 1 Hose
4 GAS 2/Exhaust 2 Hose
5 Manifold 1/GAS 1 Hose
6 Manifold 2/GAS 2 Hose
7 Integration Container 1/GAS 1 Hose
8 Integration Container 2/GAS 2 Hose

## SPARE PARTS KITS 1, 2

The Spare Parts Kits contain the GEMS subassemblies and supplies most likely to be required during the mission.

Spare Parts Kit 1 contains:
- 12 Air filters (same filter used in several systems)

Spare Parts Kit 2 contains:
- Two Blowers (for Air Filtration & Integration Assembly)
- Infrared source (for Gas Analyzer)
- $O_2$ sensor (for EDS)
- Hard disk (for Portable Computer)
- Two Scrubber cylinders (for GAS Calibration Unit)
- Two Cooling Fans (same fan used in several systems)

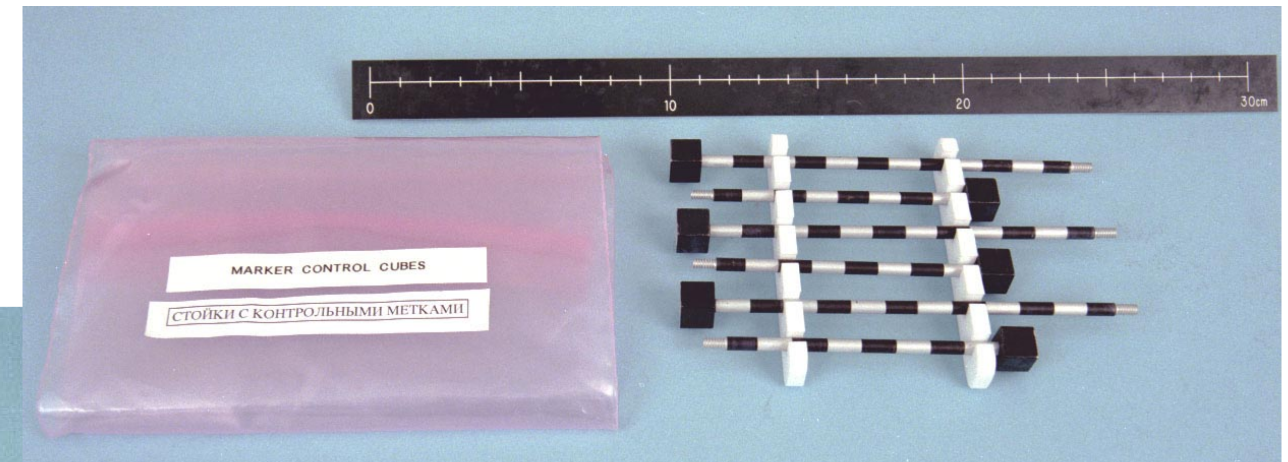



S96-18286

Figure FB-59 Greenhouse Cable

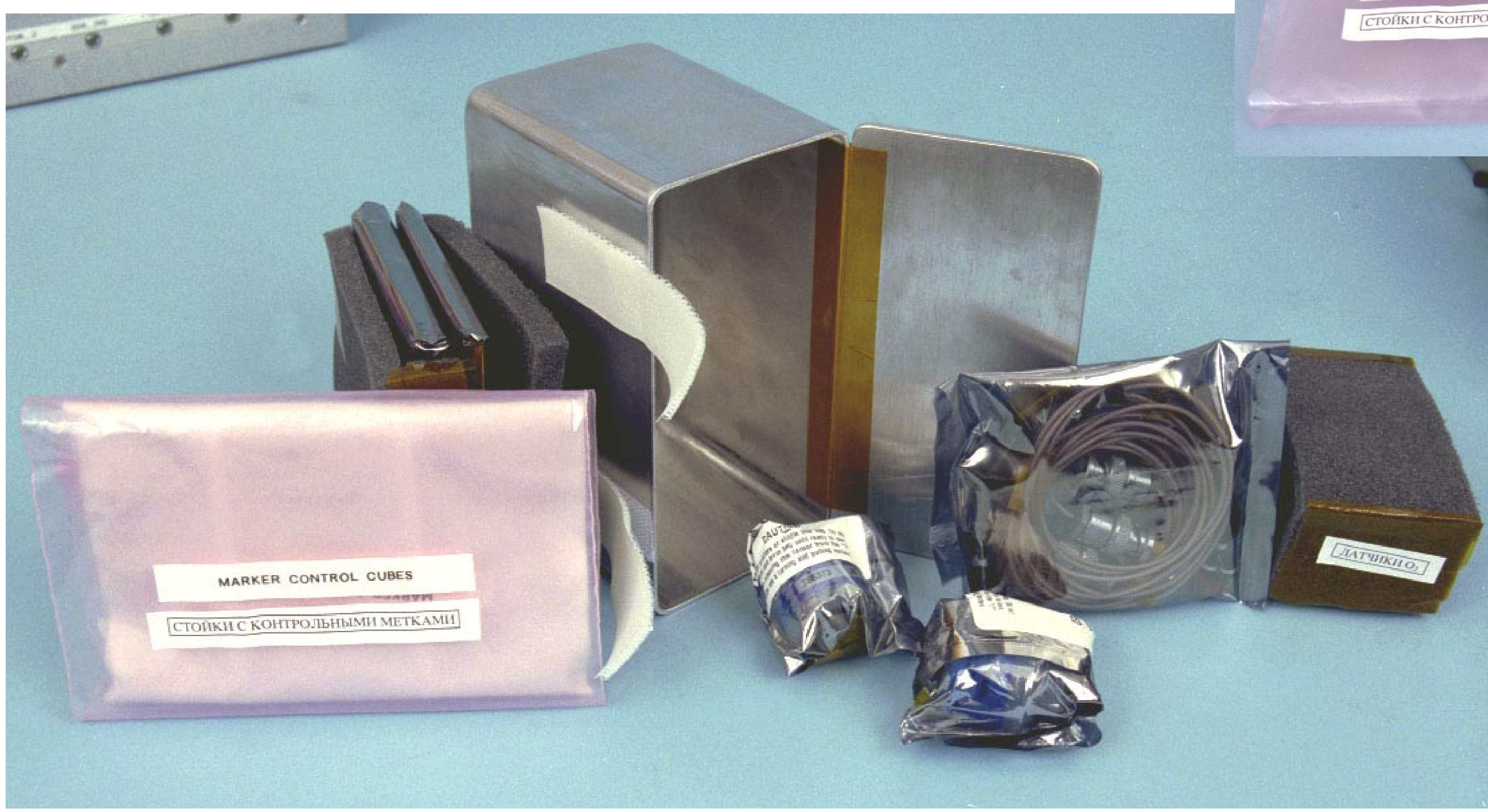
Each Gas Analyzer consists of the following components:

- One Mounting Bracket (to hold both gas analyzers)
- Infrared Sensor at entrance of each Leaf Bag Assembly
- Infrared Sensor at exit of each Leaf Bag Assembly
- Barometric Air Pressure Sensor in each gas analyzer
- Pressure Differential Sensor between the two absorption cells
- Two Thermometers, one in each absorption cell
- Internal Gas Analyzer microprocessor and IEEE-488-2 communications link
- Electronic Circuit Boards
- Cooling Fan
- Air Filter coded ring, will be provided in the log book.




S96-18289

Figure FB-60 Marker Control Cubes




S96-18287

Figure FB-61 Spare Parts Kit


S96-18288

Figure FB-62 Oxygen Sensors from the Spare Parts Kit

**SPARE PARTS KIT #3 (S/N510)**

P/N: D3-4213-01
Qty.: 1
Mass: 0.65 kg
Power: N/A
x, y, z: 15.30 x 10.50 x 7.70 cm
Loc: Kristall

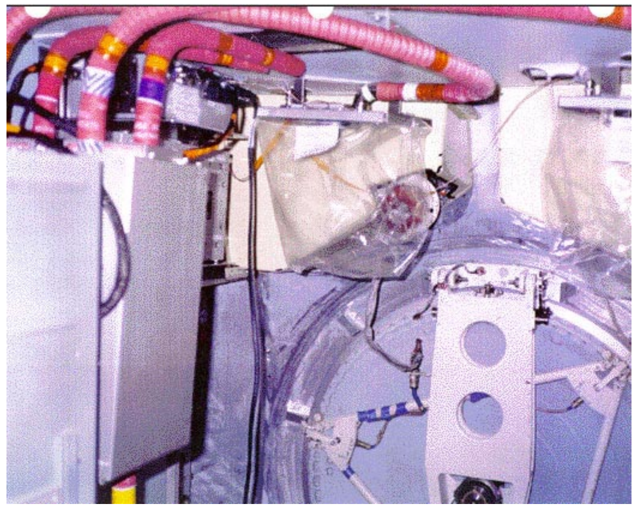


Figure FB-63 Greenhouse Setup Assembly Installed

NOTE: Two more hard disks were provided on the STS-71 launch for the Mir-19/20 Mission. One disk was returned on Soyuz and another was returned on STS-74. Additional disks are to be launched for the Mir-22/NASA-3 Mission, on STS-79.

## SIGB

Fixation of plant samples and operations with seeds is done inside the SIGB, which has been installed in the Priroda module. A crew familiarization manual, the Standard Interface Glovebox Experiment manual, provides detailed information on this glovebox.

## $GN_2$ FREEZER (STOWED ON STS-86)

The passive $GN_2$ Freezer is a vacuum-insulated container with an inner container lined with a calcium silicate absorbent material. This inner container is loaded with liquid nitrogen ($LN_2$), which is released as gaseous nitrogen ($GN_2$) as heat is absorbed from the specimens and surroundings. The $GN_2$ Freezer itself will remain in its Shuttle stowage locker.

A sample container, the $GN_2$ Freezer Insert, will be stowed separately and transferred to Mir during final harvest of the third planting. Plant samples to be frozen will be placed in the insert, and the insert then placed inside the freezer. The samples must be prepared and the insert transferred within 30 minutes of harvesting to preserve labile enzymes and hormones for analysis. ❋


Figure FB-64 PDS Filter Backs

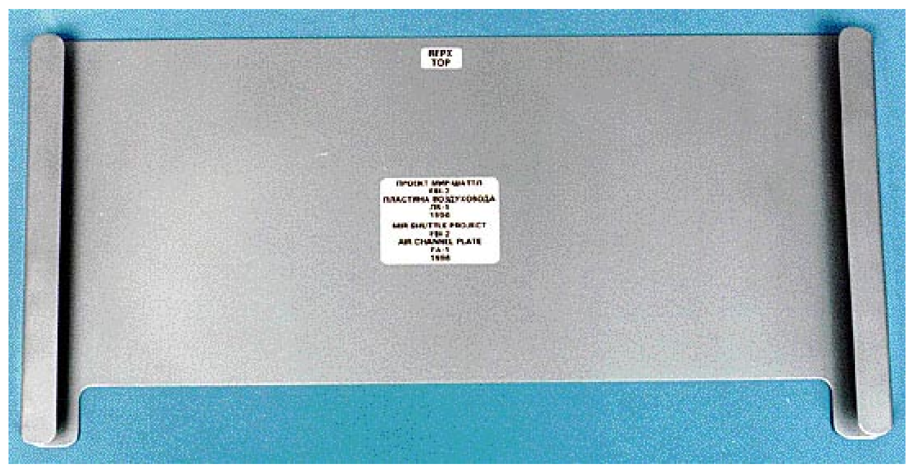


Figure FB-65 Air Channel Plate

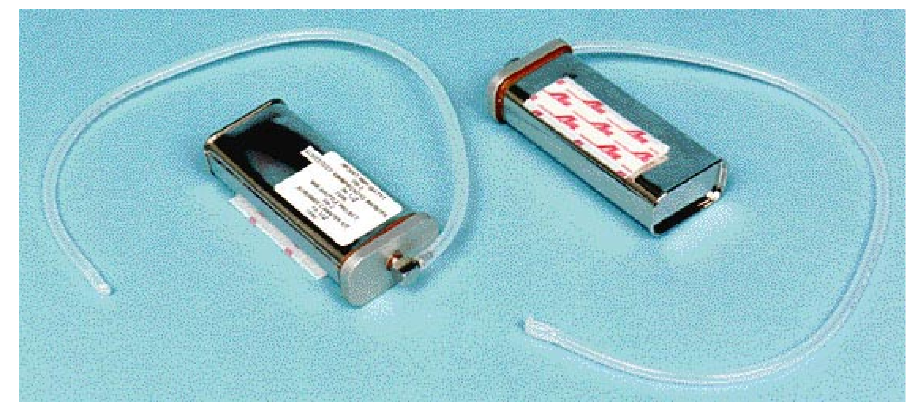


Figure FB-66 Cartridges

Figure FB-67 IR Source Block

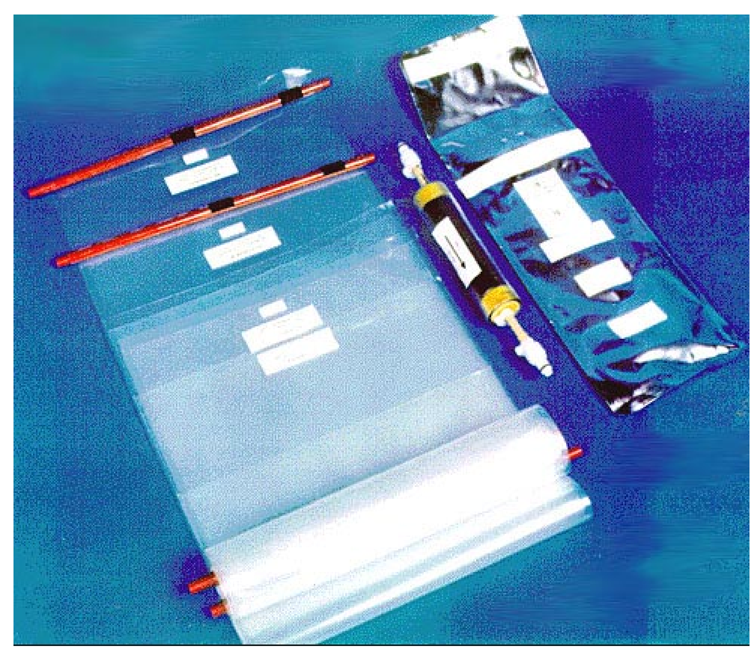


Figure FB-68 Filter/Pump Kit

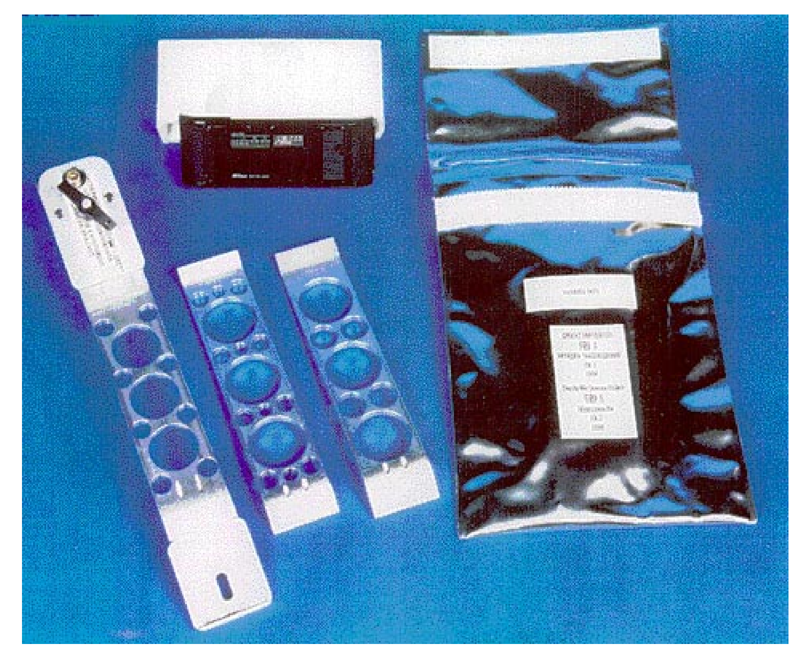


Figure FB-69

D.I.D.

Filter Pump Kit

**SPARE IR SOURCE BLOCK**

P/N: D3-4166
Qty: 1
Mass: .25 kg
Power: N/A
x,y,z: 9.27 x 4.72 4.29 cm
Loc: Kvant
DID#: N/A

**FILTER/PUMP KIT, FA-4**

DID#: 101676-001
Qty: 1
Mass: 1.70 kg
Power: N/A
x,y,z: 37.60 x 11.40 x 9.40 cm
Loc: Kvant
DID#: 101796

**AIR CHANNEL PLATE**

P/N: C1-5219-01
Qty: 1
Mass: 0.14
Power: N/A
x,y,z: 36.40 x 17.80 x 1.30
Loc: Kvant
DID#: N/A

**FBI2 GAS ANALYZER**

P/N: E3-1145-01
Qty: 2
Mass: 10.20 kg
Power: 18.45 W
x,y,z: 41.4 x 20 x 13 cm
Loc: Spektr, A3
DID#: E3-1145

**GREENHOUSE GAS ANALYZERS**

P/N: E3-1145-01
Qty: 2
Mass: 10.60 kg
Power: 0
x,y,z: 41.80 x 18.60 x 12.80 cm
Loc: Kristall
DID#: E3-1145

S97-09500

Figure FB-70  MASU PCMCIA Hard Drives

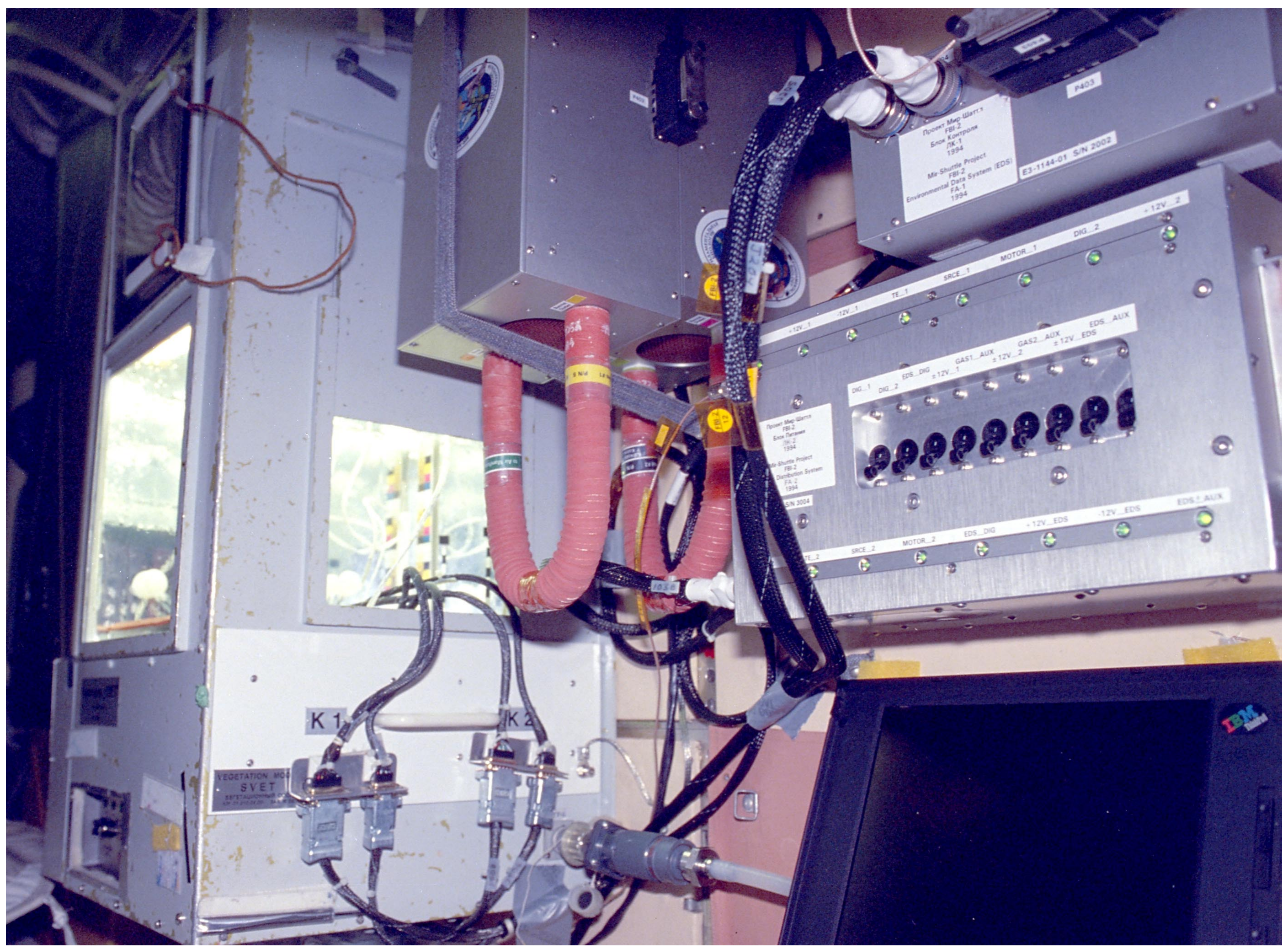

NASA5-305-18

Figure FB-71  Mixed Gas Analyzers in Kristall

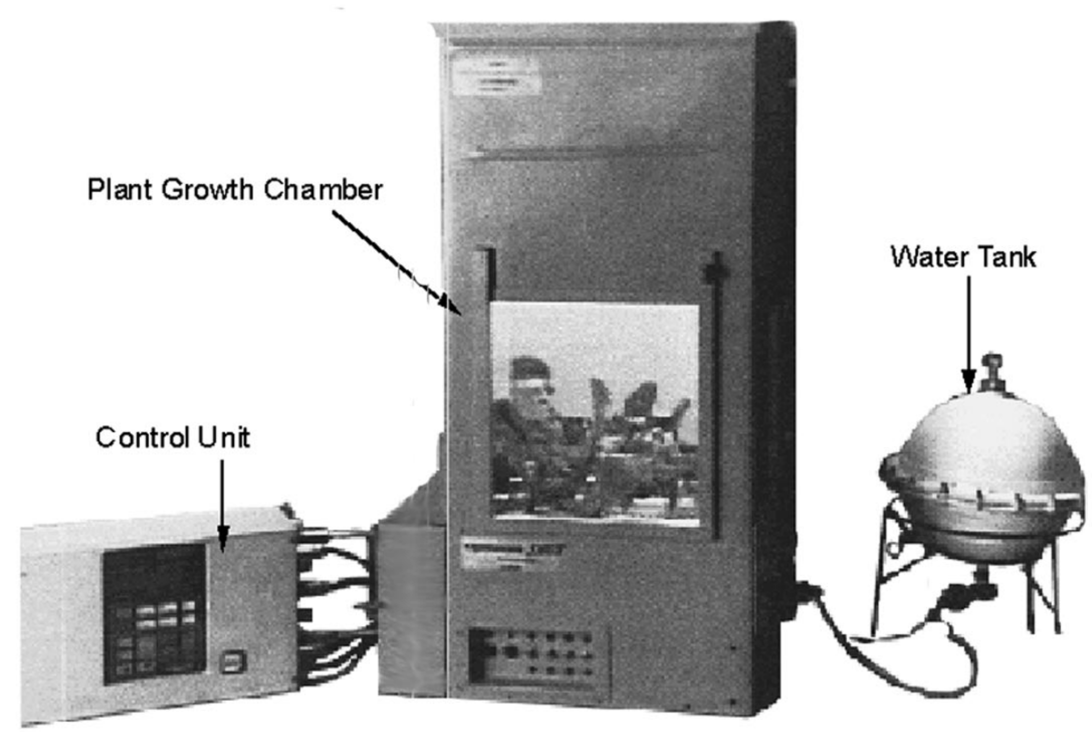


Figure FB-72  Svet Greenhouse, Ground Unit

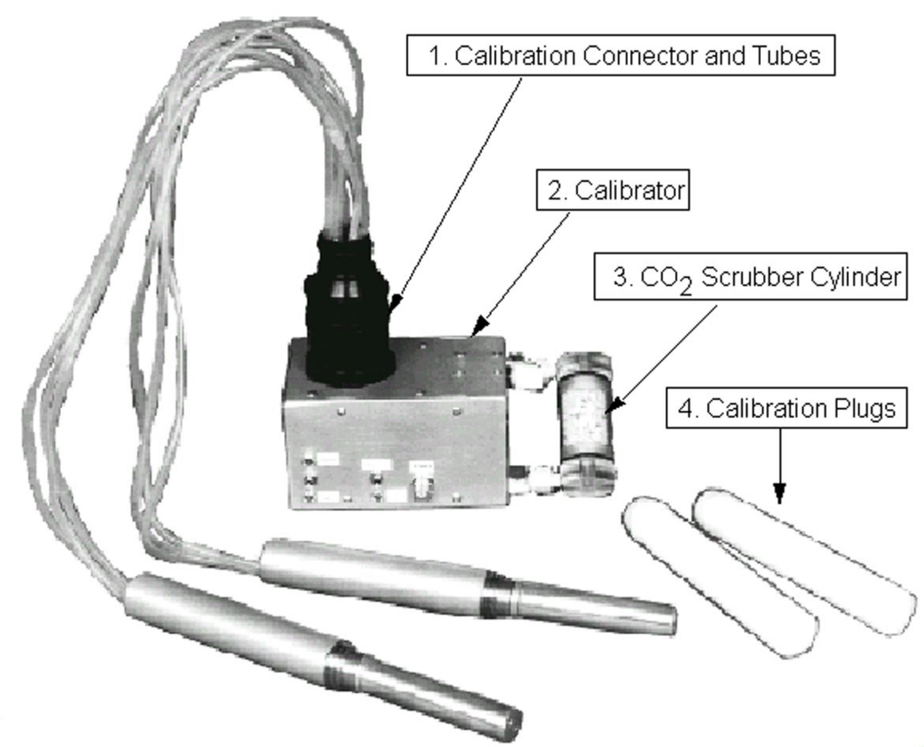


Figure FB-73  GEMS Calibration Hardware [S95-11635]

**1020 LEAF BAG ASSY 2**

P/N: E3-1133-02
Qty: 1
Mass: 0.67 kg
Power: N/A
x,y,z: 31.44 x 15.31 x 18.56 cm
Loc: Kvant
DID#: N/A

**FBI2 ENVIRONMENTAL DATA SYSTEM**

P/N: E3-1144-01
Qty: 1
Mass: 1.75 kg
Power: 10.81 W
x,y,z: 25.7 x 19.2 x 9.4 cm
DID#: E3-1144

**FBI2 AIR FILTRATION & INTEGRATION ASSY**

P/N: E3-1172-01
Qty: 2
Mass: 1.59 kg
Power: N/A
x,y,z: 23.80 x 23.80 x 7.00 cm
DID#: E3-1172

**FBI2 POWER DISTRIBUTION SYSTEM**

P/N: E3-1147-01
Qty: 1
Mass: 5.54 kg
Power: 70 W
x,y,z: 35.10 x 19.60 x 13.20 cm
DID#: E3-1147

**GREENHOUSE POWER DISTRIBUTION SYSTEM**

P/N: E3-1147-01
Qty: 1
Mass: 5.54 kg
Power: 70 W
x,y,z: 35.90 x 19.70 x 13.50 cm
Loc: Kristall
DID#: E3-1147

# STANDARD INTERFACE GLOVEBOX (SIGB)

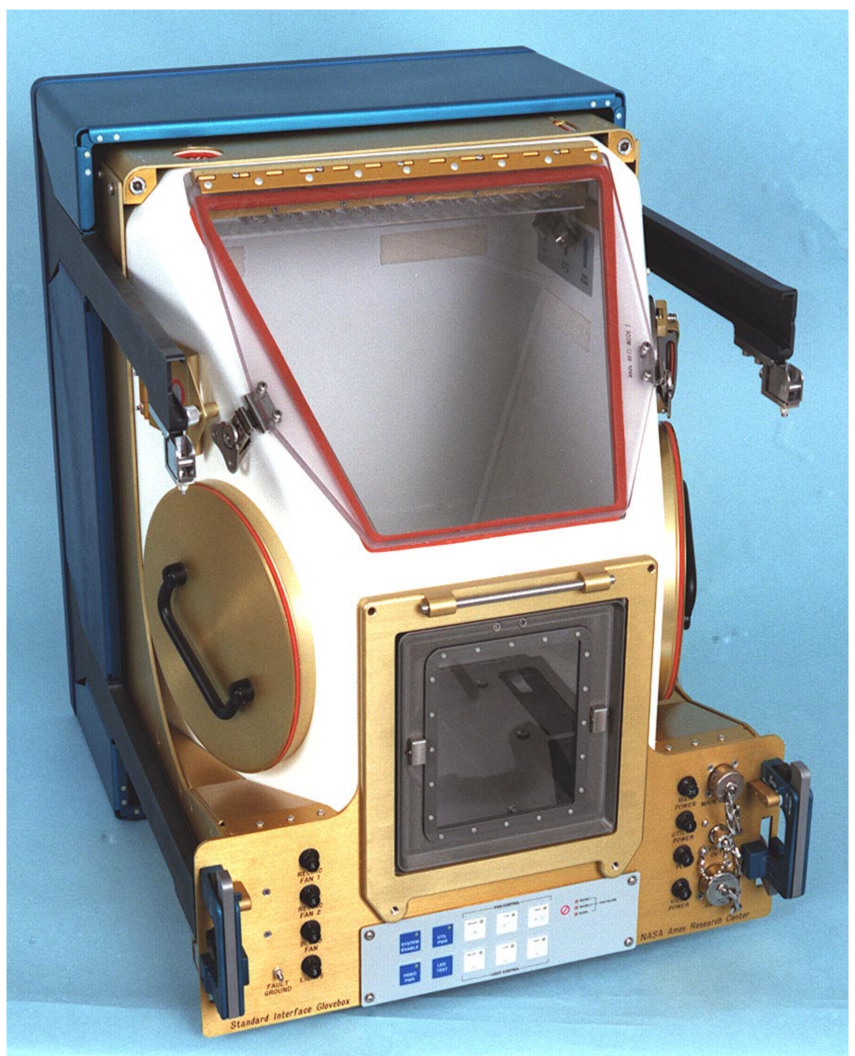
## HARDWARE DESCRIPTION

The SIGB is designed to provide a fully enclosed workspace for the execution of inflight science procedures. It utilizes sliding rails and latches adapted from the Johnson Space Center's Standard Interface Rack (SIR) which allows it to fly in virtually any current or future space platform.

### GLOVEBOX

The SIGB has a work surface of approximately 1 sq. ft (929 sq. cm.) and a work volume of 2.3 cubic ft. (.065 cubic m). It is bounded by a fiberglass shell consisting of five layers of an epoxy resin and finished with white urethane paint for easy cleaning.

In the stowed configuration, the SIGB is fully inserted into the MRS, with the closeout panel attached. Various items of stowage may be placed directly within the work volume or within the closeout panel stowage compartment.



S96-12354

Figure FB-74 SIGBx

### AIR FILTRATION SYSTEM

The airflow in the work volume of the SIGB is modeled after a laminar flow hood. Airflow is relatively slow across the upper half of the work volume and increases in speed through the lower half of the work volume. By exhausting the air along the edges of the work volume, airflow is drawn along the periphery of the chamber, minimizing the problem of dried tissue samples.

The SIGB air filtration system provides a net negative pressure of 0.1 to 0.6 in. $H_2O$ with respect to ambient within the work volume in all operational modes, with viewing window and transporter interface doors closed and latched. In addition, all portions of the SIGB airflow system, including filter inlets, exhausts and plenums, maintain negative pressure with respect to ambient at all times in all operational modes.

The SIGB filtration system has been designed such that full containment is provided for spills of the specific chemicals and quantities provided proper cleanup procedures are followed. Other chemicals may be accommodated after additional testing and/or analysis of filter capacity on a case-by-case basis.

### Recirculation and Bleed Fans

Two radial fans provide the recirculation of air and one radial fan provides the bleed air function. The fans have a speed of 2500 rpm and operate within a voltage range of 18-28 Vdc. The design of the SIGB is such that the operator cannot come into contact with any of the rotating components of the fans.

There are two fan speeds available to the operator: LOW and HIGH. In both modes, the bleed fan operates at a constant speed. The recirculation fans, however, will change speeds to produce a lower or higher recirculation flow rate depending upon the mode selected.

NOTE: It is absolutely CRITICAL that the fans remain on the LOW setting during the cleanup of any toxic chemical spill. This will ensure that sufficient residence time of the flowing air through the lower recirculation filter is provided to maintain the efficiency of the filter. Using the HIGH fan mode will not allow for adequate scrubbing in all cases.

### Filtration: Recirculation

Air enters the work volume via a rectangular filter at the top of the chamber and exits through a horseshoe-shaped single-pass filter at the bottom of the work volume. The upper recirculation filter consists of one layer of 165 mesh stainless steel screen, one layer of activated carbon web, and two layers of "filtrete" material, providing 97% efficiency High Efficiency Particulate Air (HEPA) filtration as well as stagnant containment of lightweight organics (as in the case of complete fan failure).

The lower recirculation (scrubbing) filter consists of four layers of activated carbon web between two Teflon-coated 200 mesh screens. It provides particulate containment (≥90 µm) and single-pass scrubbing of lightweight organics. The Teflon-coated screen is hydro-phobic, which will help keep liquids from passing through. Both the upper and lower recirculation filters are replaceable in flight without breaking material containment of the work volume.

S96-12353

Figure FB-75 SIGBx with Cover On

D.I.D

Standard Interface Glovebox

D.I.D

Standard Interface Glovebox Cleanup Kit

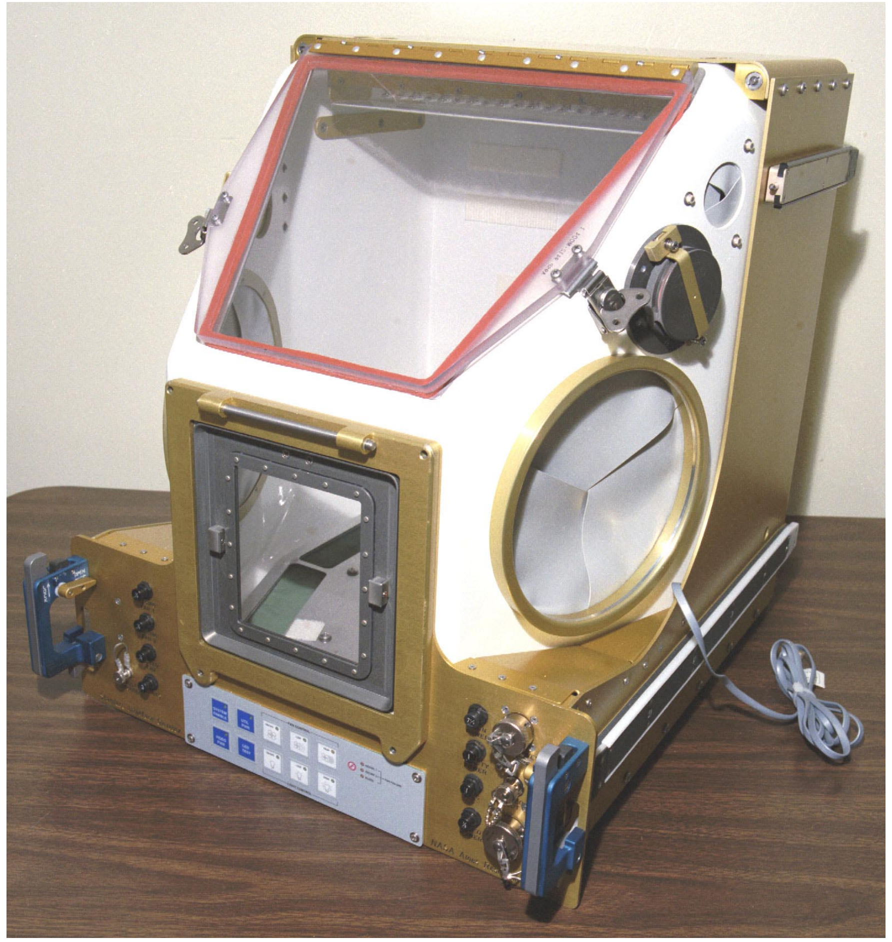
**Principal Investigator:**
Kimberly Hines
Sverdrup Technology
Project Manager
(650)604-5911

**STANDARD INTERFACE GLOVEBOX**

P/N: A9SP-9412-M500-1
Qty: 1
Mass: 38.14 Kg
Power: 125 W
x,y,z: 55.6 x 46.10 x 55.70 cm
Loc: PR, SIC3-0-1/2
DID#: SLM46114795

**LAUNCH STOWAGE AND DEPLOYED CONFIGURATION GLOVEBOX KIT**

DID#: 101794



S97-01200

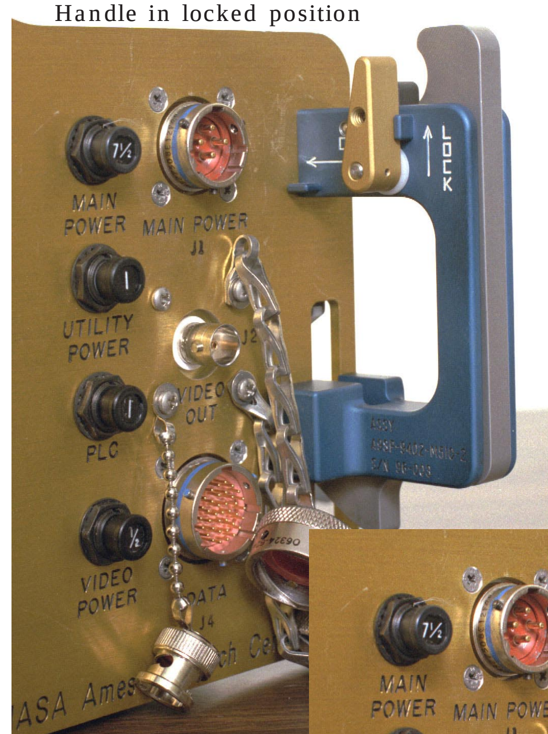
Figure FB-76  Training Unit Side View

### Filtration: Bleed

The bleed air inlet valve, which provides an adjustable orifice, is located on the right side of the work volume. It allows a small amount of control over the bleed airflow rate and the negative pressure inside the work volume. Opening the bleed air inlet valve will reduce the internal negative pressure and will also increase the speed of the bleed airflow exhausted out the back of the SIGB.

It is operated by unscrewing the captive cap and has a relatively large surface area to prevent a high-velocity stream from disturbing the airflow. The bleed valve might be used to introduce more fresh cabin air into the work volume for added cooling if internal temperatures are higher than desired.

Figure FB-77 (Below)
Handle in locked position




S97-01215

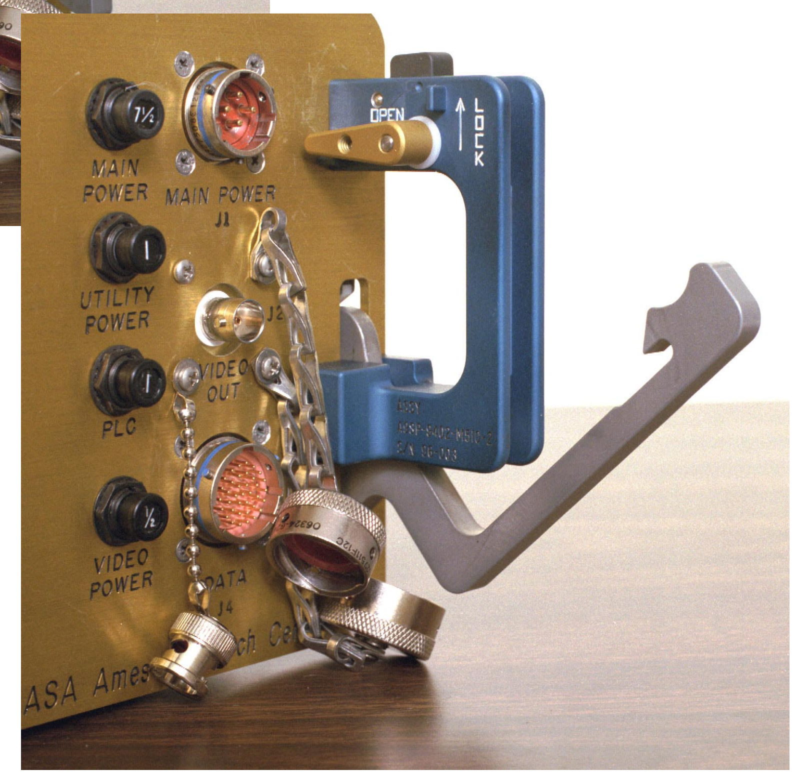
The bleed exhaust filter consists of one layer of Teflon-coated 200 mesh screen. It is accessible with the SIGB removed from the rack.

## MECHANICAL INTERFACES AND USER ACCESS

### Slide Assembly

The SIGB has four Slide Assemblies which allow for the insertion of the unit into the MRS, or any other rack of the SIR design. The Slides on the lower portion of the SIGB are full-length, while those on the upper portion are shortened due to the shape of the SIGB. When the Closeout Panel is installed, however, it supplies the remaining portion of the “shortened” Slide. They operate without any moving parts, using Acetyl runners, which prevent any metal-to-metal contact.

The full-length Slide is made with a taper, or wedge, at both ends, which mate to tapered sections in the Slide Guides of the MRS. The design allows for a loose fit of the slides within the Slide Guides until the Latch Handles are fully engaged and locked. When the Latches are engaged, the wedge sections are then pressed together to rigidly hold the entire assembly in place.




S97-01214

Figure FB-78  Handle in Unlocked position

### Closeout Panel

The Closeout Panel acts as a shear panel and transmits launch and landing loads to the top rails, since the shape of the SIGB of itself does not allow a direct use of the rails and latching handles on the upper half of the assembly. While the SIGB is in use, the Closeout Panel is removed and set aside. The SIGB may then be deployed for nominal operations.

The Closeout Panel also protects the glovebox from kick-off loads while in the stowed position, and may provide a level work space for crew operations on Mir.

### Latch Handle Assembly

The Latch Handle Assemblies are modeled after the latches designed for the SIR program, with some modifications to accommodate the narrow width requirements of Middeck payloads. They hold the SIGB into the MRS by means of structural “hooks” which mate with striker assemblies fixed to the rack Slide Guides. The SIGB employs two Latch Handles on the lower half of the front panel with the Closeout Panel adding two more on the top half.

The SIGB latch handle assembly has been designed for one-handed operation for the convenience of the crew.

### Top-Access Window

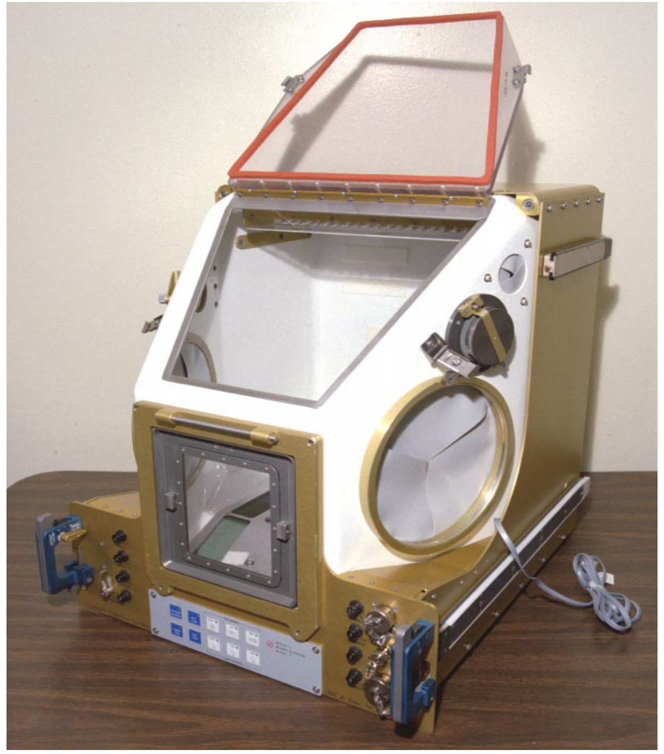
The canted viewing window doubles as a large access door. The window is secured via a piano hinge at the upper edge and two one-hand-operation toggle latches at the sides. The window is made from Lexan and sealed with a silicon foam gasket.

### Armports and Gauntlets

During operation, the work volume is accessed via two armports on either side of the glovebox. The holes through the fiberglass work volume are lined with aluminum rings, onto which Tyvek gauntlets are attached. The gauntlets feature a Velcro strap to tighten the gauntlet snugly around the elbow, as well as elastic to minimize ballooning. While the gauntlet design is meant to allow bare-handed operations inside the SIGB, surgical gloves (or any other glove of choice) may also be worn if required.

Armport closeout covers are provided for when the SIGB is not in use. These covers have large handles and snap into place on the armport rings.

The armport covers are removed for operation and the gauntlets installed around the armport rings. The arms are then simply inserted into the gauntlets with the small end of the gauntlet fitting snugly around the operator’s wrist.



S97-01201

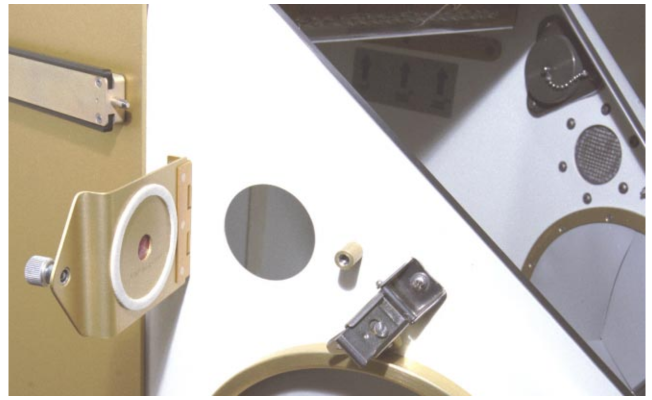
Figure FB-79  SIGBx with Lid Open

## Cable Pass-Through

A 1.75 inch (4.44 cm) diameter cable pass-through port is provided above the right glove port ring. It features a three-layer rubber "iris" which stretches to allow the plug through yet closes up snug around the cord. This feature allows insertion of non-standard cables into the work volume with minimal effect on containment. A cap secured on a chain is used to cover the port when not in use.

## Quick-Access Port and Fire Port

The SIGB is equipped with a quick-access port for small items near the top access window above the left side armport. Tools or small samples in vials, for example, can be passed through this interface when it is necessary to introduce or remove these items without breaking containment of the work volume, such as a rapid transfer of samples to liquid nitrogen. This port should be used as expediently as possible to avoid contamination. The negative pressure developed within the work volume will prevent work volume contents from escaping into the cabin. The 2.0 inch (5.1 cm) diameter opening is covered by a sealing door, hinged on one edge and fixed with a captive knurled knob.



S97-01199

Figure FB-80  Fire Hatch

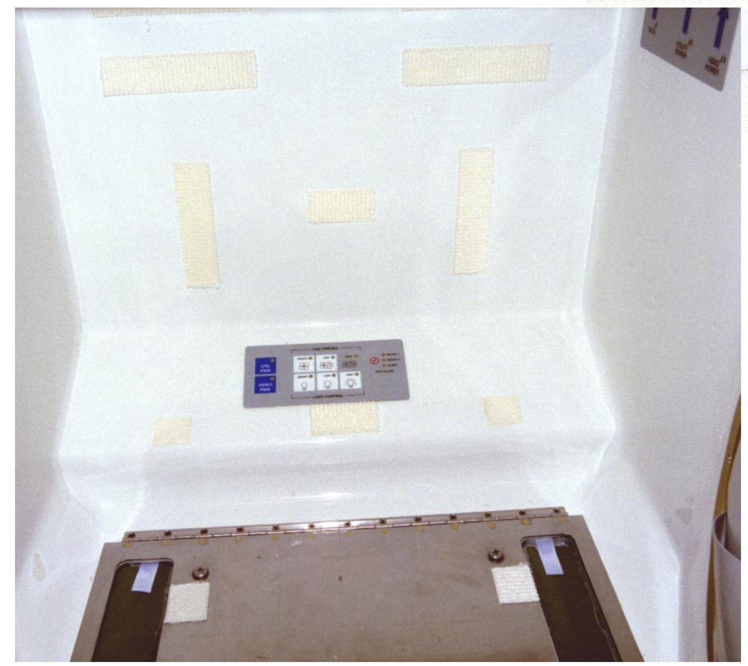
S97-01216

Figure FB-81  SIGBx Right Side View

In the center of the quick access port is a fire port for the work volume, a 0.5 inch (1.3 cm) diameter hole, covered by a decal.

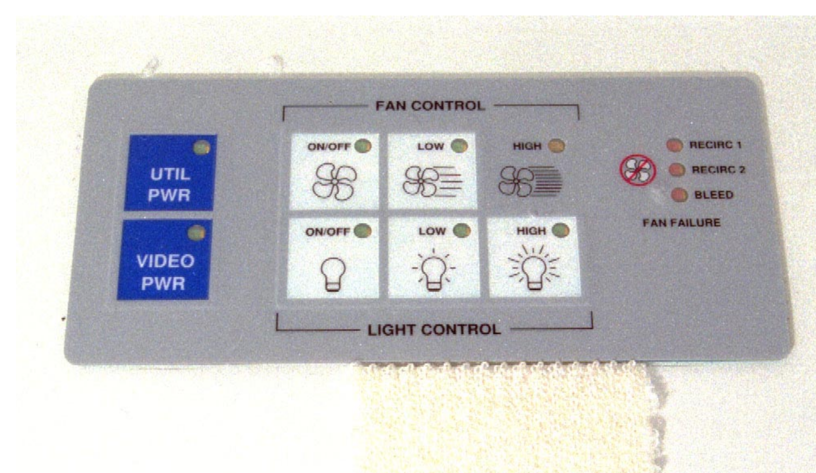
## Transporter Door

The SIGB features a "transporter" door/airlock on the front plane of the work volume. This allows for introduction of materials into the work volume while simultaneously maintaining material containment when the transporter/airlock is attached.



S97-01217

Figure FB-82  Interior of SIGBx




S97-01212

Figure FB-83  Interior Controls

S97-01198

Figure FB-84  Interior Cable Connections

## Stowage Volume

When the closeout panel is in place, the shape of the entire assembly becomes a cube. Since the SIGB top access window lies at an angle to this "cube", there is an open volume between the two. This volume has been utilized as an addition stowage area, in which various items may be stowed for a given experiment. This stowage area will accommodate approximately 5 lbs (2.3 kg) of additional hardware.

## SYSTEM CONTROLS

The switches which control glovebox functions utilize membrane panel technology, and have indicating LEDs imbedded into the panel layers. They are simple momentary, snap action switches. To operate, they need only be pushed gently to make contact and released. There are panels both inside the work volume and on the front panel of the SIGB. For the most part they have identical functions, but there are some differences.

The inner panel does not have a switch for the "fans high" setting for safety reasons. This is because if there is a toxic chemical spill, it is undesirable for the fans to be in the high circulation mode since this would decrease the residence time of air flowing through the filter, thus causing less than optimum scrubbing of volatiles.

The "fan failure" indicator on both panels includes one LED for the bleed fan and one for each recirculation fan circuit, each of which will light to indicate failure of their respective components.

## LIGHTING SYSTEM

Lighting from above is provided by fluorescent tubes powered by 24V DC and furnishing 400 lux at the work surface in the high setting. The current design incorporates 20 small bulbs, approximately 2 inches (5.1 cm) in length. Each bulb contains a maximum of .8 mg of mercury each, with some tubes tested showing as little as .1 mg, which is significantly lower than the 6 mg per tube allowed by the Space Payload Accommodations Handbook (SPAH).

## VIDEO SYSTEM

The SIGB provides an interface for an internally-mounted video camera for monitoring and recording of inflight operations. The exact type and configuration of the camera must be determined by users with particular needs. The interface connector in the SIGB work volume supplies power to the camera and carries image data directly to a BNC connector on the front panel. From here, video processing equipment must be connected for recording or other manipulation of the camera output.

TABLE FB.10
SYSTEM CONTROLS

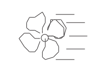
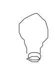
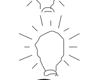
| Switch Label | Icon | Front | Inside | Function |
|---|---|---|---|---|
| SYSTEM ENABLE | N/A | X | NO | Engages outputs from PLC to allow operation of all SIGB systems. |
| LED TEST | N/A | X | NO | First push disengages all functions and lights each LED on membrane panels to ensure proper operation. Second push begins operation in same configuration as before LED test was initiated. |
| VIDEO PWR | N/A | X | X | Supplies power to the internal VIDEO PWR connector. |
| UTILITY PWR | N/A | X | X | Supplies power to the internal UTILITY PWR connector. |
| FANS ON/OFF |  | X | X | Supplies power to both recirculation and bleed fans. Initial default mode is LOW. |
| FANS LOW |  | X | X | Switches fans to the low speed setting—used for most nominal operations and ALL emergency cleanup operations. |
| FANS HIGH |  | X | NO | Switches fans to the high speed—used when required by Principal Investigator (PI). |
| LIGHTS ON/OFF |  | X | X | Supplies power to the internal lighting system. Initial default mode is HIGH. |
| LIGHTS LOW |  | X | X | Switches internal lighting to LOW. |
| LIGHTS HIGH |  | X | X | Switches internal lighting to HIGH. |
| FAN FAILURE |  | X | X | Indicator lights only—show failure of recirc and bleed fans |


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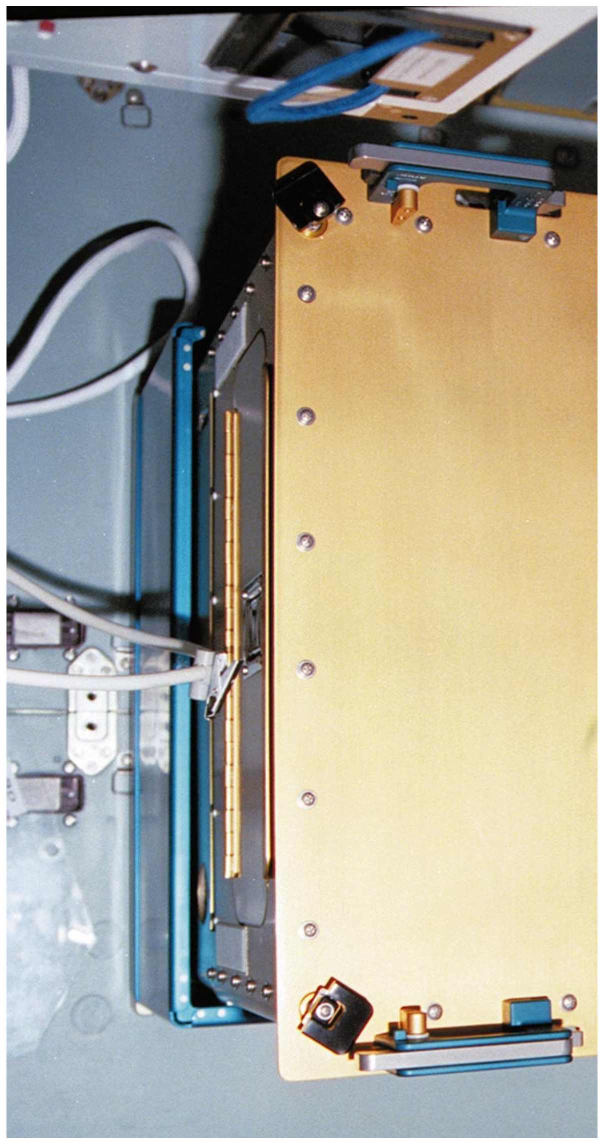
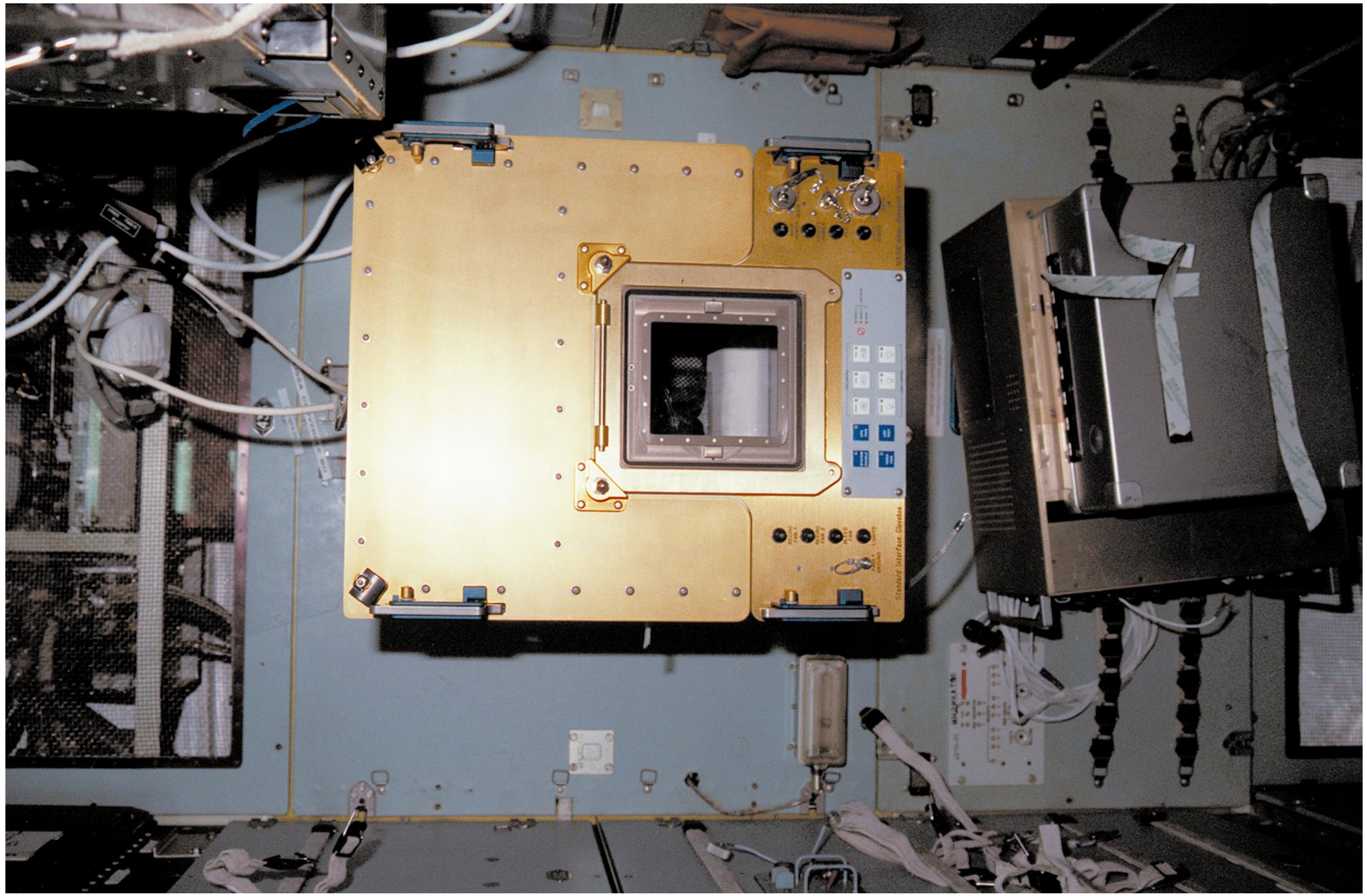
Figure FB-85 Front Panel of SIGBx



NM22-039-34
Figure FB-86  SIGB, Top End View



NM22-039-25
Figure FB-87  SIGB Mounted in the Aft End Cone of Priroda