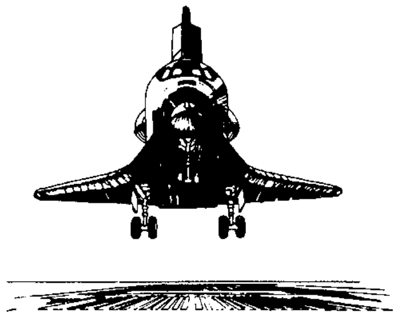
October 1981

STS-2 PRESS INFORMATION

Rockwell International

Space Transportation & Systems Group



NEWS ABOUT AMERICA'S SPACE SHUTTLE

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Modifications to *Columbia* (changes from the STS-1 to the STS-2 configuration) consists primarily of the relocation of the Development Flight Instrumentation (DFI) pallet to accommodate the OSTA (Office of Space Terrestrial Applications) -1 experiment pallet in the payload bay, addition of the remote manipulator system (RMS) and addition of orbiter experiments (OEX). These additions also required supporting system modifications as well as additions to the applicable display and control panels.

Additional modifications were also made to selected onboard systems and/or components uprating them to an operational configuration.

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SUE COMETA

CONTENTS

MODIFICATIONS TO ORBITER 102 FOR STS-2

- Addition of cryogenic storage tank set No. 3 (liquid oxygen and liquid hydrogen) in mid-fuselage to the power reactant storage distribution system for the STS-2 flight

  A fourth set will be added between STS-2 and STS-3 for the provisions of the seven-day mission capability

- Addition of jettison control circuit for remote manipulator system. This is a planned installation for all flights in the event the remote manipulator system could not be stowed, which would prohibit payload bay door closure.

- Relocation of DFI pallet in payload bay from station Xo1069 to 1179, to accommodate OSTA-1 payload at Xo951.

- Remove and replace fuel cells 1, 2, and 3.

  Due to subsequent development and qualification testing, improvements were made to the fuel cell components which were not in orbiter 102 STS-1 fuel cells. These improvements are in the fuel cells for STS-2 and subsequent fuel cells for subsequent orbiters.

- Remove and replace elevon cove Felt Reusable Surface Insulation (FRSI) with Advanced Flexible Reusable Surface Insulation (AFRSI).

Modifications at the Hypergolic Maintenance Facility (HMF) to the Aft Orbital Maneuvering System/Reaction Control System (OMS/RCS) Pod Structure.

- Right Pod – forward end

  1 diced Low Temperature Reusable Surface Insulation (LRSI) tile lost and 9 damaged. Tiles in this area not proof tested and densified on either pod. LRSI tiles will be replaced with densified tiles. Do not believe damage is from debris.

- Left Pod – forward end

  4 damaged LRSI tiles. LRSI tiles. LRSI tiles will be replaced with densified tiles.

- Aft outboard corner of each pod

  Felt Reusable Surface Insulation (FRSI) will be replaced with densified High Temperature Reusable Surface Insulation (HRSI) tiles.

  This area saw an over temperature delamination at back end of each pod. Damaged panels being removed and replaced by McDonnell Douglas (MCDAC) personnel at KSC with RI personnel being trained for future turn around.

  Damaged panels sent to MCDAC to assess where in flight the over temperature occurred (SRB plume or entry)

The Modifications at the Hypergolic Maintenance Facility (HMF) to the Aft and Forward RCS are:

- Remove and replace all relief valves

  STS-1 the valves were limited from 60 to 100°F, STS-2 and subsequent, new ones redesigned for 40 to 150°F

- Remove and replace oxidizer helium regulator

  Removed gold from main poppet valves and increased tolerance to prevent binding of similar materials

- Change out 31 nylon gear A-C motor operated valve actuators

  Actuators replaced with metal gears and circuitry changed to prevent over driving of valve.

The Modifications at the HMF to the Aft OMS are:

- Gauging probe failure, right fuel tank – Remove and replace probe.
- Remove and replace OMS relief valves – same reason as in RCS
- Replacing right-hand pitch actuator – primary response very slow.

Modification to the Solid Rocket Booster (SRB) Holddown Posts

- Were irreparable after STS-1. Building a shield on mobile launches platform to prevent burning on STS-2

Modifications to the Landing Gear

- The tires, wheels and bearings are being changed from the STS-1 Orbiter 102 to an STS-2 Orbiter 102 configuration which is the operational wheel, tires, and bearing configuration.
- Replacing the landing gear uplock roller on the strut with a metal to metal material to alleviate the cracking problem on STS-1 Orbiter 102 flight and re-rigging.

Auxiliary Power Unit (APU) No. 2 removed and replaced in Orbiter 102 for STS-2.

This APU was removed due to the failure of both electrical heaters in the gas generator catalyst bed driving the STS-1 flight. The heaters cannot be repaired in place, thus the APU was removed and replaced.

The APU will be hot fired after the orbiter is in place on LC39A, ten minute run.

Data acquisition cameras added to payload bay

Payload bay floodlights and thermal insulation

External Tank for STS-2

- Cryogenic load and pressure tested at NASA's National Space Technology Laboratory (NSTL) to verify insulation.

Installation of Experiments for STS-2 are:

- Tile Gap Heating (TGH) effects
- Catalytic Surface Effects (CSE)
- Aerodynamic Coefficient Identification Package (ACIP)
- Induced Environment Contamination Monitor (IECM)
- OSTA (Office of Space Terrestrial Applications) -1
- Orbiter Experiments (OEX) Support System
- Dynamics, Acoustic, and Thermal Environment (DATE)

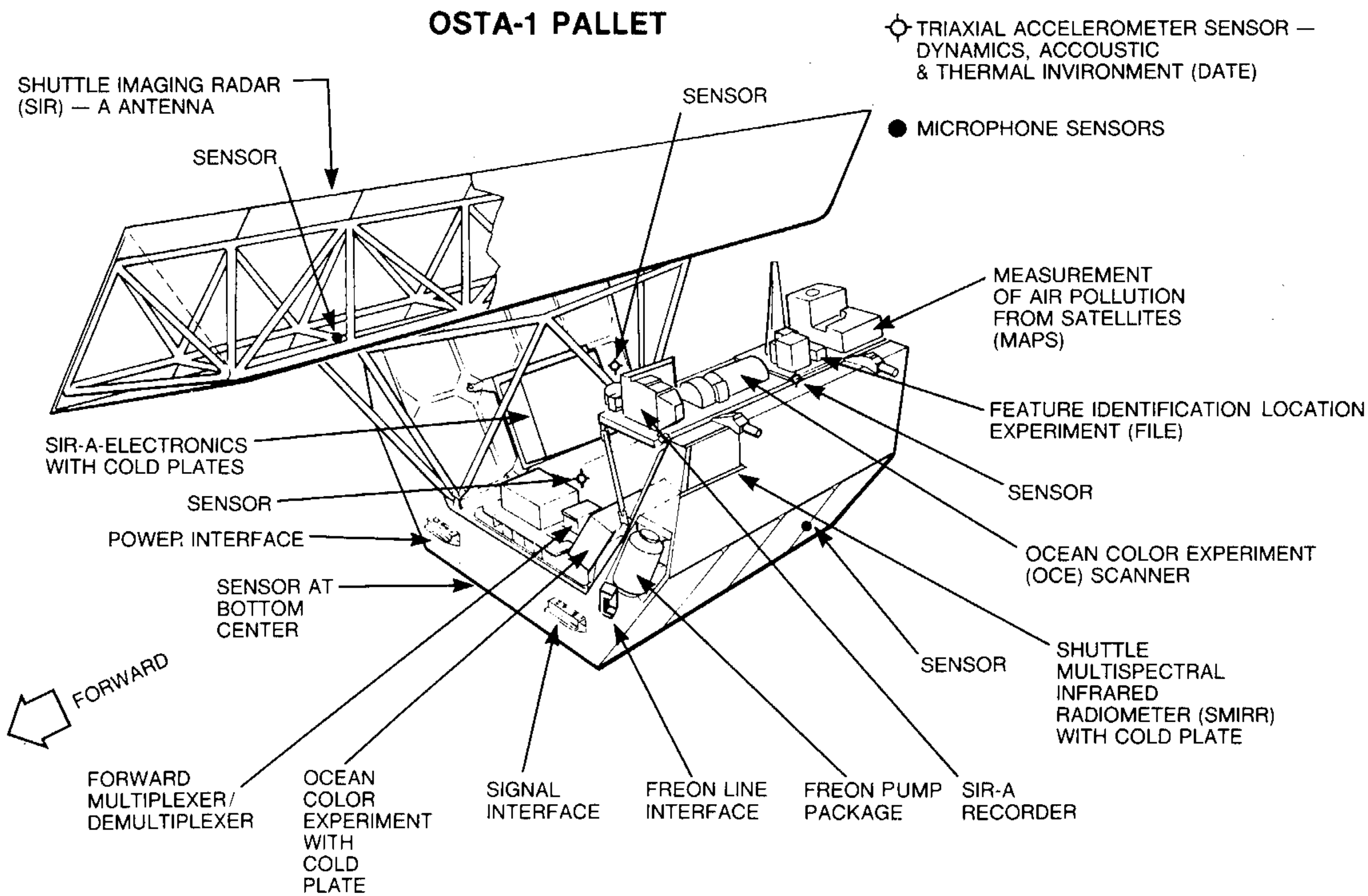
OSTA (OFFICE OF SPACE TERRESTRIAL APPLICATIONS) -1

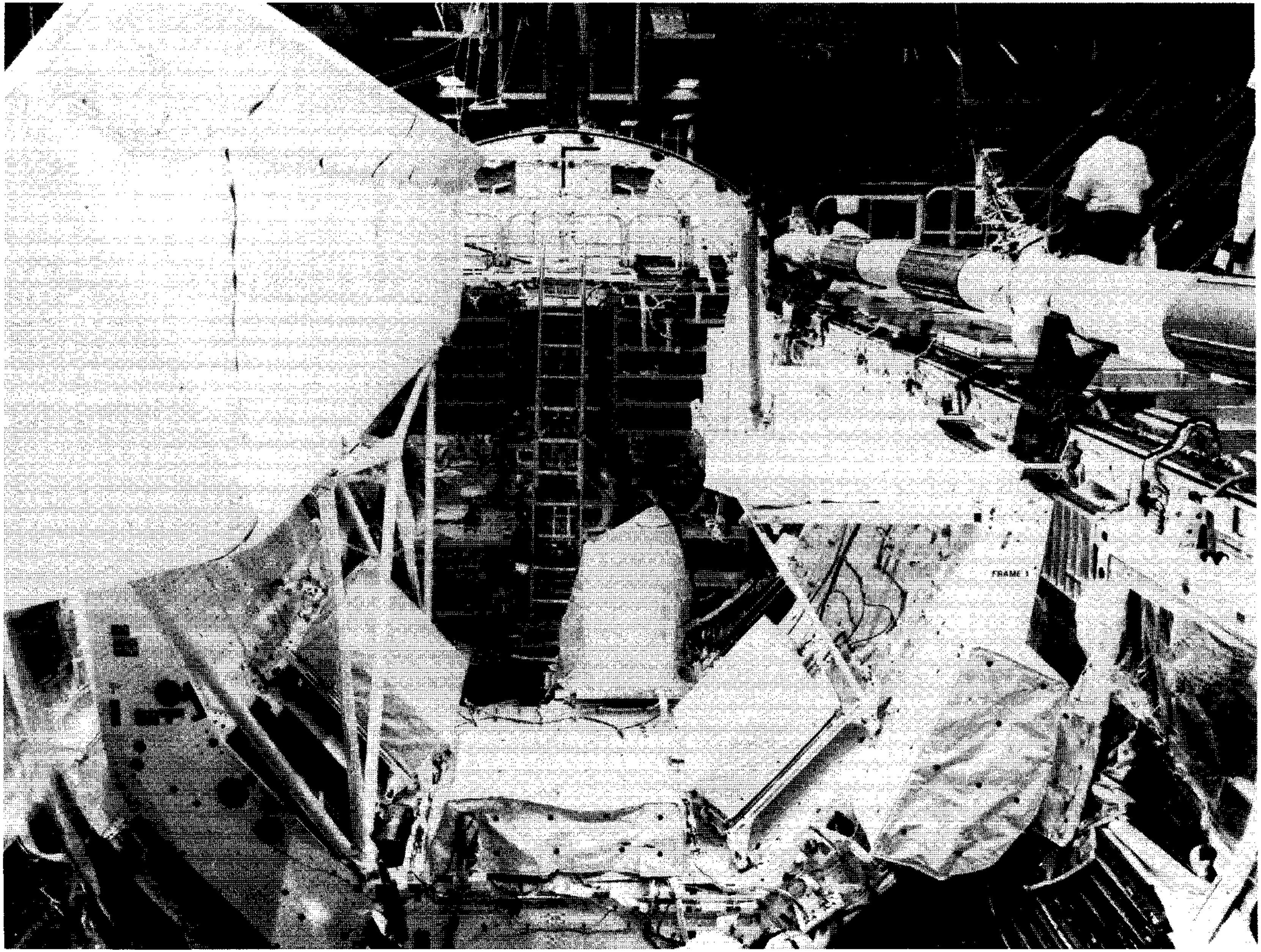
OSTA-1 consists of five experiments installed on a U-shaped 3-meter (10 feet) long pallet built by the British Aerospace Corp. under contract to ERNO (Zentral Gesellschaft) VFW-Fokker mbh) and the ESA (European Space Agency). Two experiments are installed in the orbiter pressurized crew compartment. Rockwell's Space Operations is responsible for the final assembly of the pallet, installation, integration, and testing of the payload.

NASA's OSTA-1 scientific payload will occupy approximately 0.84 cubic meters (30 cubic feet) of the *Columbia's* payload bay in STS-2 and will weigh 2,438 kilograms (5,375 pounds).

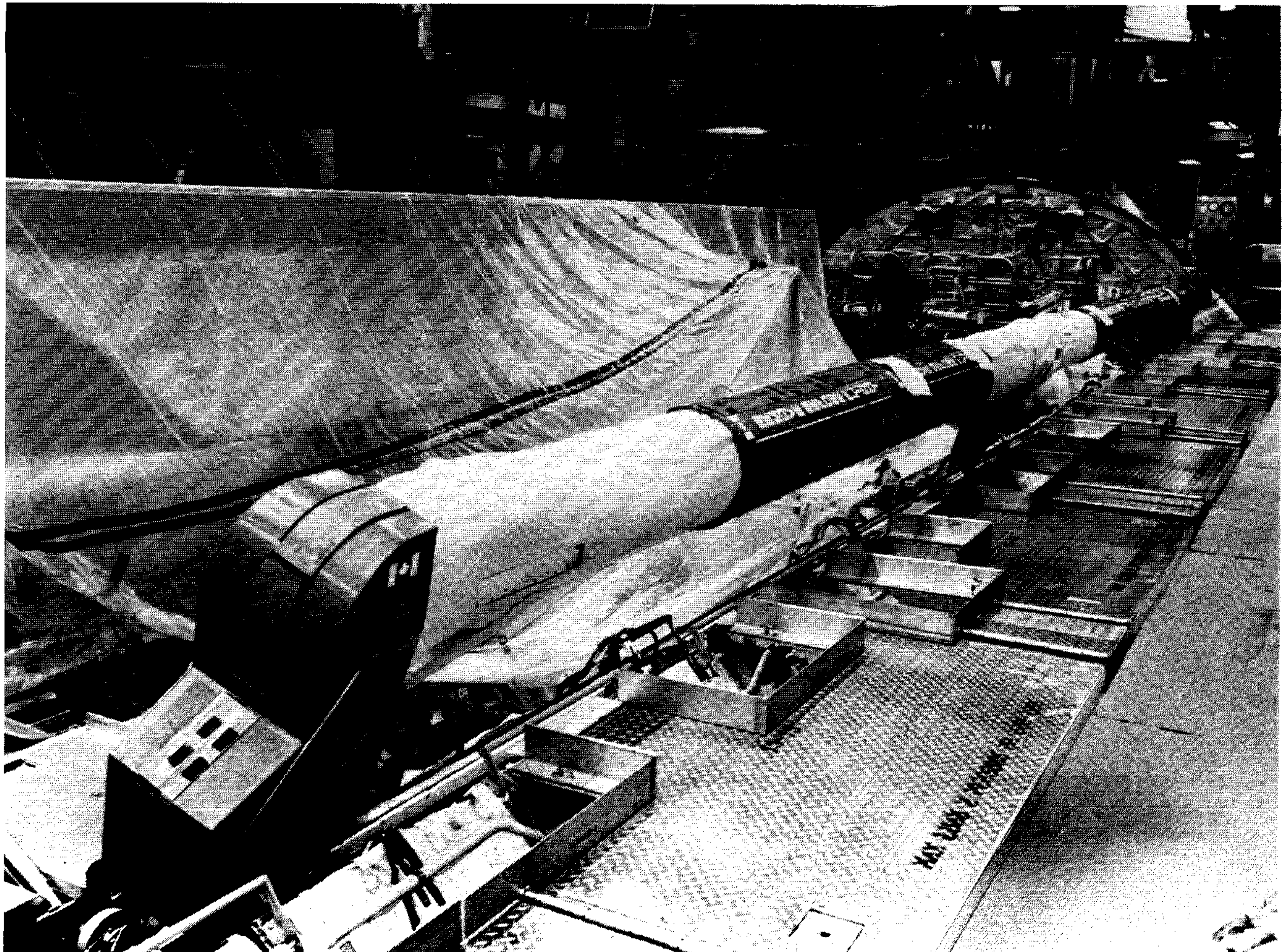
OSTA-1 consists of five experiments, two from NASA's Langley Research Center, two from the Jet Propulsion Laboratory, and one from NASA's Goddard Research Center. The five

OSTA-1 PALLET





OSTA-1 Pallet



Remote Manipulator System and OSTA-1 Pallet experiments are a Shuttle Imaging Radar-A (SIR-A); Shuttle Multispectral Infrared Radiometer (SMIRR); the SIR-A and SMIRR are managed by the Jet Propulsion Laboratory; a Measurement of Air Pollution from Satellites (MAPS); a Feature Identification and Location Experiment (FILE); managed by NASA's Langley Research Center; and the Ocean Color Experiment is managed by NASA's Goddard Space Flight Center.

In orbit, the spacecraft will assume an Earth-viewing orientation, thus accommodating the experiments of the OSTA-1 payload in this attitude, called Z-axis local vertical (ZLV), the spacecraft's payload bay faces the earth on a line perpendicular to the earth's surface.

The experiments selected for the OSTA-1 payload concern remote sensing of land resources, environmental quality, ocean conditions, and meteorological phenomena.

The Pallet provides a platform for mounting the experiments and can also cool equipment, provide electrical power, and furnish connections for command and acquiring data from the experiments.

SHUTTLE IMAGING RADAR-A (SIR-A) EXPERIMENT

The SIR-A antenna is the most obvious piece of equipment mounted on the OSTA-1 pallet. It is 9.35 meters (30 feet) long, 2.16 meters (7 feet) wide, and 15 centimeters (5.9 inches) thick and weighs 181 kilograms (399 pounds). The antenna will send and receive radar signals which will be used to create maplike images of the earth's surface to evaluate their utility for geologic exploration.

The delineation of geological structures when combined with Landsat imagery (from the visible portion of the energy spectrum) may be used to develop geological information helpful in locating valuable mineral resources.

The seven epoxy-fiberglass honeycomb panels are supported by aluminum tubular truss hardware mounted to the pallet so that the viewing angle is 47 degrees from nadir.

Radar is a day or night, all weather system because it uses its own energy to illuminate the surface and that energy is neither weakened nor scattered by water droplets. Thus, it is independent of sunlight and able to penetrate cloud cover.

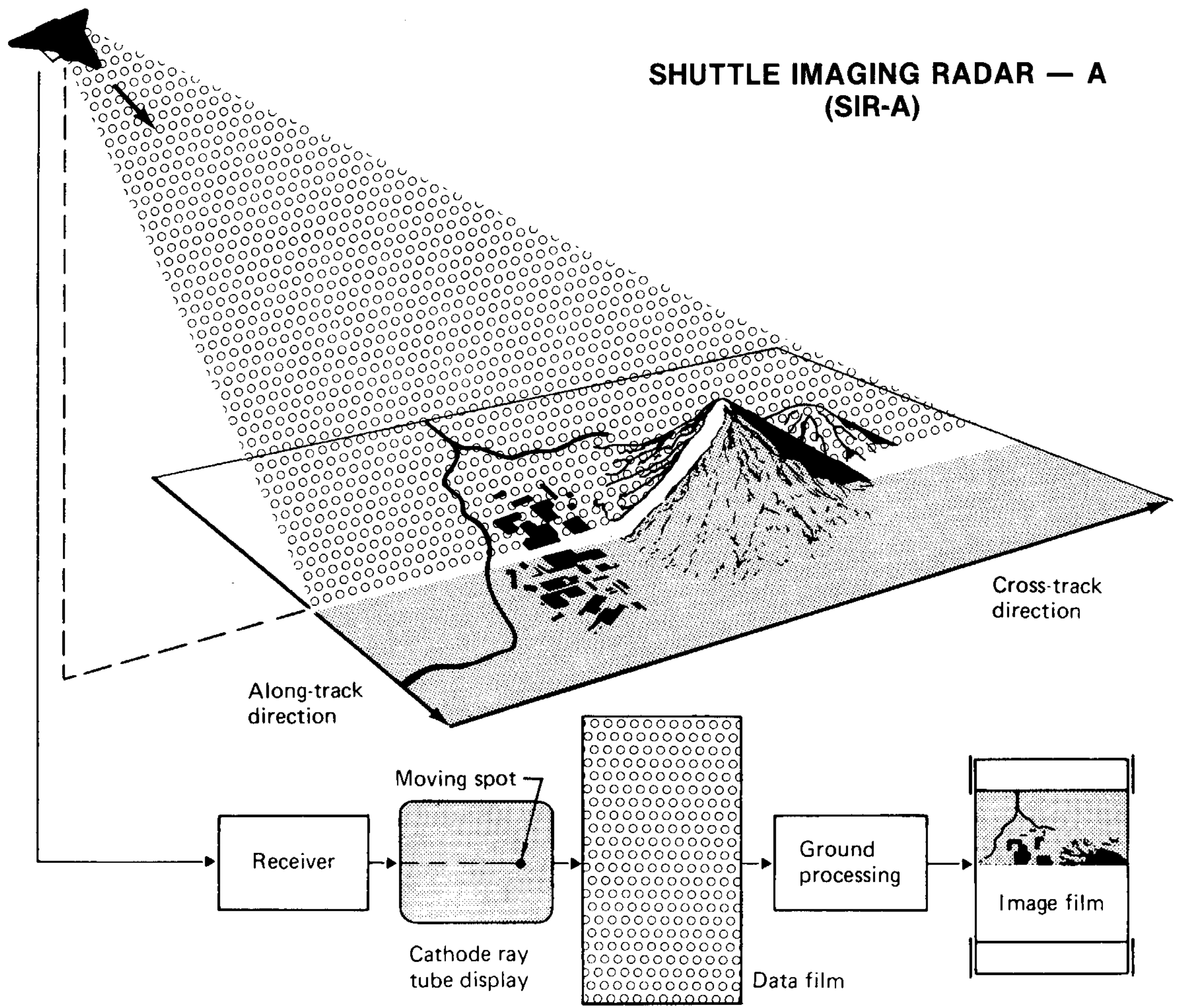
A two-dimensional image can be made from three properties of the reflected signal. The first property is the time delay, the time a signal takes to make the round trip from radar to target and back. The second property is the Doppler shift, the signal's apparent change in frequency (pitch) as the radar and target pass each other. These two properties locate a spot on a geometric grid. The third property, the strength of the returned signal, determines the brightness of the spot.

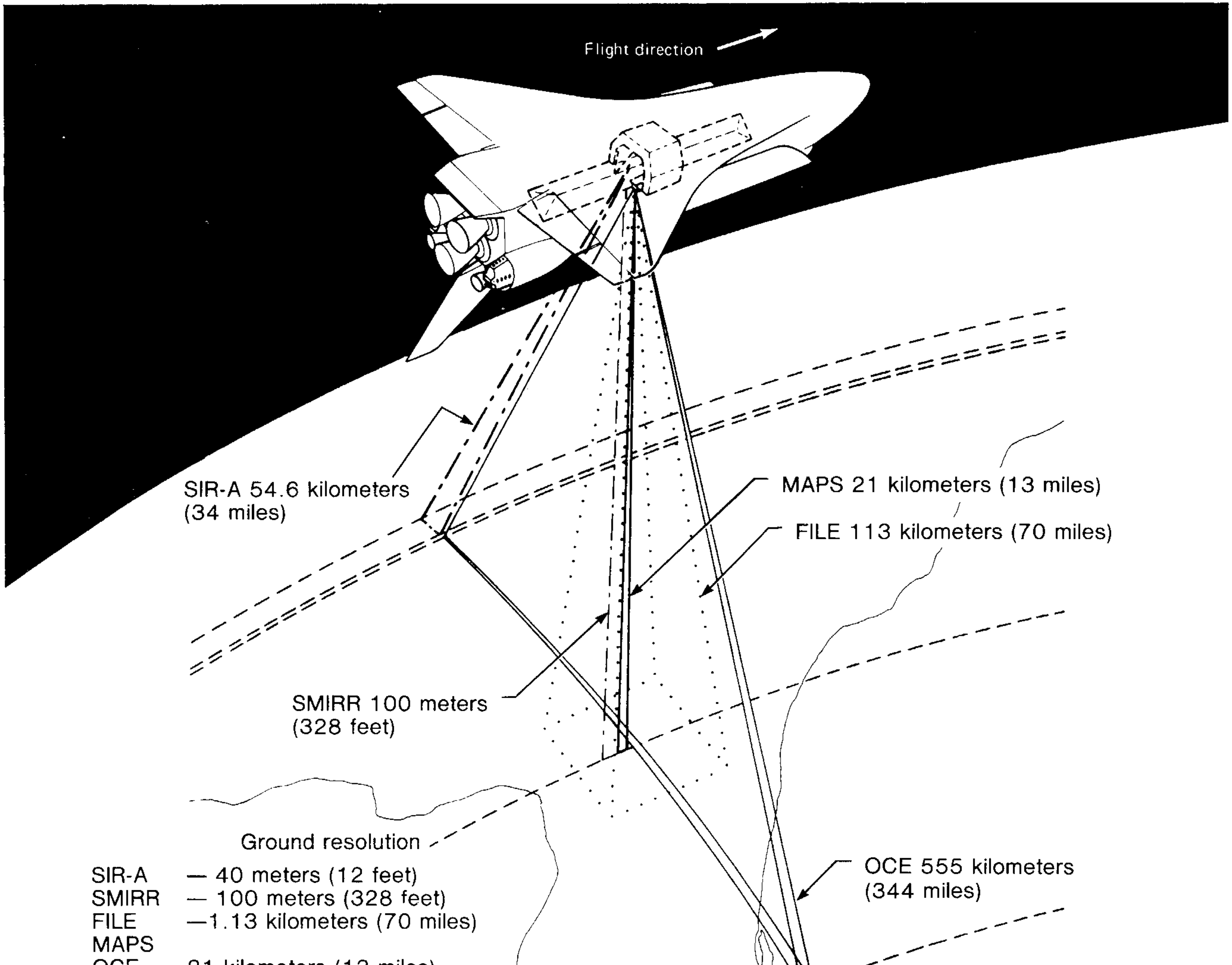
A circular-scan image, such as one showing area precipitation on the television weather report, is poorly defined because it is made by a small rotating antenna. The resolution of an image depends on antenna size: large antenna, high resolution, small antenna, low resolution. But is is possible to make a relatively short antenna "synthesize", or behave like, a very long antenna by mounting it on a moving vehicle and adding successive pulses.

Since a radar antenna collects radio waves as a camera lens collects light waves, such a system is called a "synthetic aperture radar."

An ordinary altimeter, which aims its microwave beam perpendicular to the Earth's surface, cannot distinguish between the right and left sides of a symmetrical object passing directly beneath it. But the beam of a side looking radar hits the ground at an angle and the resulting image has perspective. Furthermore, given this angle of illumination, vertical objects show up in a shadowed relief. Thus, the SIR-A is a side looking, synthetic aperture radar that creates two-dimensional images of the Earth's surface.

SHUTTLE IMAGING RADAR — A (SIR-A)





GROUND COVERAGE AND RESOLUTION FOR THE FIVE OSTA-1 EXPERIMENTS

The SIR-A electronics are coupled to coldplates and mounted on the pallet. The electronics module is 1.5 meters (4.9 feet) long, 1 meter (3.2 feet) wide, and 25 centimeters (9.8 inches) deep. It weighs 136 kilograms (304 pounds). The electronics module consists of a transmitter, receiver, calibrator, and control computer. The transmitter generates a frequency-modulated radio frequency (RF) pulse. The pulse repetition frequency can be changed to accommodate a varying range and thus prevent the instrument from transmitting while signals are being received. The receiver contains a variable gain amplifier to control the instrument's sensitivity in the return signal and a video amplifier to maintain a relatively constant amplitude in the signal output to the optical recorder. The calibrator generates a controlled-amplitude signal which is fed to the receiver and used to measure the intensity of the echo. The control computer controls all operating modes for the radar. It contains the sequencer.

The SIR-A optical recorder is a modified spare from the Apollo 17 mission. It is mounted on the pallet shelf. It is 60 by 60 by 50 centimeters (23 by 23 by 19 inches) and weighs 68 kilograms (144 pounds). Its film capacity is 8 hours, 1,097 meters (3,600 feet). The intensity of the echoes from the target surface controls the brightness of a spot tracing a line across a cathode ray tube (CRT) (TV screen). An overlapping succession of these lines is recorded on the strip of photographic film moving past the CRT. The film moves past the CRT of a rate, proportional to the speed of the orbiter. Thus the terrain echo is recorded on the data film with the cross-track dimension across the width of the film and the along-track dimension along the length of the film.

The SIR-A will take data over designated land areas. A sequencer will operate the experiment. Normally, it will follow stored program commands, but these can be overridden by real-time commands from the ground or the crew. A radar image 50 kilometers (31 miles) wide and a total of 200,000 kilometers (124,280 miles) long will be produced. Thus, the total coverage will be 10 million square kilometers or about the area of the United States. A resolution of 40 meters (131 feet) both across and along the track of the beam can be attained by this system.

The radar images gathered by SIR-A will be compared with other data, particularly Landsat images, to develop geologic information for locating hydrocarbons and mineral deposits. The different types of data will be compared in either registered or side-by-side fashion. Radar imagery records differences in surface roughness and terrain attitude and thus can be used to delineate such geological features as faults, anticlines, folds and domes, drainage patterns, and stratification. Landsat multi-spectral imagery can provide the supplementary information necessary to identify rock types and types of vegetation.

Canals built by the Mayans and hidden beneath a dense rain forest for more than 1,000 years have been revealed by a radar system developed for NASA by the Jet Propulsion Laboratory. A future version of the system will penetrate the dense cloud cover of Venus and provide maplike images of that planet's hidden surface.

The SIR-A experiment will be conducted by Principal Investigator Charles Elachi of the Jet Propulsion Laboratory (JPL) and the following Co-Investigators:

Walter E. Brown,
JPL

Louis Dellwig,
University of Kansas

Anthony W. England,
JSC

Max Guy,
Centre National Etudes Spatiales
(France)

Harold MacDonald,
University of Arkansas

R. Stephen Saunders,
JPL

Gerald Schaber,
U.S. Geological Survey at Flagstaff

SHUTTLE MULTISPECTRAL INFRARED RADIOMETER (SMIRR)

SMIRR may be seen as complementary to the SIR-A experiment in that both are concerned with geologic mapping of mineral indicators from orbit. The microwave data provided by SIR-A can be used to delineate geological structures such as faults. The improved data supplied by SMIRR can be used to identify rock type asscciated with mineral deposits from space. But SMIRR is not an imaging system as is SIR-A and Landsat. Its purpose is to find the best spectral bands in which to gather remotely sensed data to distinguish rock types. Ground gathered data indicates that the infrared range is better for distinguishing rock types than is the visible range detected by Landsat (designed as a multipurpose instrument). A global map of mineral deposit indicators could be made from data gathered by orbiting spacecraft. Electromagnetic radiation in the visible and infrared portion of the spectrum is preferentially absorbed and reflected by rocks of differing mineral content. Thus, after determining the spectral signatures of the basic rock types and noting the variance of these spectral signatures from one climate to another, technologists could build an imaging system to gather from orbit the data needed to map these geological units on world-wide basis. The bands determined by SMIRR could then be included in future spaceborne imaging systems for mapping rock types.

The Shuttle Multispectral Infrared Radiometer (SMIRR) of the OSTA-1 package will evaluate 10 bands in the 0.5- to 2.5- μm range to determine their effectiveness in discriminating geological units when the data are gathered from orbit.

The SMIRR data will be correlated with the field spectrometer data to determine whether the data gathered on the ground over a small area are sufficient to specify bands for future orbiting multispectral scanners designed for geological mapping. The experiment will assess the variability in reflectance signature of similar geological units in different climatic environments. The SMIRR experiment will also assess the effect of variable atmospheric absorption on the quality of the data.

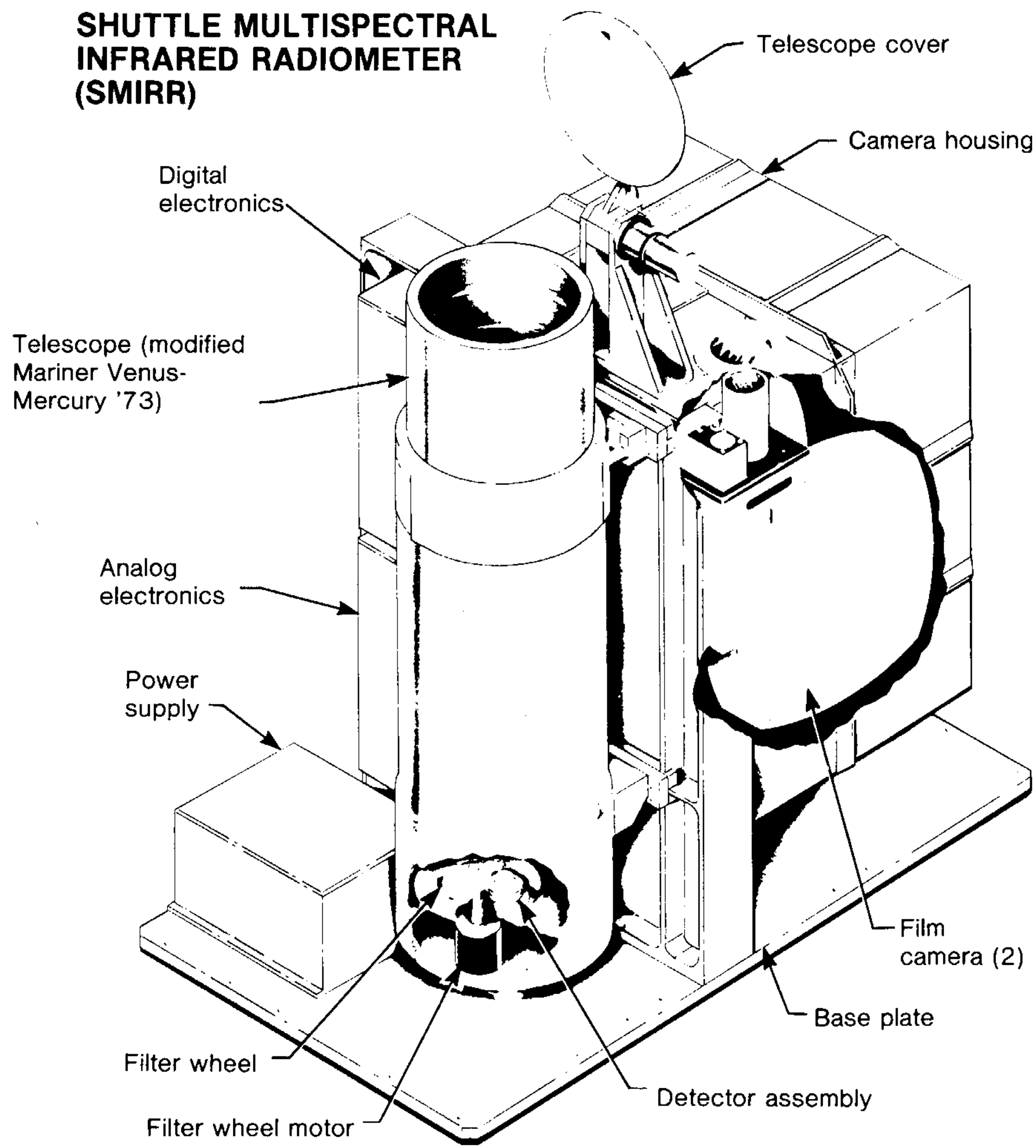
The SMIRR system consists of a telescope, a filter wheel, two detectors, two film cameras, and supporting electronics. This equipment has been carefully shielded from extraneous radiation and packaged as a unit on the pallet. The unit weighs 99 kilograms (218 pounds) and measures 56 by 94 by 117 centimeters (22 by 37 by 46 inches). It is mounted on the pallet so that the telescope view is obstructed by neither the SIR-A antenna nor the experiment shelf.

The telescope is a modified version of the Mariner telescope that gathered images of Venus and Mercury in 1973. Calibration lamps are mounted inside the telescope barrel. An opaque cover rotates over the top of the telescope to protect the optics when the experiment is not in operation.

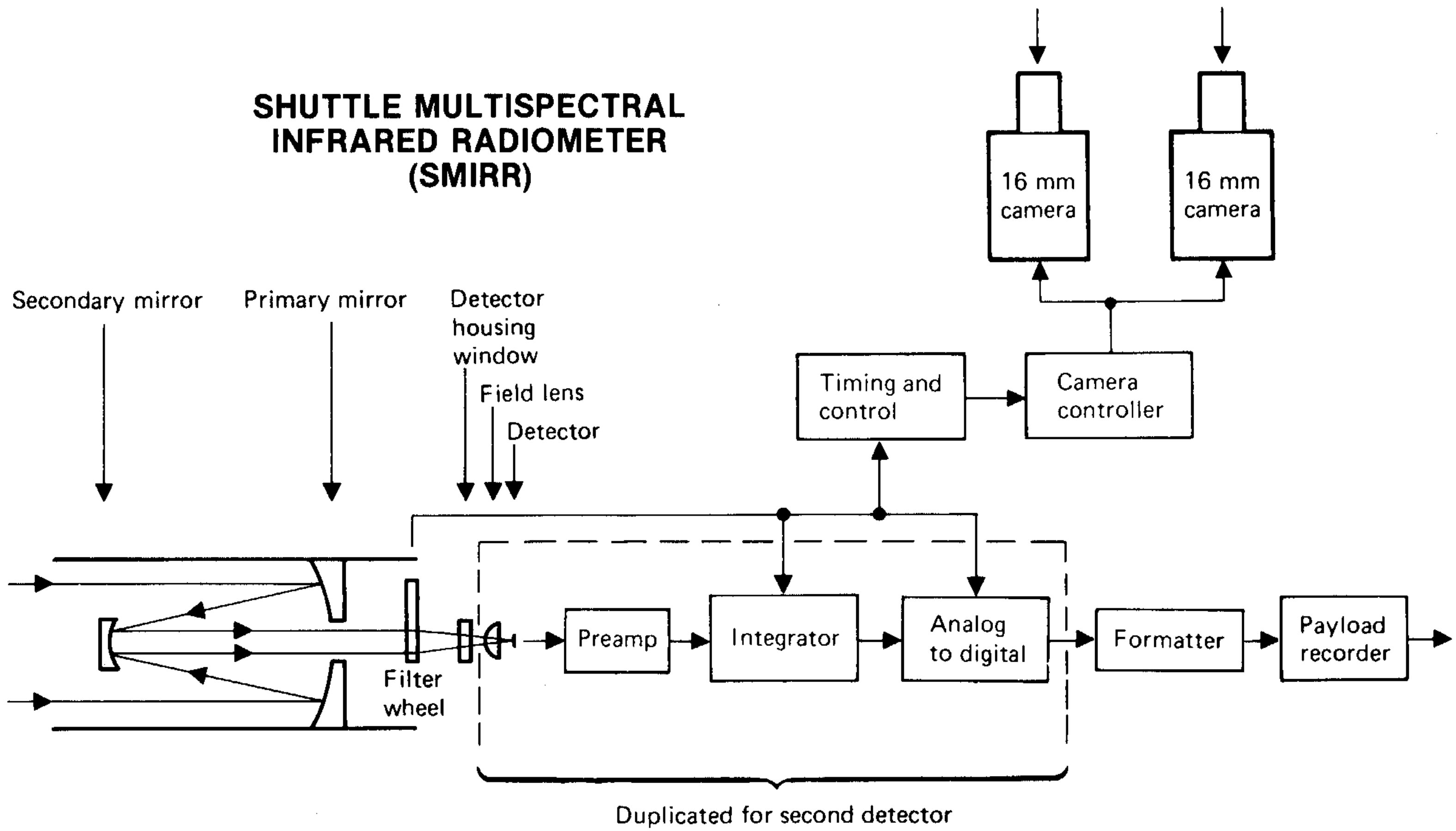
As soon as the orbiter is put into its Earth-viewing orientation, the pallet power and active thermal control system will be turned on. The SMIRR instrument can then be turned on, calibrated, uncovered, operated, placed in standby mode, covered again, and turned off. These operations will be controlled by stored commands or by real-time commands from the crew or the ground.

The SMIRR will collect data during daytime passes over land masses. Cloud coverage should be less than 30 percent, SMIRR will not be operated for 10 minutes after water dumps or fuel cell purges because the optics are sensitive to moisture and contamination. A data-taking cycle can last from 2 to 20 minutes, with a total of 6 hours allowed. The data are generated at 36 kilobits per second. These data are recorded on the

SHUTTLE MULTISPECTRAL INFRARED RADIOMETER (SMIRR)



SHUTTLE MULTISPECTRAL INFRARED RADIOMETER (SMIRR)



12

four tracks of the payload recorder at 5 centimeters per second (6 inches per second). After the flight, the data on the payload recorder will be transferred to computer compatible tape.

The filter wheel contains 15 evenly spaced positions. Every third position is opaque to provide a zero base for the detector electronics. The remaining ten positions contain filters to sample the spectral bands of interest. Optical pickoffs are mounted at the edge of the wheel to provide synchronization of the filter wheel and the detector electronics. The wheel spins at 100 revolutions per second.

Two mercury-cadmium-telluride detectors convert photons to electrons, which comprise the transmission signal. The detector assembly is mounted on a special thermoelectric cooler to maintain a temperature of −81°C.

Two 16-mm cameras are aligned with the telescope to within plus or minus 1 milliradian. Since SMIRR is not an imaging device, photographs are necessary to locate the 100 meter (328 feet) diameter radiometer reading within the cameras' ground view 20 by 25 kilometers (12 by 15 miles). One camera will take black and white pictures; the other color. Both cameras will be triggered during each 1.28-sec cycle, half a cycle or 0.64 sec apart.

The detector electronics assembly amplifies the detector signal, integrates the signal over the time an individual filter is in the optical path, and converts the signal from analog to digital form for recording on the payload recorder. The timing and control electronics coordinate the filter wheel, the detector readout, and the cameras.

The 0.5- to 1.1- μm data gathered by Landsats 1, 2, and 3 really do not enable analysis to identify rock types on the basis of their reflectances. Over the past several years, scientists from the Jet Propulsion Laboratory and the U. S. Geological Survey have been gathering spectral data from ground surfaces with a field spectrometer to determine the best bands for distinguishing classes of rock. These studies indicate that the 1.0- to 2.5- μm range is of great importance.

The SMIRR experiment has been planned by Principal Investigator Alexander F. H. Goetz of the Jet Propulsion Laboratory and Co-Investigator Lawrence C. Rowan of the U. S. Geological Survey at Reston, Virginia.

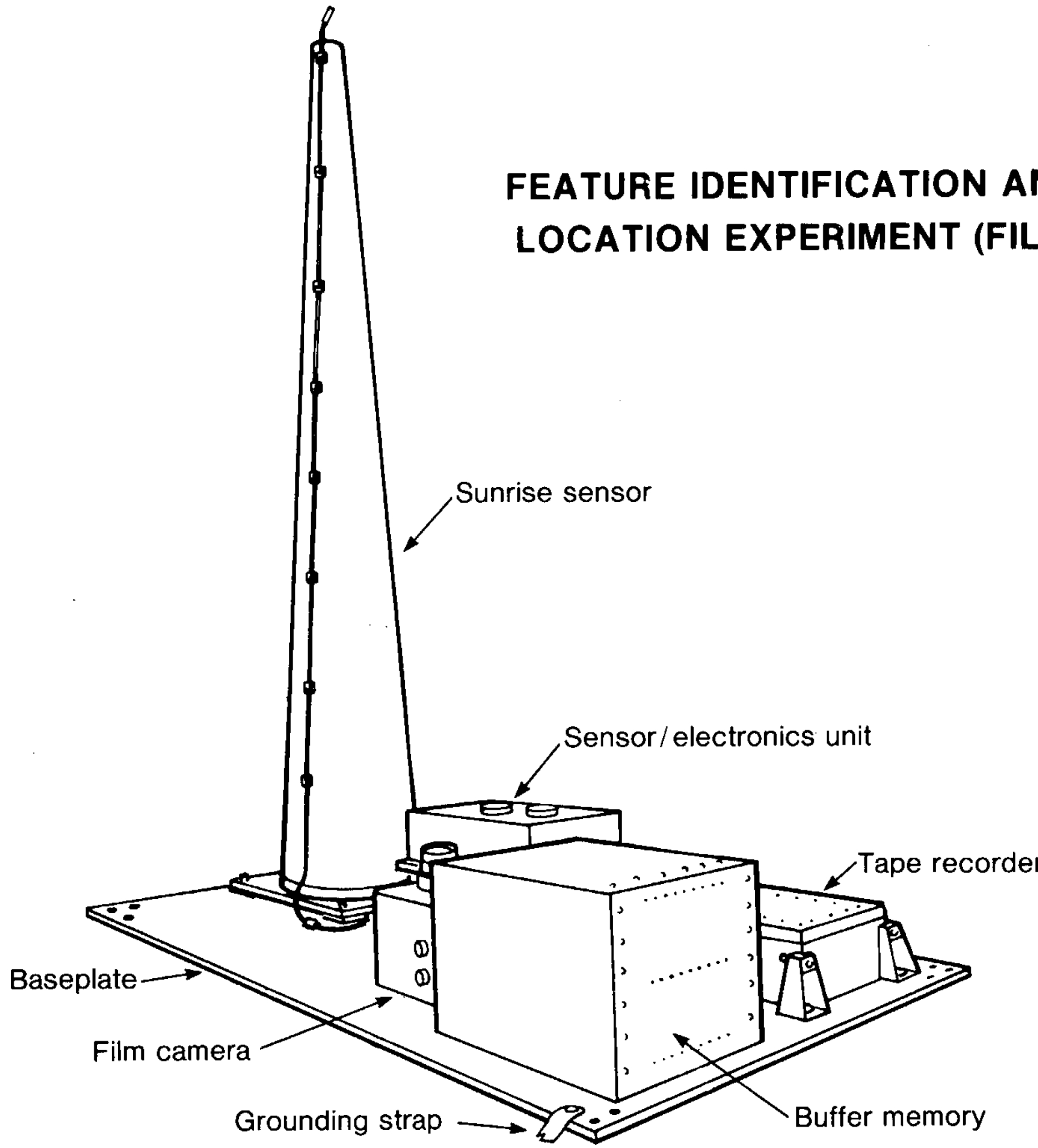
FEATURE IDENTIFICATION AND LOCATION EXPERIMENT (FILE)

FILE is intended to help such direct sensors as SIR-A and SMIRR find the scenes from which data are to be taken. The enormous quantities of data collected by the three Landsats that have orbited the earth and the even more mammoth quantities expected from advanced systems demand onboard intelligence to select the data that can be efficiently turned into information. FILE is such a data management technique. Using the ratio between visual and red reflectance and near infra-red reflectance, it will attempt to select specified quantities of data to categorize scenes as vegetation, bare ground, water, or snow and clouds. It will suppress further data acquisition in a certain category after it has acquired a given number of scenes.

The long term goal, extending over several Shuttle flights, is to develop landmark tracking technology that will meet the needs of future Earth resources and global monitoring missions. These future needs include the automatic acquisition of specific landmarks or generic surface features such as coniferous or deciduous forests, the location of those surface features without precise knowledge of spacecraft position, and the suppression of data acquisition when the scientific objectives are not in view or when cloud cover is excessive.

FILE will measure the spectral reflectance of scenes at red and near-infrared wavelengths and determine the ratio of these measurements. The ratio of target reflectance at 0.65 μm (visual red) to that at 0.85 μm (near infrared) is characteristic

FEATURE IDENTIFICATION AND LOCATION EXPERIMENT (FILE)



for each of the categories being studied and is relatively insensitive to viewing angle, Sun angle, and atmospheric effects. Vegetation generally has a ratio between 0 and 1; bare ground, snow, and clouds generally have ratios between 1 and 2; and water generally has a ratio greater than 2. Clouds and snow can be distinguished from bare ground on the basis of absolute brightness; their reflectance is about twice that of bare ground.

After the orbiter attains its Earth-viewing orientation, a command from the crew or the ground will provide power to the experiment. Under control of the sunrise sensor, FILE will operate during the sunlit intervals of the Earth-observing period. Then it will be turned off, again by a command from the crew or the ground. The experiment will be autonomous while it is in operation.

FILE system consists of a sunrise sensor, two television cameras, a decision making electronics unit, a buffer memory, a tape recorder, and a 70-mm camera. This equipment is mounted on the pallet.

The sunrise sensor will activate the experiment when the Sun is 60° from the Space Shuttle's zenith (30° above the horizon).

One of the two TV cameras is equipped with an optical filter for visual red; the other, with a filter for near infrared.

The output of these cameras is sent to the decision making electronics unit, where the ratio of the TV camera measurements for each picture element (pixel) is determined. FILE will contain scene class counters to determine when the instrument has recorded an adequate number of scenes of each type and suppress further data acquisition from such scenes.

The buffer memory accepts the high-speed output of the decision making electronics unit and sends it to the tape recorder at the lower speed it can accept.

The digitized video signal and the classification data will be recorded on a Lockheed Mark V tape recorder.

The Hasselblad 70-mm camera will take a color photograph for each frame of TV data.

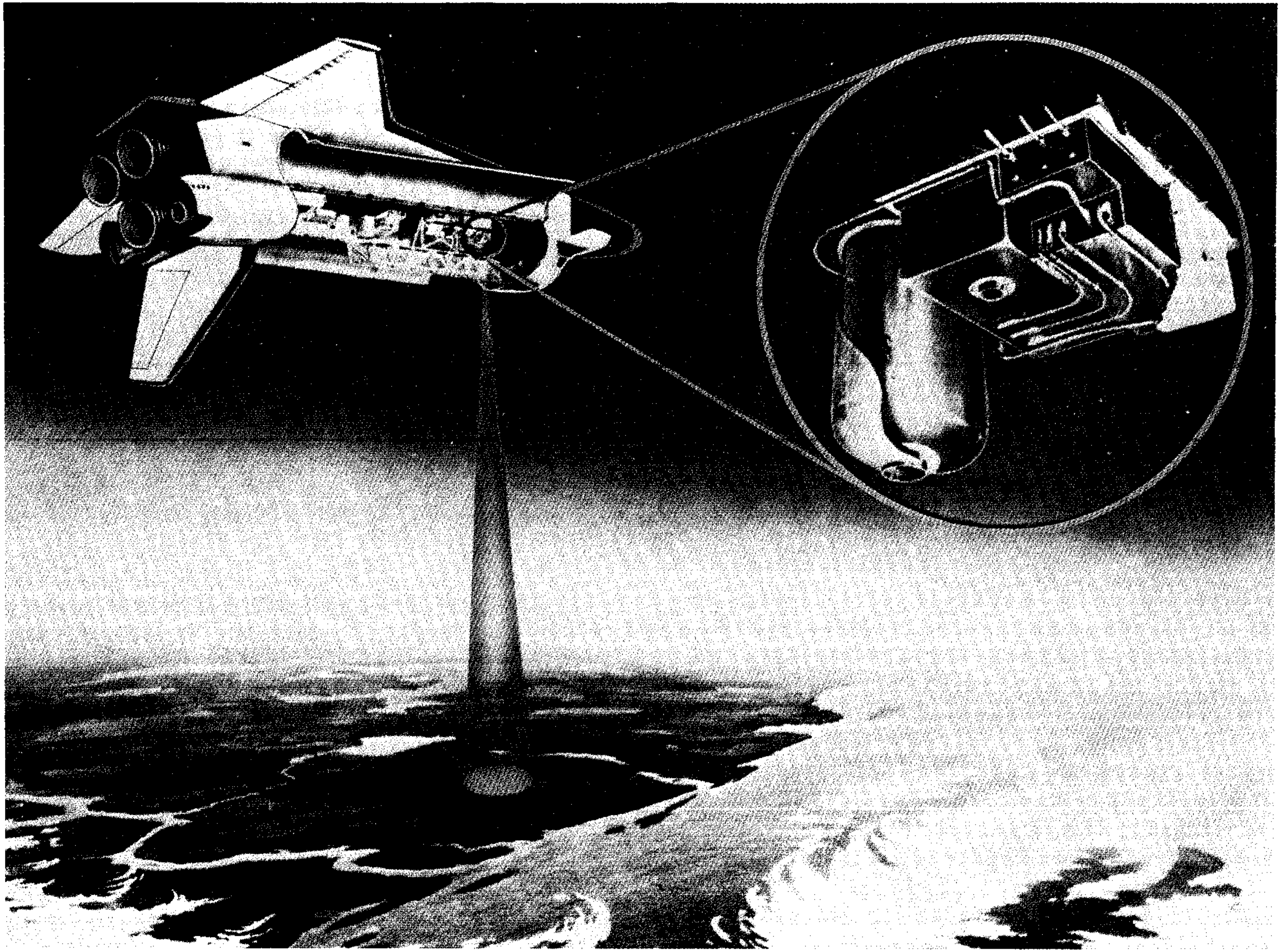
Landsats 1, 2, and 3 have gathered hundreds of thousands of data images in their orbits around the Earth. If, for example, a group of experimenters wanted to estimate the acreage of wheat in various countries, they would have to order the data covering regions where wheat is thought to grow, sift the data for images with few clouds, and develop techniques to distinguish wheat cultivation from other land uses. How much more efficient it would be to develop sensor capable of some data selection.

After the flight, analysts will examine four-color images of the TV data. Each pixel in each image will be colored according to its inflight classification as representing water, vegetation, bare ground, or snow and clouds. These images will be compared with the color photographs taken during the mission and with related images collected by other spacecraft, such as Landsat and Skylab. These comparisons should allow the evaluation of the preselected parameters-center frequency and bandwidth for each of the two spectral bands, the brightness threshold used to distinguish bare ground from snow or clouds, various camera settings, and film type.

Principal Investigator, Roger T. Schappell of Martin Marietta Aerospace in Denver and Co-Investigators John C. Tietz, also of Martin Marietta, and W. Eugene Silvertson and R. Gale Wilson, both of NASA's Langley Research Center, will conduct the FILE.

MEASUREMENT OF AIR POLLUTION FROM SATELLITES (MAPS)

Industrial wastes, such as carbon monoxide, are polluting the Earth's atmosphere. What happens to such wastes in the air? Are they sufficiently diluted? What patterns of transport exist? A gas-measuring instrument carried on an orbiting spacecraft might provide answers to such questions.



Measurement of Air Pollution
From Satellites (MAPS)

MAPS will measure the distribution of carbon monoxide in the middle and upper troposphere. The troposphere extends from the Earth's surface to the stratosphere that is to an altitude of 12 to 18 kilometers (7 to 11 miles). The performance of the MAPS instrument under various temperatures and other orbital conditions will indicate the efficiency of using orbiting spacecraft to measure environment quality.

When the orbiter has attained its Earth-viewing position, pallet power will be supplied and the MAPS instrument turned on. After a 30-minute warmup, the instrument is balanced and its gain is checked before it begins to take data. Data-taking continues throughout the Earth-observing period, with balance and gain check recurring at 12-hour intervals or upon request sent from the Principal Investigator. The three instrument outputs (two difference signals and one radiometer signal) are digitized, formatted, and stored on the experiment's tape recorder. The aerial camera mounted alongside the MAPS electro-optical head will provide information on cloud cover and the terrain over which the data are gathered.

The MAPS equipment consists of an electro-optical head, an electronics module, a digital tape recorder, and an aerial camera mounted on the pallet. The 80 kilogram (176 pound) MAPS package is 90 centimeters (35 inches) long, 76 centimeters (29 inches) wide, and 58 centimeters (22 inches) high. The equipment is coupled to a cold plate and mounted on the experiment pallet shelf.

The electro-optical head contains two gas cells, one at 266 torr CO, the other at 76 torr CO; their corresponding detectors; a direct radiation detector; an external balance and gain check system; and an internal balance system.

The electronics module consists of the signal processors, the balance system controls, and the circuits needed to operate the system.

The Lockheed Mark V digital tape recorder records data at 50 bits per second.

The aerial camera, equipped with a light sensor, will photograph the ground track during sunlit portions of the orbit.

The core of the MAPS instrument is a gas filter correlation radiometer. Thermal radiation passes up through the atmosphere into the viewport of the down-looking instrument. The carbon monoxide in the air produces unique absorption lines in the transmitted energy. A beam of the incident radiation passes through the high pressure CO gas cell and onto a detector. This high pressure CO gas cell acts as a filter for the effects of CO present at low altitudes. A second beam falls directly onto a detector without passing through any gas filter. The difference in the voltage of the signals from these two detectors can be used to determine the amount of carbon monoxide present in the atmosphere at an altitude of 7 to 8 kilometers (4.3 miles to 4.9 miles). A third beam of the incident radiation passes through the low pressure CO gas cell and onto a detector. The low pressure CO gas cell filters out the effects of CO present at high altitudes. The difference in voltage from this and the direct detector provides a measure of CO concentration at an altitude of 10 to 12 kilometers (6 to 7 miles).

The instrument is internally balanced so as to be relatively insensitive to changes in background temperature. Two blackbodies, one at the hot end of the expected temperature range, the other at the cold end, are introduced one at a time into the optical path with no gas between them and the instrument. The gain of each gas cell detector is adjusted so that each blackbody registers the same voltage, thus providing a baseline for signal measurement.

A similar system located externally serves to check both the balance set by the internal system and the instrument's gain stability. A pointer mirror rotates from a hot blackbody, to a cold blackbody, to a normalizing source, and finally to the viewport.

The MAPS experiment will be conducted by Principal Investigator Henry G. Reichie, Jr., of NASA's Langley Research Center (LaRC) and the following members of the science team.

William L. Chameides,
Georgia Institute of Technology

W. Donald Hesketh,
NASA/LaRC

Claus B. Ludwig,
Photon Research, Inc.
(LaJolla, Calif.)

Reginald E. Newell,
Massachusetts Institute of Technology

Leonard K, Peters,
University of Kentucky

Wolfgang Seiler,
Max Planck Institute for Chemistry at Mainz

John W. Winnerton,
Naval Research Laboratory

H. Andrew Wallio,
NASA/LaRC

OCEAN COLOR EXPERIMENT (OCE)

Ocean fishing has been practiced as an art since ancient times. Now a scientific aid to finding schools of fish is being developed. Algae are the basic link in the marine food chain. Where they are concentrated, we can expect higher forms of sealife to be concentrated also. The dominant pigment in these algae is chlorophyll α. The green color reflected by chlorophyll α can be detected by an ocean color sensor. By mapping the combination of chlorophyll concentration with temperature, we can determine the approximate locations of fish schools. In addition, mapping the distribution of algae can alert us to upsets in the marine ecosystem caused by pollutants.

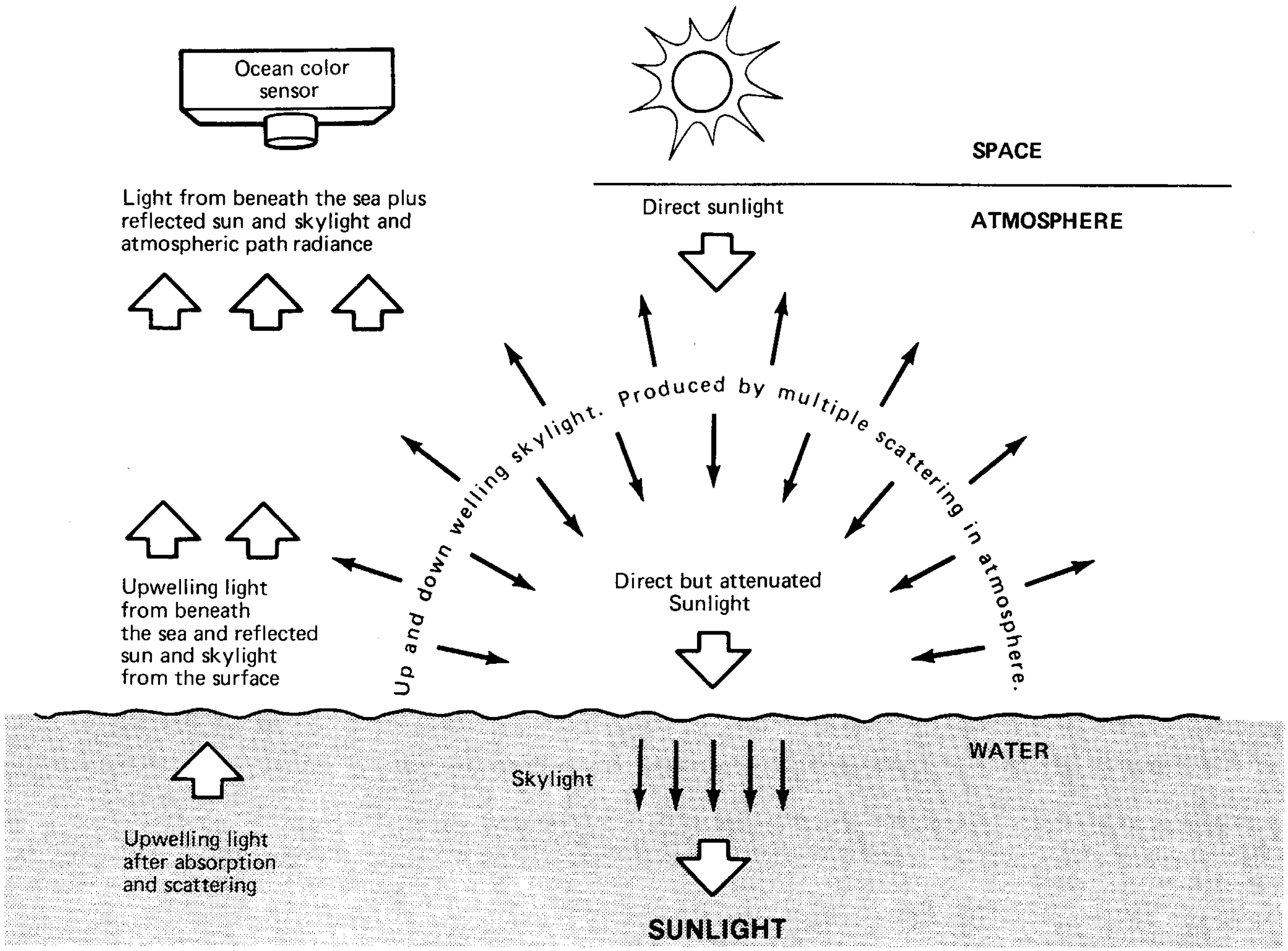
OCE will scan water-upwelling zones seeking areas where a high concentration of chlorophyll-bearing algae shifts the pure blue of ocean water to greenish. Using this information to map the distribution of algae can help locate fish schools or ecological upsets caused by pollutants. Considerable experimental effort will be spent eliminating the effects of surface reflections and atmospheric scatterings that obscure the information sought.

There are difficulties in obtaining ocean color information. Several NASA-built ocean color sensors have been flown by aircraft at both low and high altitudes. Most of these flights have been over coastal waters. In these areas, significant data were often obscured by high sediment concentrations and reflections from the sea floor. One satellite-borne experiment, the Coastal Zone Color Scanner, is currently attacking this problem in an attempt to interpret coastal phenomena on the basis of ocean color information.

The OCE will avoid the special problems presented by coastal waters and concentrate on deepwater areas on the eastern side of both the Atlantic and the Pacific Ocean. Here, in nutrient-rich, water-upwelling zones, there is low sediment suspension and negligible seafloor reflectance. But the problem of obscuring radiation remains. Only 10 to 20 percent of the radiation received by the instrument will be useful information emanating from the body of water. The rest will be light scattered by air molecules and aerosols and reflected directly off the ocean surface. Thus, much of the effort involved in this experiment will be the scientific analysis of the effects of atmospheric aerosols, sea state, and Sun angle.

OCE will take data during sunlit passes over two main test areas—the friction area between the Canary Island current and equatorial countercurrent and the upwelling area off the coast of Peru. The experiment will also take data along the eastern coast of the United States—off Cape Cod and Georgia. Surface truth will be gathered by ships and low-flying aircraft over portions of these four areas.

OCEAN COLOR EXPERIMENT (OCE)



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Shortly before a data-taking pass, the instrument will be switched from standby mode into a warmup. After the 5-min. warmup period, the payload recorder will be activated and will begin to record data at 307.2 kilobits per second. At 96 centimeters per second (38 inches per second), the tape record time is about 2 hours. Thus, about 25 2- to 13-minute ocean flyovers can be recorded. After each data-taking pass, the payload recorder and the OCE sensor will be returned to standby mode, in which the doors are closed and the temperature regulated by thermostatically controlled scanner heaters.

The OCE instrument is a modified version of the U-2-borne Ocean Color Scanner. It consists of two main modules—the scanner and the electronics. The scanner is mounted on the pallet shelf, and the electronics are coupled to a cold plate on the pallet deck.

The 34 kilogram (74 pound) scanner module is a cylinder 75 centimeters (29 inches) long flattened on one side 27 centimeters by 23 centimeters (10 by 9 inches) mounted on the pallet. The instrument components are mounted on an aluminum plate which is divided into four sections by bulkheads. The second section contains the scanner mirror and is equipped with bomb-bay type doors which protect the instrument during ascent and descent. The third section contains the telescope. The first section houses the motors for the scanner mirror and doors and the devices for timing pickup. The fourth section houses the optics and an electronics box.

The electronics module weighs 60 kilograms (132 pounds) and measures 29 by 71 by 91 centimeters (11 by 27 by 35 inches). It consists of the signal amplifiers, a digitizer, and the data handling system.

The rotating mirror on the OCE instrument scans plus or minus 45 degrees from nadir across the direction of flight and reflects radiation into a Dall-Kirkham telescope. The telescope images the scene through a 1- by 2-mm field stop and onto a diffraction grating. The diffracted light (that is, light separated into its component colors) is directed onto a bundle of 24 glass fibers, and a different spectral band is channeled through each glass fiber.

The fibers are coupled to eight silicon photodiode detectors.

The signal from the 700- to 800-nanometer channel contains almost none of the information sought by this experiment (subsurface scattering) because the water itself absorbs radiance in this spectral range. This signal is caused mostly by light reflected from the surface and scattered off air molecules. Thus, this signal can be used to calculate the contribution of these noise factors to the radiance received by the other spectral channels. The useful information is contained in the difference between the total radiation registered in each of the other channels and the radiation registered in the 700- to 800-nm channel. The signal from each of the other channels will be examined to determine what color bands were scattered by the ocean contents. Chlorophyll α absorbs flue light and reflects green. Thus, a high concentration of chlorophyll-bearing phytoplankton will shift the pure blueness of ocean water to a greenish color.

OCE will be conducted by Principal Investigator Hongsuk H. Kim of NASA's Goddard Space Flight Center (GSFC) and the following Co-Investigators:

Lamdin R. Blaine,
NASA/GSFC

Robert S. Fraser,
NASA/GSFC

Norden E. Huang,
NASA/Wallops Flight Center

Heinz van der Piepen,
DFVLR (West German Research and
Development Institute for Air and Spacecraft)

The following two experiments are located in the orbiter pressurized crew module.

NIGHT/DAY OPTICAL SURVEY OF LIGHTNING (NOSL)

NOSL will involve the orbiter flight crew in taking the first motion pictures and correlated photocell sensor signals of lightning and thunderstorm as seen from orbit.

The area of the Earth's surface in the view of the orbiting spacecraft is so large that lightning storms will probably be visible on almost every orbit. Because of the high speed of the orbiter, these storms will remain in view only a short time, just a few minutes for storms directly beneath the flight path, somewhat longer for storms off to either side.

During passage over the dark side of the Earth, observers in the orbiter will readily recognize nocturnal storms by their lightning flashes, which should be visible for hundreds of kilometers (miles). On the sunlit side of the Earth, the crew will recognize storms by their prior familiarization with the appearance of cumulonimbus clouds and associated anvils as viewed from above. An observer can also locate lightning storms by listening to the audio signal from the photocell detector in monitor mode (as radiation is located using a Geiger counter). The astronauts will also be sent meteorological information to alert them to possible storm locations.

When a target is in view, a crewmember will mount the camera so that it can photograph through the overhead window of the crew cabin. The tape recorder will be mounted on the aft bulkhead. Using both visual and audio clues, the observer will focus the camera on the target. The camera will film the lightning storm while audio signals corresponding to camera shutter pulses are recorded on one track of the stereo tape recorder and the photocell output is recorded on the other track.

The crew will use a motion picture camera to film the lightning flashes of nighttime thunderstorms. A diffraction grating will be attached to the camera lens during nighttime observations to provide lightning spectrographs, which can be used to determine the temperature, pressure, molecular species, electron density, and percent ionization in the lightning's path. During the day, lightning discharges will be delineated by a photo-optical system, which creates an audio pulse in response to the detection of a lightning flash. These pulses will be recorded on magnetic tape. A lightning event, which is visible as only one flash, is usually composed of many separate discharges, called strokes, which can be detected by the photocell. Thus, the photocell will also be used during the night to record lightning strokes. And the motion picture camera will be used during the day as well to film the cloud structure and the convective circulation in the storm. These techniques may be adaptable to identifying severe weather situations from meteorological satellites.

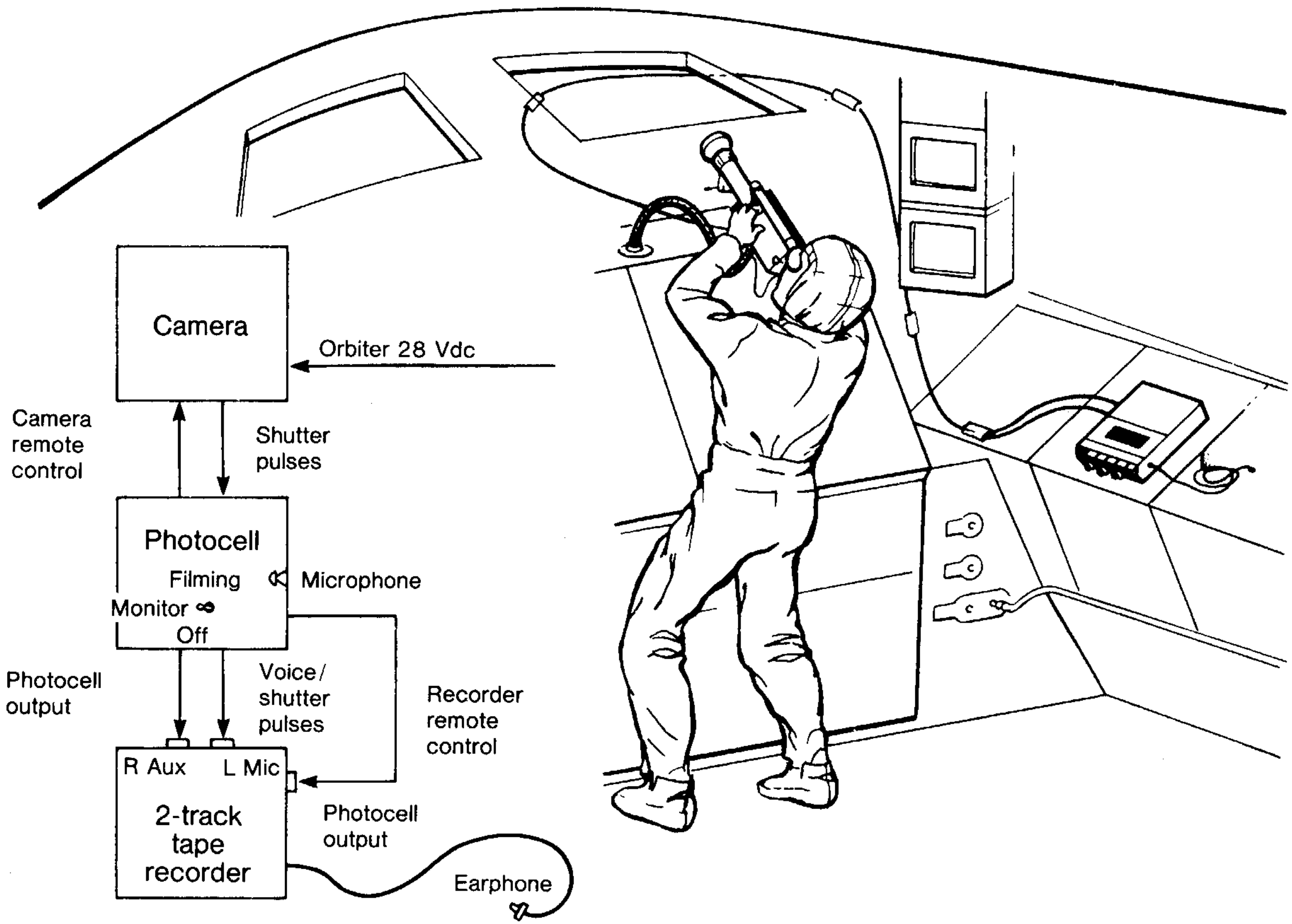
The NOSL equipment consists of the camera, the attached photocell sensor, and the connected tape recorder. During launch, boost, and reentry, this equipment will be secured in stowage lockers in the crew compartment. In orbit, the equipment will be retrieved and assembled for use in the crew cabin. Because it is both stowed and used in crew quarters, the NOSL apparatus has been designed to withstand the same pressure, temperature, humidity, and acceleration conditions that human beings can tolerate.

The motion picture camera is a 16-mm Data Acquisition Camera (DAC), a model which has been flight tested on Apollo and Skylab missions. The camera will run on 28 Vdc power supplied by the orbiter.

The photocell sensor is mounted on top of the camera, and its field of view is aligned with the camera's. The camera/sensor package is 40 centimeters (15 inches) long, 24 centimeters (9 inches) wide, and 20 centimeters (7 inches) high. The photocell/amplifier assembly contains its own battery power supply.

The stereo cassette tape recorder, 25 centimeters (9 inches) long, 18 centimeters (7 inches) wide, and 6 centimeters (2

NIGHT/DAY OPTICAL SURVEY OF LIGHTNING (NOSL)



inches) high, is a Sony TC 124, equipped with a plug-in earphone. The tape recorder interfaces with the photocell, which in turn interfaces with the camera, via connecting wires. The recorder is battery powered.

Twenty 42 meter (140 feet) film magazines, three 60-min. tape cassetts, and spare batteries will be kept in a stowage apron mounted on the crew cabin wall.

These are a few of the existing accounts of unusual lightning phenomena. It is interesting to note that the sophisticated scientific observer finds the phenomena quite as baffling as does the layman. There are few photographs of such lightning discharges, none taken from above the storm. We need photographic and quantitative data to come to understand lightning and thunderstorms. These data and resulting knowledge may lead to the development of systems providing early warning of severe storms. Experience from the Gemini, Apollo, Skylab, and Apollo-Soyuz missions indicates that an orbiting platform several hundred kilometers (miles) above the Earth affords a view of thunderstorms and lightning that cannot be equaled on the ground or from aircraft. Thus, the Night/Day Optical Survey of Lightning (NOSL) has been designed to fly on the Space Shuttle.

"I approached a vigorous, convective turret close to my altitude 20 kilometers (20 miles) that was illuminated from within by frequency lightning. The cloud had not yet formed an anvil. When I was about 10 or 20 kilometers (6 to 12 miles) away, I was surprised to see at about 5 degrees to the right of my course a bright lightning discharge, whitish-yellow in color, that came directly out of the center of the cloud at its apex and extended vertically upwards far above my altitude. The discharge was very nearly straight, like a beam of light, showing no tortuosity or branching. Its duration was greater than an ordinary lightning flash, perhaps as much as 5 seconds." Ronald Williams, U-2 pilot NASA Ames Research Center, 1973.

"There was a line of thunderstorms that I assume was associated with frontal activity. . . .I estimate that in 2 or 3 seconds the lightning would propagate out to cover the whole line, which was probably at least 200 or 300 kilometers (124 to 186 miles) long. If you assume that it started near the middle, it went 100 to 150 kilometers (62 to 93 miles) in a couple of seconds. . . ." Paul Weitz, Skylab I, 1973.

The tornado "was accompanied by heavy rain and intense lightning of the most unusual nature. It was brightly colored in pink, red, yellow, and some green. At times, a flash would emit red balls of fire that arched down like fireworks displays. Sometimes 10 or 15 balls would be visible. The lightning was bright enough to shut off light-operated street lights almost continuously." Kenneth Noel, of nocturnal tornadoes in Huntsville, Ala., April 3, 1974.

"I saw this tremendous flash of green light. Now, this was like a green finger of light, a green column. It was surrounded by a real pale apple green coloration, and then that had around it somewhat of a lightish blue tinge and then from that a very, very light blue, almost like a halo." Otha H. Vaughan, Jr., of the same tornadoes. April 3 1974.

The NOSL has been planned by Principal Investigator Bernard Vonnegut of the State University of New York at Albany and by Co-Investigators Otha H. Vaughan, Jr., of NASA's Marshall Space Flight Center and Marx Brook of the New Mexico Institute of Mining and Technology.

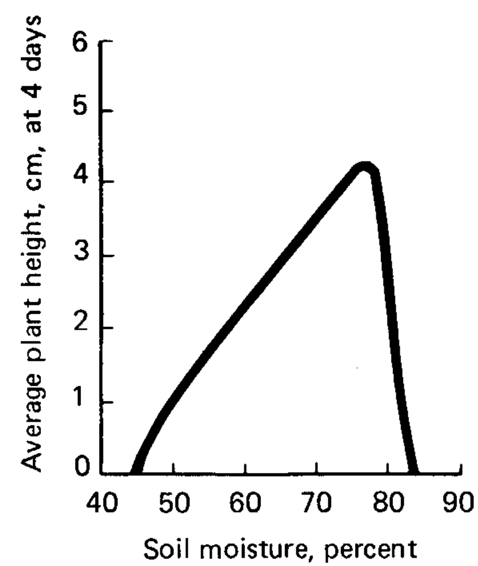
HEFLEX BIOENGINEERING TEST (HBT)

HBT is a preliminary step leading to a plant physiology experiment scheduled for Spacelab 1. The HBT hardware consists of a container of planted pots with varying soil moisture levels. The HBT experiment is to determine the relationship between initial soil moisture content and final plant height after growth in a microgravity environment. The results will help determine the optimal soil moisture contents for the Spacelab experiment.

The Heflex Bioengineering Test (HBT), unlike the other components of the OSTA-1 payload, is not a full-blown experiment. Rather it is a preliminary test that supports an experiment called Heflex (for Helianthus annuus Flight Experiment), part of the planned Spacelab 1 mission. Heflex depends on plants grown to a particular height range. The relationship between final dwarf sunflower height and initial soil moisture content at 1 g is shown in the figure. This relationship may be affected by the near weightlessness in an orbiting spacecraft. The purpose of the Heflex Bioengineering Test is to determine any such effect in order to adjust accordingly the amount of water used for Heflex.

Shortly before launch, a suitcase-like container will be loaded with 72 sealed plant modules varying in soil moisture content from 58 percent by weight (below which plant growth is minimal) to 80 percent by weight (above which anaerobic conditions inhibit growth). The aluminum container is 50 centimeters (19 inches) high, 43 centimeters (16 inches) wide, and 24 centimeters (9 inches) thick: it weighs 21 kilograms (46 pounds) when fully loaded. It contains a battery-powered temperature recorder. This plant carry-on container will be stowed in a locker in the crew compartment of the orbiter middeck soon after the modules are planted and loaded and as near launch time as feasible. This test will require no crew attention. As soon as possible after the flight, the unopened container will be returned to the Principle Investigator for evaluation. Principal Investigator Allan H. Brown, of the University of Pennsylvania, and his colleagues will conduct the Heflex Bioengineering Test.

Relationship between dwarf sunflower growth and soil moisture content at 1 g



ORBITER EXPERIMENTS

ORBITER EXPERIMENTS (OEX) SUPPORT SYSTEMS

The support system for the orbiter experiment (SSO) was developed to record the data obtained by orbiter experiments and to provide time correlation for the recorded data. The information obtained through the sensors of the OEX instruments must be recorded during the orbiter mission because there will be no real time or delayed downlink of OEX data. In addition, the analog data produced by certain instruments must be digitized for recording.

The support system for the OEX consists of five packages: the OEX recorder, the interface control module (ICM), and the pulse code modulation (PCM) master, PCM slave, and data hand handling electronics (DHE) package. The ICM is the primary interface between the OEX recorder and the experiment instruments and between the recorder and the orbiter subsystems. The ICM transmits operating commands from the orbiter MDM to the instruments and after such commands are transmitted, will control the operation of the recorder to correspond to the instrument operation. Time signals will be received by the ICM from the orbiter timing buffer, converted to a frequency-modulated signal, and transmitted to the recorder to provide the time information needed. The recorder will carry 9200 feet of magnetic tape that will permit up to two hours of recording time at the rate of 15 inches per second. After the return of the orbiter, the data tape will be played back for recording on a ground system, the tape will not usually be removed from the orbiter.

AERODYNAMIC COEFFICIENT IDENTIFICATION PACKAGE (ACIP)

The implementation of the ACIP will benefit the Space Shuttle because the more precise data obtainable through the ACIP will enable earlier attainment of the full operational capability of the Space Shuttle. Currently installed instrumentation provides data that is sufficiently precise for spacecraft operations but not for research. The result is that constraint removal would either be based on less substantive data, or would require a long-term program of gathering the less accurate data.

Although all of the generic types of data required for aerodynamic parameter identification are available from the baseline spacecraft systems, the data is not suitable for experimentation due to such factors as sample rate deficiencies, sensor ranges too large for bit resolutions or computer cycle time/core size interactions. In addition, the baseline data compromises operational measurements and not subject to the desired changes required for experiments. The ACIP places a sensor package on the spacecraft to obtain experiment measurements that are not available through the baseline system.

The ACIP is a sensor package installed below the payload bay area in the aft area of the mid-fuselage of the orbiter at station Xo1069. It contains a rate gyro package, a linear accelerometer package, an angular accelerometer package, and associated electronics.

The ACIP is to collect aerodynamic data in the hypersonic, supersonic, and transonic flight regimes, regions in which there has been little opportunity for gathering and accumulating practical data: to establish an extensive aerodynamic data base for verification of and correlation with ground-based test data including assessments of the uncertainties in such data; and to provide flight dynamics state, variable data in support of other technology areas, such as aerothermal and structural dynamics.

The ACIP incorporates three triaxial of instruments: one of the dual-range linear accelerometers, one of angular accelerometers, and one of rate gyros. Also included are the power conditioner for the gyros, the power control system and the housekeeping components for the instruments. The ACIP is aligned to the orbiter axes to a very high order of accuracy. Mounted on the ACIP base is a triaxial vibrometer which will provide the structural vibration characteristics of the orbiter affecting the ACIP experiment necessary for baseline filtration of accelerometer data. The output signals of the instruments are recorded on the OEX tape recorder. The ACIP operates through the launch and through the entry and descent phases orbiter flight. The internal instruments continuously sense the dynamic X, Y, and Z phases. In addition, the ACIP receives the indications of position of the control surfaces and converts these indications into higher orders of precision before recording them with the attitude data.

Power is supplied from the mid-power control assembly 3 main bus C. Heaters are employed on the package and controlled by a switch on panel R11.

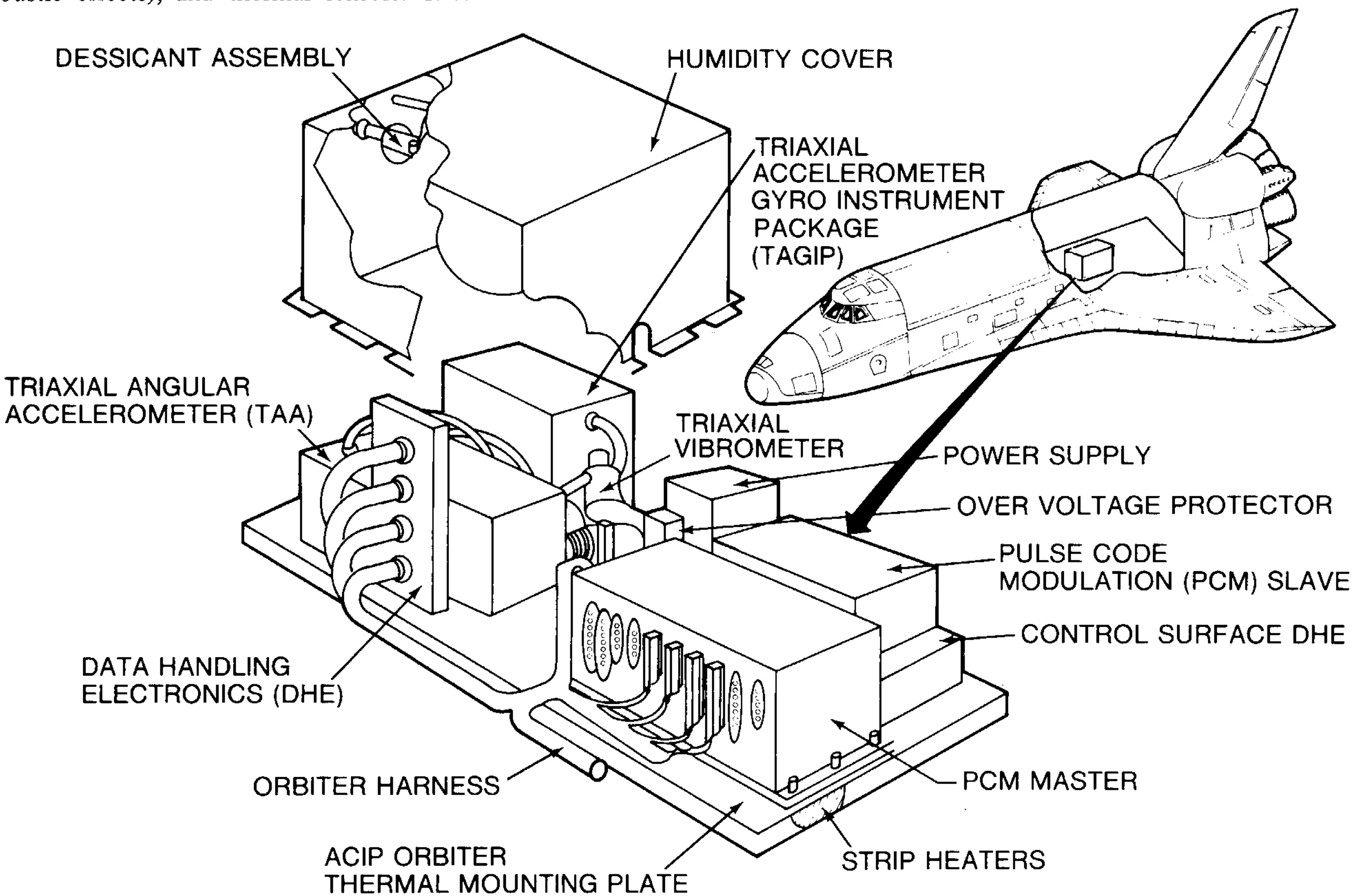
Weight of the ACIP is 119 kilograms (262 pounds).

DYNAMICS, ACOUSTIC, AND THERMAL ENVIRONMENT (DATE)

The DATE experiment is to acquire environmental response and input data for prediction of environments for future payloads. The environments are neither constant nor consistent throughout the payload bay and are influenced by interactions between cargo elements.

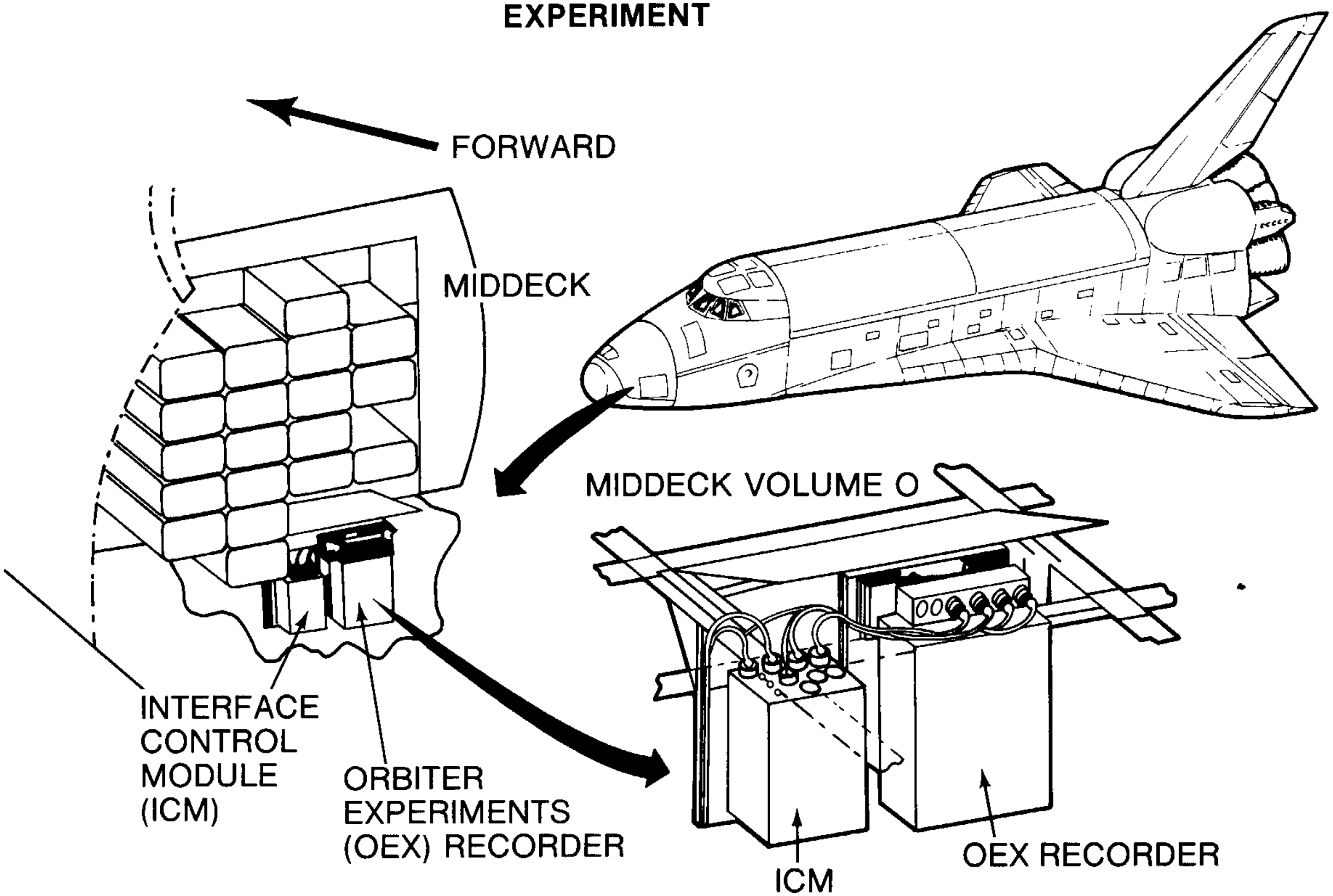
The DATE experiment consists of accelerometers and force gauges (for dynamic influences), microphones (for vibra-acoustic effects), and thermal sensors. These devices will be installed on both payload components and carrying structure (pallet, shelf, etc.).

DATE has no commands or telemetry interfaces. This data is recorded on the OEX recorder whenever the recorder is on.

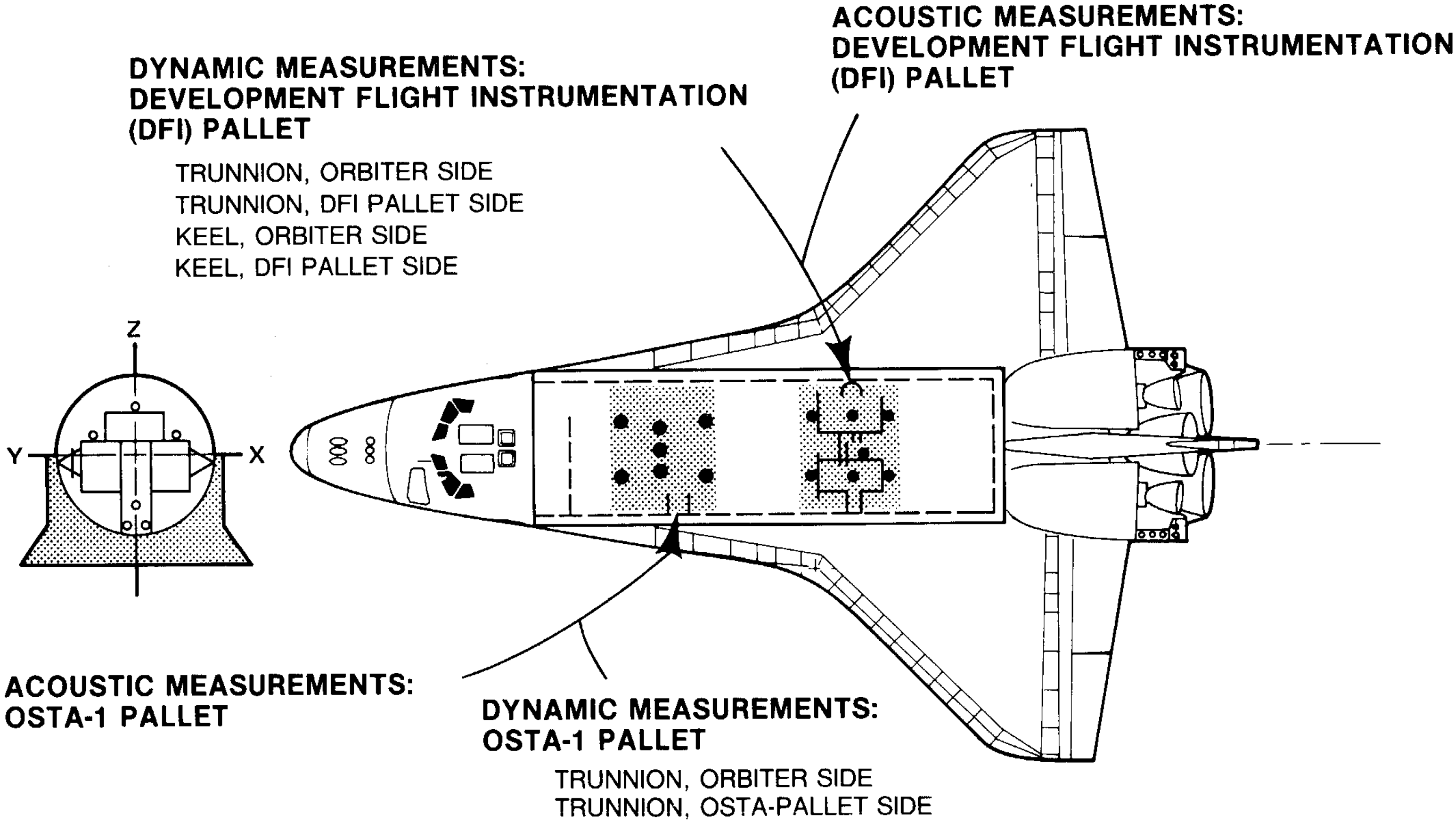


AERODYNAMIC COEFFICIENT IDENTIFICATON PACKAGE (ACIP) EXPERIMENT

AERODYNAMIC COEFFICIENT IDENTIFICATION PACKAGE (ACIP) EXPERIMENT



AERODYNAMIC COEFFICIENT IDENTIFICATON PACKAGE (ACIP) EXPERIMENT



DYNAMICS, ACOUSTIC, AND THERMAL EXPERIMENT ENVIRONMENT (DATE)

INDUCED ENVIRONMENT CONTAMINATION MONITOR (IECM)

Measurements of the Space Shuttle environment are needed to verify that contamination associated with the Space Shuttle will not preclude or seriously interfere with the gathering of data during preparation for or during orbital flight. Definition of the Space Shuttle contamination environment will help define solutions to contaminant problems that may possibly arise during the Space Shuttle operational phase.

Measurements of the contamination environment will be made using the integrated set of instruments which is designated the IECM.

The IECM will measure and record concentration levels of gases and particulate contamination emitted by the Space Shuttle during all phases of the mission.

The IECM is self-contained aluminum unit and contains ten instruments and supporting systems mounted on the Development Flight Instrument Unit (DFI). The IECM weighs 360 kilograms (793.9 pounds). The instruments are: humidity monitor, dew point hygrometers, air sampler, cascade impactor, passive sample array, optical effects module (OEM), temperature controlled quartz crystal microbalance (TCQCM), cryogenic quartz crystal microbalance (CQCM), camera/photometer mass spectrometer and gas.

The IECM has an internal battery for launch/deorbit and utilizes orbiter 28vdc power on-orbit. The IECM is passively cooled via structural baffles and warmed by 28 vdc electrical heaters. The IECM self-contained tape recorder is automatically controlled by the data acquisition control system.

Humidity monitor is in operation during prelaunch through launch, entry and landing. An oscillator varies the frequency as a function of the amount of water present.

Dew point hygrometer is in operation during prelaunch through launch, entry and landing. A mirror is cooled until condensation begins and a thermister on a mirror provides the data.

Air samplers consists of five bottles. Two are open for one minute at launch. One opens for a short period after solid rocket booster staging. The remaining two are opened for a period during entry.

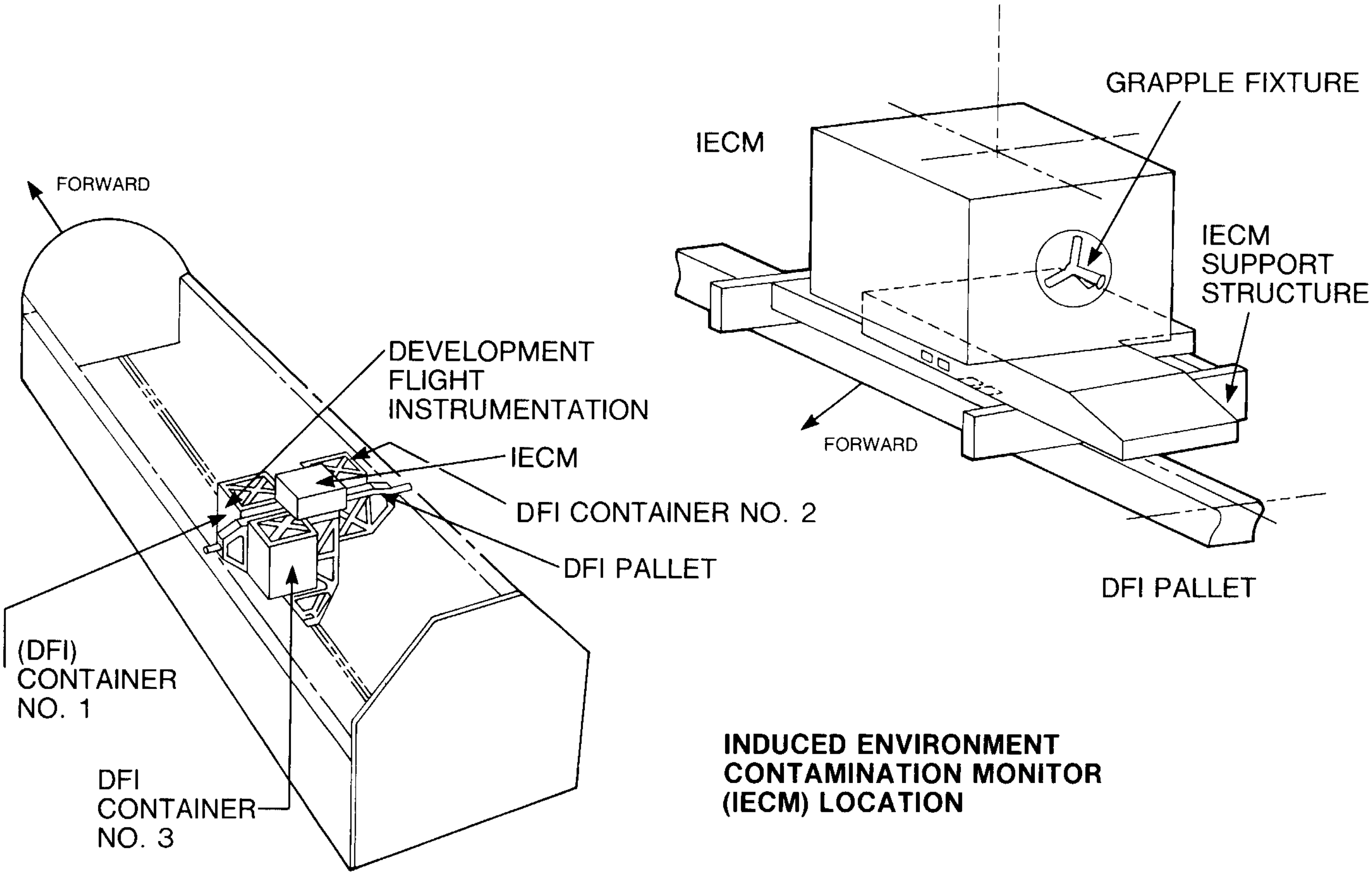
Cascade impactor operates premission and throughout the mission. A quartz, crystal microbalance system measures the concentration and particle size distribution of contaminants. The data rate varies by mission phase such as, one per minute during orbit.

Passive sample array consists of 48 optical samples which are exposed to the Space Shuttle environment throughout the mission.

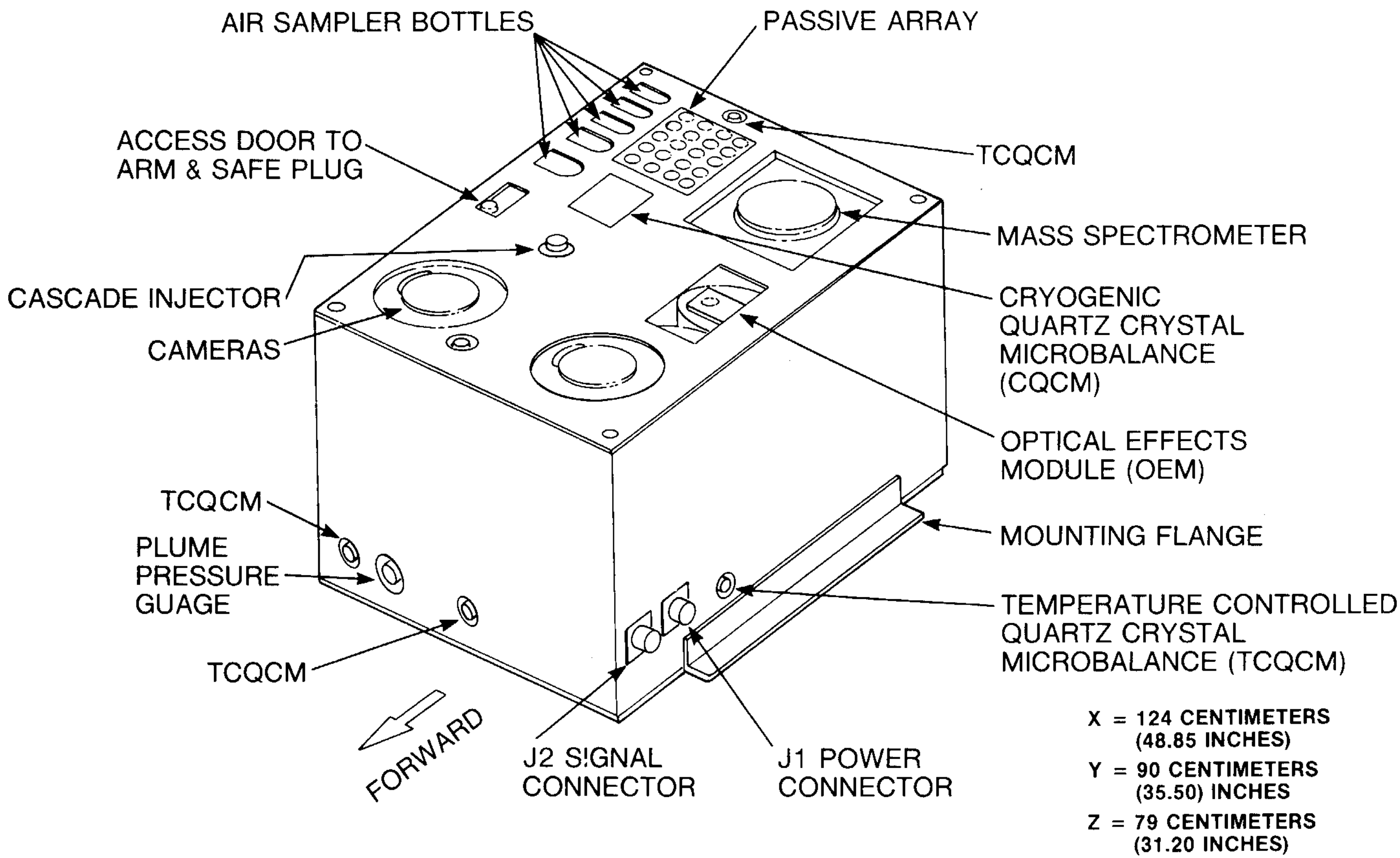
Optical effects module (OEM) measures light transmission and scattering sequentially on six optical samples mounted on a carousel exposed to the payload bay. Data is taken on each sample approximately every nine and one-half minutes.

Temperature controlled quartz crystal microbalance (TCQCM) measures the amount of molecular contamination deposited on a crystal sensor periodically at various temperatures. There are five sensors, one on each of the exposed sides of the IECM. Between each data take, sensor temperature is raised to clean off deposited material. It takes 10 hours to run through a complete sequence on-orbit.

Cryogenic quartz crystal microbalance (CQCM) measures the amount of molecular contamination deposited on the crystal sensor, plus Z only. The CQCM is similar to the TCQCM, but uses passive radiative detector cooling.



INDUCED ENVIRONMENT CONTAMINATION MONITOR (IECM) LOCATION



INDUCED ENVIRONMENT CONTAMINATION MONITOR (IECM)

Camera/photometer makes optical measurements of induced particulate environment and background brightness. It uses two 16 millimeter Bolex movie cameras, 24 frames per hour.

Mass spectrometer and gas identify the off gassing and out gassing modecules in the payload bay and define the gas cloud through which optical experiments must look. It is activated/deactivated by the flight crew via the IECM switch on the flight deck display and control panel, RII. It analyzes a series of mass groups of data taken every scan then idles for five minutes between scans. It is calibrated by gas release exercise.

The IECM operations prelaunch uplink ascent mode multiplexer/demultiplexer (MDM) resets commands and configures the IECM for ascent mode processing. The T-O disconnect initiates mode processing and at T-O plus 150 seconds, completes ascent mode processing.

On orbit the IECM uplink orbit mode MDM reset command initiates orbit mode processing. One to two hours after payload bay door opening on orbit 1 or 2, the IECM switch on panel R11 is moved to position 1, and the mass spectrometer is on low bit rate. At a convenient time the IECM switch on panel R11 is moved to position 2, and starts gas release and the mass spectrometer is on high bit rate. After 45 minutes, the IECM switch panel R11 is positioned to 1, and the mass spectrometer is on low bit rate. Fifteen to 45 minutes prior to final payload bay door closure, the IECM switch on panel R11 is positioned to 2, and the mass spectrometer is off. The uplink deorbit mode MDM reset command configures the IECM for the deorbit mode.

The Thermal Protection System (TPS) experiment is subdivided into two different groups, the tile gap heating (TGH) effects and the catalytic surface effects (CSE).

TILE GAP HEATING (TGH) EFFECTS

The TGH effects experiment will evaluate the effects of tile gap and edge radii geometry on the spacecraft TPS convective heating. The panel will initiate the first phase of studying tile edge radii effects on gap heating during entry. Gap and edge radii geometry will be evaluated with different panels on each subsequent flight for a maximum of six flights.

The TGH experiment consists of a removable carrier panel with eleven TPS tiles of baseline material (HRSI) located on the under side of the spacecraft fuselage. Temperature measurements through the tiles and in the gaps will provide temperature data during entry. This experiment will provide flighe data on the effects of gap and edge radii variances on entry heating.

TGH effects experiment will be conducted by principle investigator technologist William Pitts and Frank Centalonzi of NASA Ames Research Center.

CATALYTIC SURFACE EFFECTS (CSE)

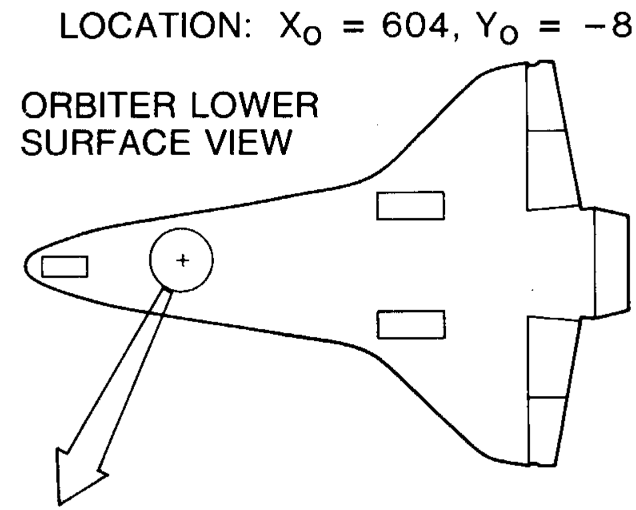
The CSE experiment will verify predictions of the effects of surface catalytic efficiency on convective heating rates. Indications from analyses and ground test are that the design criteria for the spacecraft TPS may be overly conservative because surface catalytic efficiency was not included. To obtain flight data for comparison, the CSE was proposed.

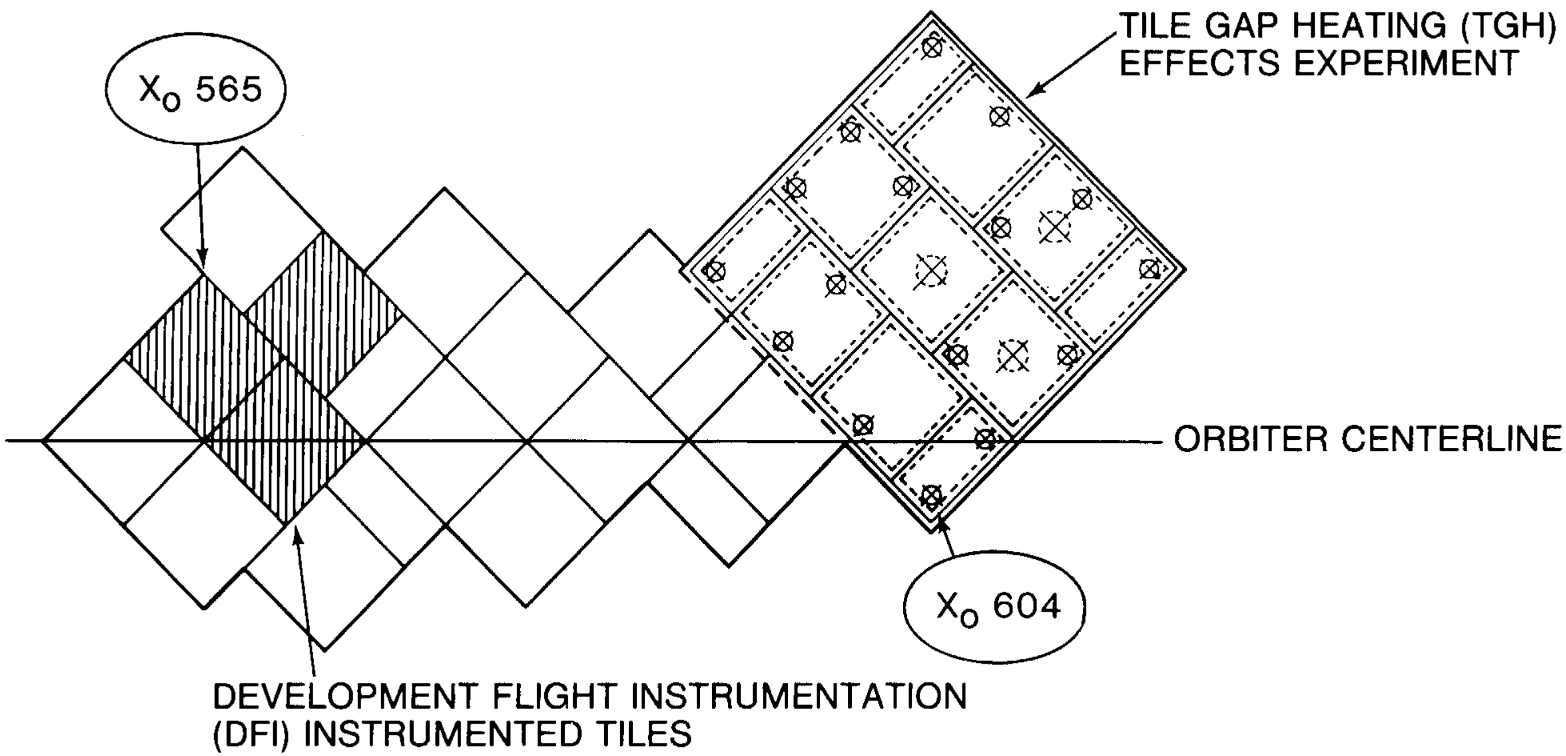
The CSE will use ten baseline tiles, having Development Flight Instrumentation (DFI) thermocouples, located along the lower mid fuselage of the spacecraft. Two of there tiles will be sprayed with an overcoat consisting of iron-cobalt-chromia spinel (a highly efficient catalytic material) in a polyvinyl acetate binder. The overcoat is compatible with the existing baseline tile coating. During ascent the polyvinyl acetate will burn out of the overcoat leaving the high emittance iron cobalt chromia spinel exposed.

During entry, beginning at 121,920,meters (400,000,feet) and continuing through landing, the thermocouple measurements will be recorded by the PCM recorder. As an aid in evaluating CSE data, comparisons will be made using DFI measurements recorded on baseline tiles adjacent to the tiles with the overcoat.

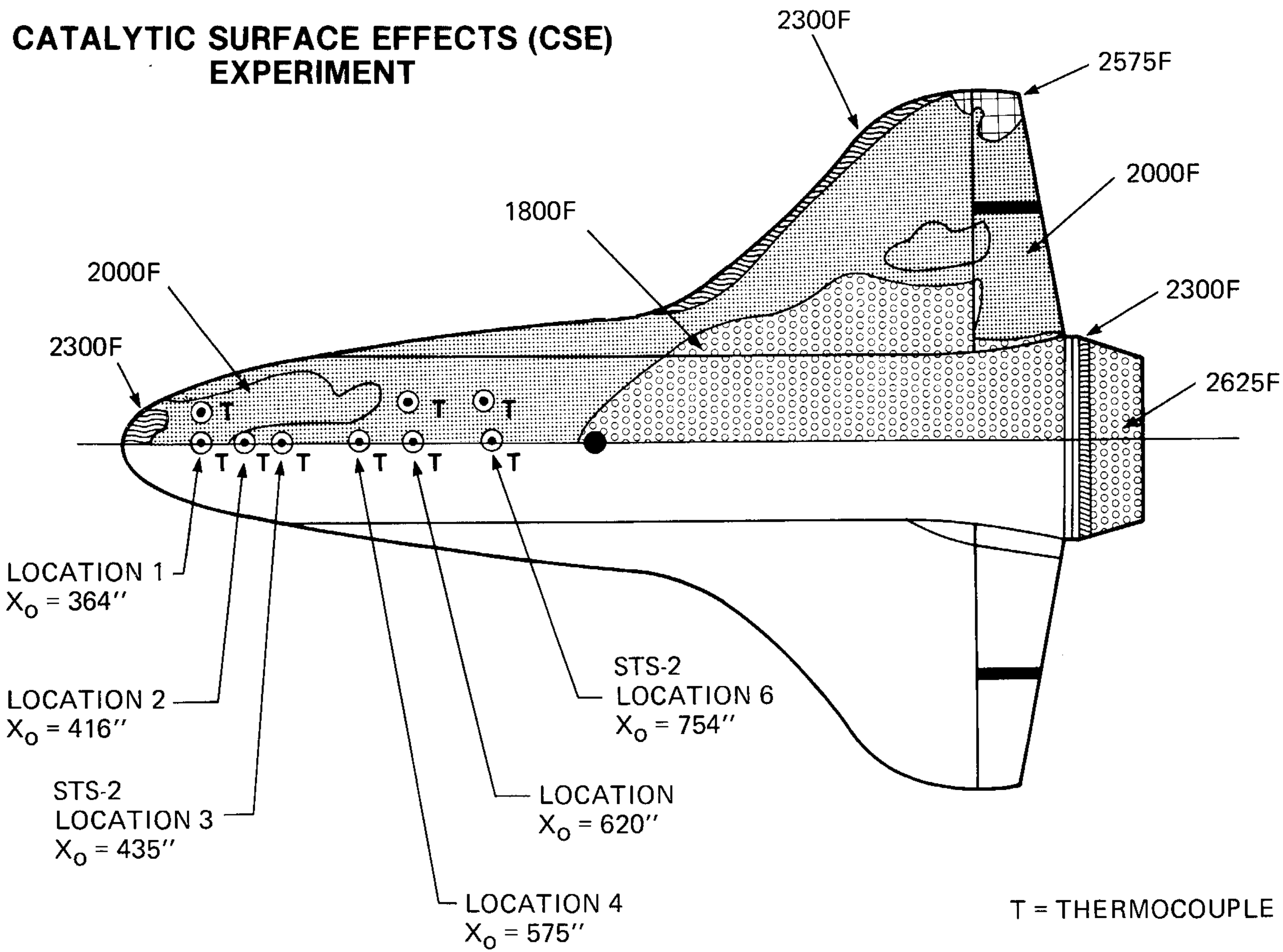
On subsequent flights, up to six tiles will be coated to provide catalytic efficiency data. CSE will be conducted by principle investigator David Stewart of NASA Ames Research Center.

TILE GAP HEATING (TGH) EFFECTS





CATALYTIC SURFACE EFFECTS (CSE) EXPERIMENT



LOWER SURFACE VIEW

The benefits derived from the TGH and CSE experiments are: a better understanding of TPS heating phenomena; a lower design surface temperature that would result in lighter TPS with greater reusability; and an optimized tile array configuration that may provide reduced TPS weight and increased reuse capabilities.

STS-1 SUMMARY

"THE SPACE SHUTTLE DID MORE THAN PROVE OUR TECHNOLOGICAL ABILITIES, IT RAISED OUR EXPECTATIONS ONCE MORE; IT STARTED US DREAMING AGAIN...", President Ronald Reagan addressing Joint Session of the United States Congress, April 28, 1981.

The success of the first Space Shuttle flight (Space Transportation System-1) was marked by superb systems performance of the Rockwell-built orbiter *Columbia*.

The 54-hour mission (April 12-14, 1981) began with a flawless and spectacular launch from Pad 39-A at NASA's Kennedy Space Center in Florida. After two days of on-orbit activities, the STS-1 crew of Commander John W. Young and Pilot Robert Crippen brought the 99-ton *Columbia* to a textbook-perfect landing on a dry lake-bed runway at Edwards Air Force Base, California, before a crowd of more than 100,000 people.

Assessment of flight test results show all major objectives were accomplished. A problem with the on-board data recorder which developed early in the flight caused loss of some data.

The STS-1 crew described *Columbia's* maiden flight as nominal and said the spacecraft performed superbly.

Astronaut Young, at the crew's post flight press conference (April 23), said, "The first Space Shuttle flight can truly be called nominal, although I think we can do away with the word nominal. You can call it phenomenal".

According to the crew the five major test areas and performance in each:

- Propulsion systems... "went super."
- Mechanical systems... "worked great."
- Man/machine interface... "was superb."
- Thermal tests checked out... "very well."
- Avionics systems test... "were just terrific."

Of the 135 test objectives, Young said, with the exception of the loss of some data (recorder malfunctions), "We got them all."

STS-1 SUMMARY

LIFT-OFF THROUGH OMS-2 MANEUVER. Lift-off of STS-1 occurred at 102:12:00:03.8 G.M.T. on April 12, 1981. The trajectory was as planned with all events up through payload bay door opening and radiator deployment occurring normally. The orbital parameters after the OMS (orbital maneuvering system)-2 firing were an apogee of 133.7 n.mi. (246 Km) and a perigee of 132.7 n.mi. (245 Km), as expected.

The main propulsion system performed normally.

The APUs (auxiliary power units) operated as expected with no apparent problems. The hydraulics systems also operated normally, although all three water boiler and vent temperatures were off-scale low. Additionally, lubrication oil temperatures were higher than expected. These conditions are thought to have been caused by freezing of boiler water.

The fuel cells, cryogenics, and electrical power distribution systems all performed satisfactorily with no anomalies. The lift-off electrical loads were about 23 kW, some 5 to 7 kW lower than predicted.

4 HOURS THROUGH 24 HOURS – APRIL 13, 1981. The OMS-3 and OMS-4 maneuvers were completed as planned, raising the orbit to a 145 n.mi. (268 Km)-apogee by a 144-n.mi. (266 Km) perigee. The propellant remaining after the maneuvers was at the predicted levels, indicating satisfactory system performance.

Orbiter temperatures remained within acceptable limits. The flight control systems checks using one auxiliary power unit went as planned.

During the first television pass at approximately 102:13:53 G.m.t., the flight crew directed the onboard TV camera at the OMS pods, showing some thermal protection system (TPS) damage on both pods.

24 HOURS THROUGH 48 HOURS – APRIL 14, 1981. An assessment of the thermal and structural loads for the area of the TPS damage on the OMS pods was completed. The overall assessment for the tile damage was the Orbiter was safe for reentry.

Three planned RCS firings were performed with the expected results.

The APU gas generator injector bed temperatures dropped to 236°F (normal range – 350°F to 410°F) at 102:23:30 G.m.t., indicating the loss of the APU 2 gas generator heater B. The heater was switched from the B to the A system and the temperatures began increasing. Approximately 4-1/2 hours later, the gas generator injector bed temperatures were again decreasing. The heater was switched to the B system, but no increase was noted and then returned to system A, again with no increase in temperature. It was determined through a real-time ground test that APU 2 would start satisfactorily at bed temperatures as low as +70° F.

During the flight control system checkout, the horizontal situation indicator (HSI) compass card did not respond properly. The indicator was off 5 degrees during the "low" test and did not drive at all during the repeated "high" test. A test procedure was performed by the crew and the indicator again failed to respond, with the card appearing stuck. Later, during the Ops 8 checkout, the crew reported normal HSI function.

The -Y star tracker experienced an anomaly at 102:16:53 G.m.t. Bright object protection was being provided by an interim backup circuit which senses light in the field of view and was latching the shutter closed. The crew opened the shutter via an override command for subsequent alignments.

The on-orbit electrical loads were about 15 to 25-1/2 kW, some 2 kW lower than predicted.

48 HOURS THROUGH LANDING – APRIL 14, 1981. Entry preparation was accomplished according to the crew activity plan and without problems. A nominal reentry was flown, and touchdown occurred at 104:18:20:56 G.m.t. Post-rollout operations were accomplished without incident, and ground cooling was connected about 16 minutes after landing. The flight crew egressed the Orbiter 1 hour and 8 minutes later. This occurred after a delay for the ground crew to clear hazardous vapors indicated in the vicinity of the Orbiter side hatch.

ENTRY LOADS AND CONSUMABLES. Structural, power, and heat rejection entry loads were generally lower than predicted as were the APU, RCS, and active thermal control subsystem (ATCS) consumables usage. Orbiter structure back-face temperatures were also lower than expected.

SOLID ROCKET BOOSTER RECOVERY. SRB recovery was accomplished after some difficulty with the nozzle plugging operations. Divers were able to plug the nozzles using backup procedures and hardware and the solid rocket motor cases, frustums. and remaining hardware have been returned to KSC for inspection and processing.

EXTERNAL TANK REENTRY. The external tank reentry and disposal process began and proceeded as planned, until the external tank rupture occurred at a higher altitude than expected. Verbal reports from the ET tracking ship indicate that the debris footprint was also larger than expected. Tracking data are being returned on an expedited basis for in-depth evaluation.

STS-1 MISSION SUMMARY

Commander: John W. Young
Pilot: Robert L. Crippen
Mission Duration – 54 hours, 21 minutes, 57 seconds
Miles Traveled – approximately 937,000 (1,733,450 Km)
Orbits of Earth – 36
Orbital Altitude – 145 nautical miles (268 Km)
Landing Touchdown – 2800 feet (850 m) beyond planned touchdown point
Landing Rollout – 8993 feet (2733 Km) from main gear touchdown

Orbiter Weight at Landing – Approximately 196,500 pounds (89,014 Kg)

Landing Speed at Main Gear Touchdown – 180 to 185 Knots (207 to 212 mph)

All of the 135 flight test objectives assigned to STS-1 were accomplished based on data available as of this date.

STS-1 TIMELINE

Day of Year	GMT * Hr-Min-Sec	Event
102	12:00:03	Liftoff
	12:00:47	Initiate throttle down of the main engines to 65%
	12.00:56	Max S (maximum dynamic pressure)
	12:01:05	Initiate throttle up of the main engines to 100%
	12:02.14	Solid Rocket Booster Separation
	12:07:36	3 "g" acceleration limit
	12:08:38	MECO (Main Engine Cutoff)
	12:09:02	External Tank Separation
	12:10:38	OMS-1 (Orbital Maneuvering System-1 Ignition)
	12:14:57	Orbiter Auxiliary Power Unit Deactivation
	12:44:06	OMS-2 Ignition
	13:43:07	Payload Bay Door Open Close/Open Tests
	18:20.50	OMS-3 Ignition
	19:05:36	OMS-4 Ignition
		RCS-1 Test (Reaction Control System)
		RCS-2 Test
103	14:48:00	Payload Bay Doors Closed, Deorbit Rehearsal RCS-3 Test
	16:47:00	Payload Bay Doors Open
104	14:29:55	Payload Bay Doors Closed
	17:17:23	Orbiter Auxiliary Power Unit No. 2 and No. 3 Activation
	17:21:35	Deorbit-OMS Ignition
	17:43:16	Orbiter Auxiliary Power Unit No. 1 Activation
	17:49:05	Entry Interface (400,000 feet)
	18:08:30	Exit Blackout
	18:14:34	Terminal Area Energy Management
	18:20:00	Landing Gear Deployment
	18:20:51	Main Landing Gear Contact
	18:21:11	Nose Landing Gear Contact
	18:21:57	Wheel Stop
	18:22:39	Orbiter Auxiliary Power Unit Deactivation
	19:28:00	Crew Egress

* GMT – Subtract 5 hrs for EDT
6 hrs for CDT
7 hrs for MDT
8 hrs for PDT