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# KidSat Final Report and Image User's Manual

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This book is dedicated to
all the students of the KidSat Pilot Program.

# Abstract

The goal of KidSat was to provide young students with the opportunity to participate directly in the NASA space program and to enhance learning in the process. The KidSat pilot project was focused on using a color digital camera, mounted on the space shuttle, to take pictures of the Earth. These could be used to enhance middle school curricula. The project not only benefited middle school students, who were essentially the Science Team, responsible for deciding where to take pictures, but it also benefited high school students and undergraduates, who were essentially the Project Team, responsible for the development and implementation of the project. KidSat flew on three missions as part of the pilot project: STS-76, STS-81, and STS-86.

This document describes the goals, project elements, results, and data for the three KidSat missions that made up the pilot program. It serves as a record for this pilot project and may be used as a reference for similar projects. It can also be a tool in using the data to its fullest extent. The KidSat Web page remains on-line at http://kidsat.jpl.nasa.gov/kidsat, and the images may be downloaded in their full resolution.

# Foreword

### *Kevin Chilton, Shuttle Commander, STS-76*

I confess that when I was approached about the possibility of flying a secondary experiment called "KidSat" on STS-76, I was more than skeptical. My crew already had a complicated mission to execute that included a rendezvous and docking with the Mir Space Station, re-supply and crew transfer operations, a space walk, and an extensive series of biological research experiments. And, from previous experience, I knew that secondary experiments often take up as much or more of the crew's pre-flight preparation schedule and on-orbit timeline as the primary mission payload. So the prospect of adding an additional experiment to our already full program of activities concerned me. But as I was introduced to the KidSat program and, more importantly, to the students who were participating in it, I found my skepticism rapidly replaced with anticipation and excitement for the success of the experiment.

Although a key element of the KidSat project was to remotely image the Earth from the shuttle, in my opinion, this was not the essence of the experiment. I think a major goal was to motivate and educate students to participate in the scientific and engineering processes required to succeed in any great technological venture. In both of these regards I can conclude that the experiment was a resounding success! The students had to learn what design and safety reviews were, and then conduct them. They had to build procedures for the flight and ground crews to execute and then personally conduct the appropriate training. They had to do fit and function checks with their hardware in the shuttle mock-ups and rehearse their experiment in pre-flight simulations. They had to put together a science team to build rationale for the targets that they would image during the flight and then make real-time adjustments to their plan during the mission. Finally they had the joy of doing post-flight analysis on the fruits of their labor: the beautiful images of the Earth that the KidSat cameras and computers sent down to them from the flight deck of Atlantis.

I can unequivocally say that the students in the KidSat program conducted their pre-flight preparation and mission execution as expertly as any seasoned professional team. This, combined with their absolutely infectious enthusiasm, made flying the KidSat experiment one of the high points of STS-76.

# Preface

Imagine viewing our world from space; a world astronauts have described as "bright and vivid" with "no borders or boundaries." Then consider how much can be learned by studying Earth from this unique vantage point. The National Aeronautics and Space Administration (NASA) began a three-year pilot program in 1995 designed by a team of scientists, engineers, educators, and high school and college students, to share astronauts' unique view of Earth with middle school students. This pilot program is called KidSat. Its primary objective was to merge real-time professional space flight with middle school education by providing students with equal access and direct contribution to the United States space program for the exploration of Earth. The long-term goal of KidSat was to produce higher student achievement in science, math, technology, and geography, and to promote an interactive understanding of Earth as an integrated system.

Students around the nation performed duties similar to those of astronauts, scientists, and engineers. They planned observations and captured images to study Earth's dynamic, fragile environment, using custom flight software, the Internet, NASA's infrastructure, and a remotely operated high-resolution color digital camera onboard the space shuttle. Using the accompanying curriculum, students determined which areas of Earth they wanted to explore and photograph along the shuttle's flight path. The Internet and orbiting communications satellites transmitted commands, telemetry, and images to and from the classrooms. Via the shuttle cargo bay video camera, NASA Television (NTV) carried video images of the mission and the Earth for simultaneous viewing in classrooms.

The KidSat pilot program was conceived in November 1993 and ended in December 1997. This report documents the results of this program and serves as a manual for those interested in using the KidSat images at home or in school. The diagrams and images are easy to copy and can be used for presentations in the classroom. We encourage such use of this document.

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# I. KidSat on the Shuttle

With the launch of shuttle flight STS-76 in March 1996, NASA broke the age barrier to scientific exploration of Earth from space. For the first time, flight hardware configured and operated by young students was launched into space with the goal of collecting imagery to meet the exploration needs of middle school students. Unlike many scientists who participate in shuttle missions, these middle school students did not wait until after landing to obtain and analyze their data. Instead, they participated directly in the mission, modifying the image requests that were developed during the months preceding the mission, and capturing their data over the Internet in real time. As a measure of the quality of the scientific analysis that went on in the months following landing, a special session was held at an international science symposium on remote sensing. Student representatives from each middle school presented the best investigations from their classes. One example was speculation about the cause of a complete freezing of the Aral Sea in March 1996 (see Section 10.1.1.)

## 1.1 History

The KidSat concept was inspired by a group of high school students working on a shuttle mission, as part of JPL's collaboration with Johns Hopkins University's (JHU) Institute for Academic Advancement of Youth (IAAY) in a program called Challenge Awards. In this program, high school students developed the procedures and performed the training for observations of Earth by the crews flying with the shuttle imaging radar (Way et al. 1994). The elements of the project that captured the students' interest were the involvement in a real shuttle mission, the photographs of Earth which provided a new perspective on the planet, and the ability to explore new territory. This program highlighted not only how valuable student involvement in space missions could be for the students, but also the value of students to the mission and science teams. It was from these ideas that the KidSat project was developed by JPL, the IAAY, and the University of California, San Diego (UCSD).

## 1.2 Mission Statement

The mission of KidSat was to demonstrate how middle school students could actively observe the Earth by using cameras mounted onboard the space shuttle and conduct scientific inquiry in support of their middle school curricula. Students selected and analyzed images of the Earth during shuttle flights and utilized the tools of modern science (computers, data analysis tools, and the Internet) to disseminate the images and results widely. A team environment was implemented that modeled scientific research and space operations and promoted student growth, discovery, and achievement while helping students participate in solving real-world problems. Teamwork, mentoring, and the active participation of educators, engineers, scientists, and precollegiate and college students, further enhanced this educational process.

## 1.3 Project Objectives

The objectives of KidSat were to capture and maintain the interest of students in the space program and in Earth exploration; to advance the learning of middle school students through their participation in a NASA mission and through the use of Earth images in science, math, technology, geography, and other subject areas; and to develop an infrastructure that fosters student intellectual exploration and discovery using images of Earth.

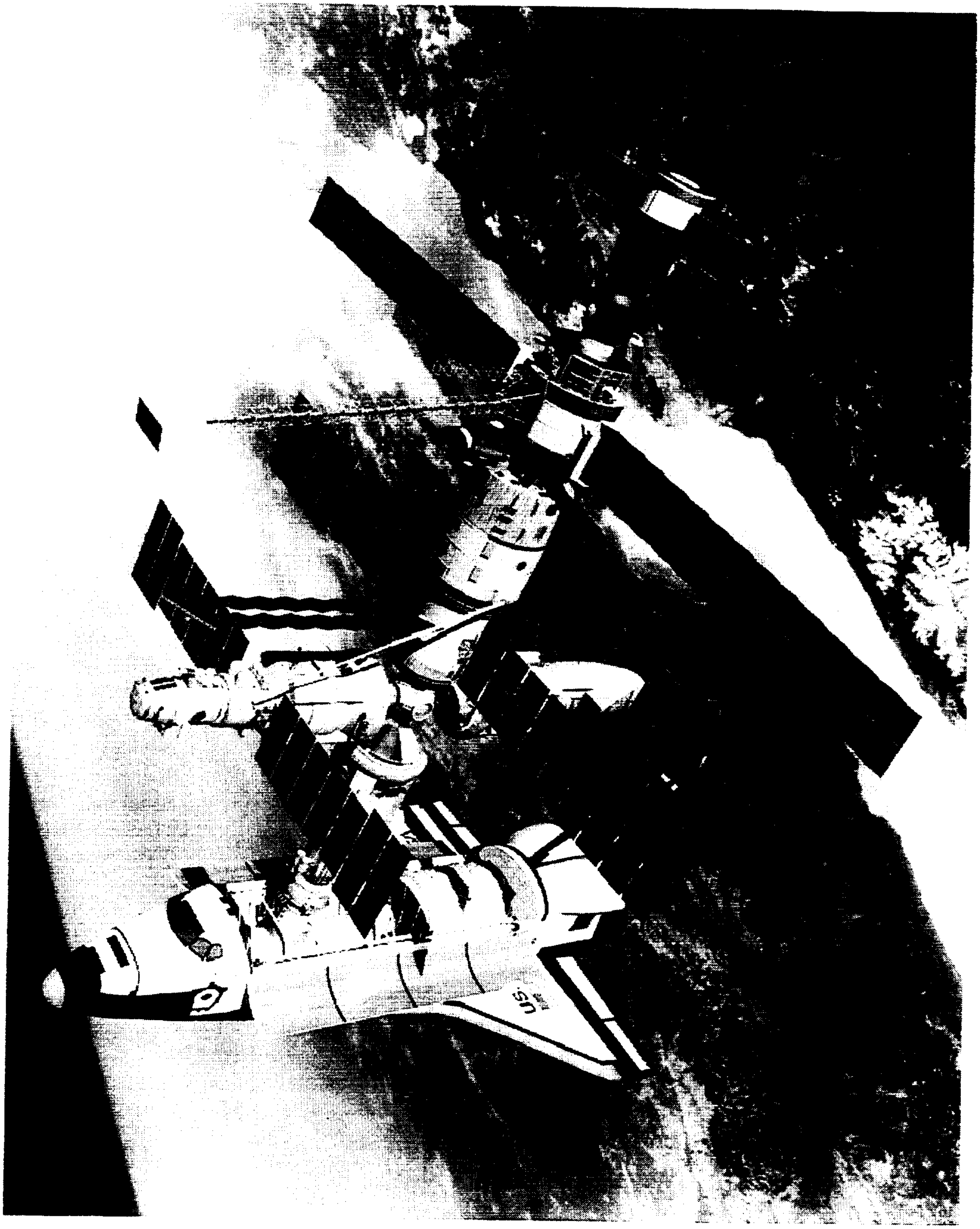

*Figure 1: Artist's conception of the space shuttle docked with the Mir Space Station.*

## 1.4 Technical Objectives

Historically, shuttle space is reserved for large-scale multimillion dollar projects designed to forward to international space exploration and science. Ten years ago, it was unthinkable for middle school students have real-time access to such professional resources. The evolution of information and commercial imaging technologies allowed KidSat to integrate and enhance several of these resources, thus enabling real-time digital photography from the shuttle.

The technical objectives for KidSat were to:

- acquire color digital images and video of the Earth's surface,
- command the KidSat instrument from classrooms across the country using the Internet and the KidSat Mission Control Gateway,
- provide the image data to classrooms across the country during and after the mission using the Internet and the KidSat Data System,
- provide tools that would allow students to do image analysis in their classrooms, and
- obtain data that could be used to design future KidSat instruments on the International Space Station, a permanently manned platform.

There were several new technologies that made KidSat possible in the mid 1990s. These included the Internet, the Kodak digital still camera, improved shuttle communication systems, and computers that could handle large image files and were cost-effective for schools.

## 1.5 Pilot Program

NASA funded a three-year research and development program to build the infrastructure and to develop and evaluate the curriculum needed for a large operational program. To make the program more appealing to young students, a partnership between the astronauts and the students was desired. The KidSat camera was therefore mounted on a piloted platform. There were three possible platforms: the NASA space shuttle, the Russian Mir Space Station and, when built, the International Space Station (ISS). For the pilot program, the shuttle was the best available option because it provided the appropriate command and data interface and was available for missions in the pilot program years. The Mir station was also considered, but limitations on data downlink prohibited the use of imaging systems on this platform. The shuttle used for all KidSat pilot missions was Space Shuttle Orbiter Atlantis, the fourth Orbiter to become operational at Kennedy Space Center. Atlantis was used for all nine Mir docking missions in preparation for the International Space Station. To link interest and learning, the program included hands-on participation in mission operations, exploration with the images, data availability through the Internet, teacher training on how to incorporate KidSat into daily classroom studies, curriculum content that met local, state, and national education standards, and continuous evaluation and improvement.

In 1995, the first pilot program year, the KidSat team developed the instrumentation and infrastructure necessary to carry out the first mission. In the second pilot program year, the first KidSat mission flew onboard shuttle mission STS-76 on Atlantis. STS-76 was a mission to dock the shuttle with the Mir Space Station. These missions were selected because the orbit inclination that was needed to rendezvous with Mir was 51°. This inclination provided viewing to all of the United States except Alaska, therefore providing opportunities for students to image their "own backyards." Pictures were taken during the pre- and post-Mir docking period when the shuttle was flying in a payload-bay-to-Earth attitude and the camera, which was mounted in the overhead window, could view the Earth. The three participating middle schools took 326 pictures of the Earth.

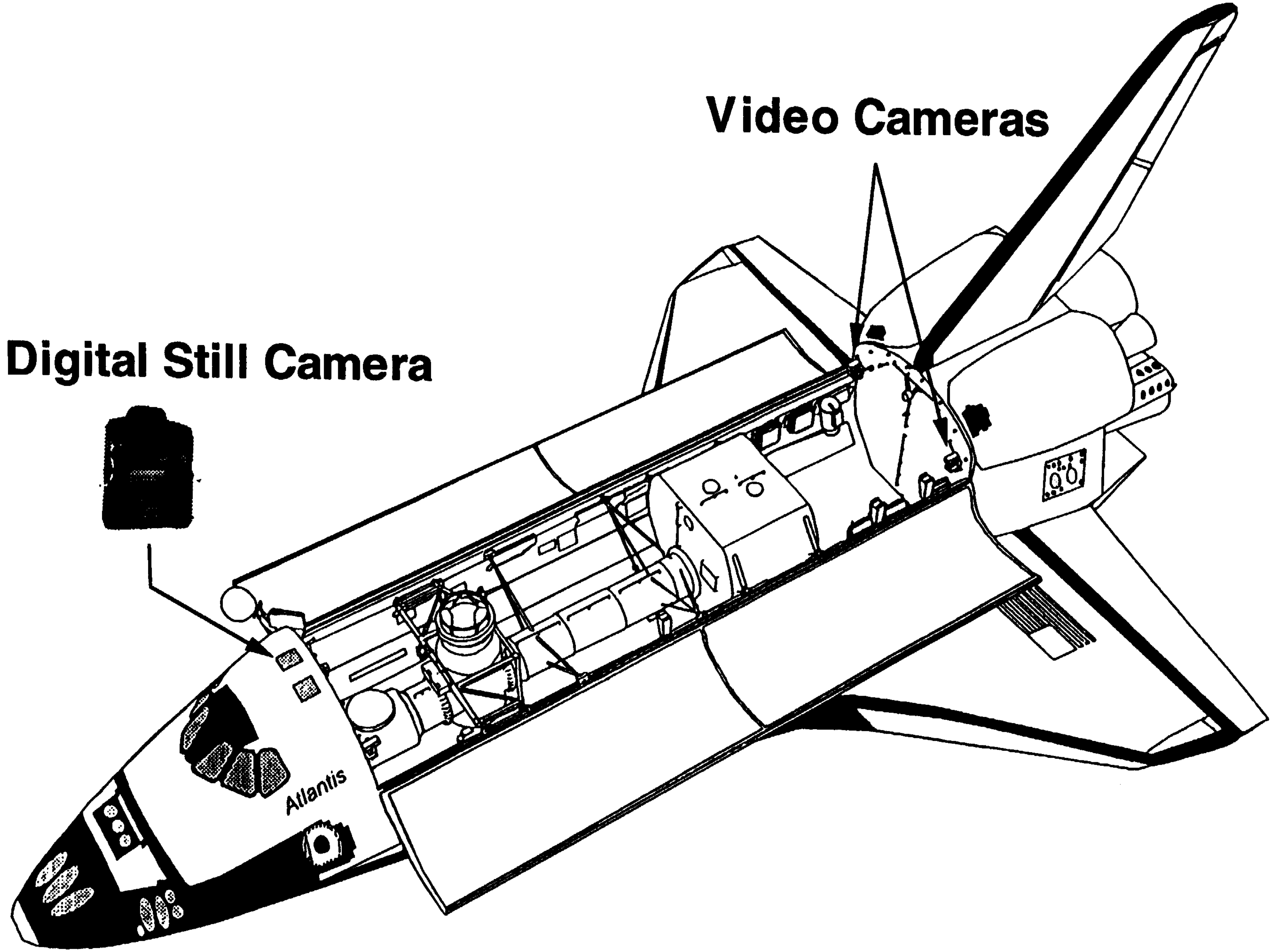


Figure 2: The locations of the KidSat digital still camera and the payload bay video cameras on the Shuttle.

Schools were added and improvements were made in the flight and data system and in the way the project was implemented in the schools on the second KidSat mission, which flew on STS-81 in 1997, another shuttle/Mir docking mission. This time, 17 middle schools and 3,000 students participated and 540 pictures were taken. Students became more involved in the analysis of the images. The third KidSat mission came in the third pilot year onboard STS-86, which again was a Mir docking. Because of the success of the first two missions, this one involved 52 middle schools and more than 6,000 students, a more advanced curriculum, upgraded flight, data, and mission operation systems, and resulted in the taking of 656 pictures.

## 1.6 KidSat Project

KidSat was managed as a flight project at JPL in the Space and Earth Science Programs Directorate (SESPD) with support from the Educational Affairs Office. JPL had the lead role in the project management of KidSat, the development of the flight system, the data system, and the exploration element. UCSD provided the mission operations for this program, and the IAAY led curriculum development, teacher training, and evaluation. The Johnson Space Center provided significant support to the project. KidSat was funded by NASA's Office of Human Resources and Education, with additional support from NASA's Offices of Mission to Planet Earth (now Earth Science), Space Flight (now Human Space Flight), and Space Science. Initial support was also provided by the National Science Foundation (NSF) along with a variety of other private foundations and companies.

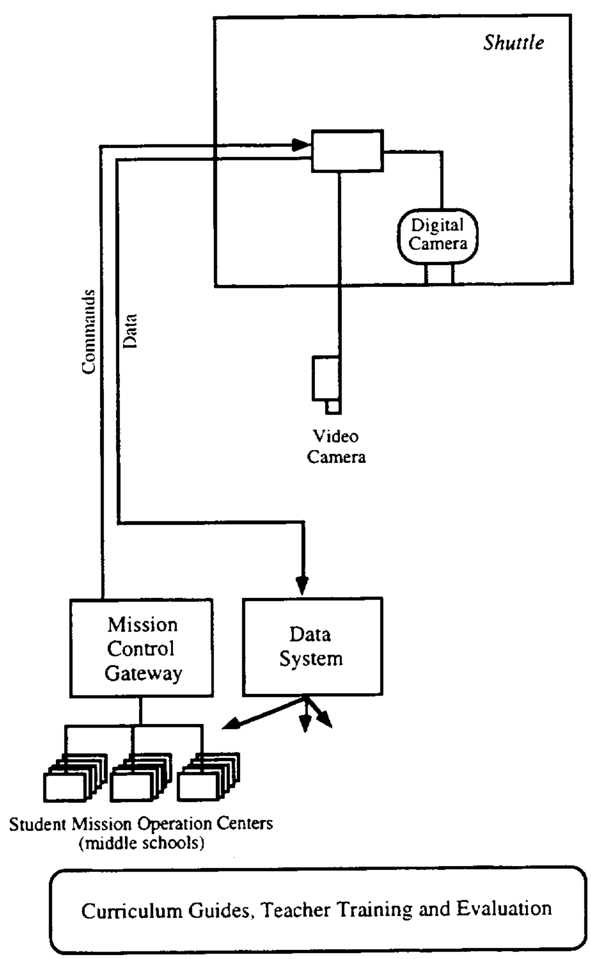


*Figure 3: The design of the KidSat project.*

## 1.7 Student Involvement

Students were involved in two different roles. There were those in middle schools who were the equivalent of a NASA science team; and there were those in high schools and universities who worked hand-in-hand with the scientists and engineers. The older students were responsible for building the project. They worked on designing and building the systems, writing the software, developing the Web pages, and operating the various systems during the missions. The middle school students were responsible for selecting the images and analyzing these images as part of their curriculum. In addition, a number of local university students supported the middle school students in the technical setup and operation of the Student Mission Operations Centers (SMOCs) and in the analysis of the images.

At JPL, the majority of students were from La Cañada High School. They worked on KidSat as part of the Institutes for the 21st Century, a business and professional mentorship program. Other high school students participated as part of the State of California's School to Career Program. Some undergraduate students were involved through the California Institute of Technology (Caltech) Summer Undergraduate Research Fellowships (SURF) and Teaching and Interdisciplinary Education (TIDE) programs, while other college students were JPL employees. At UCSD, the majority of the students were undergraduates, but they received some assistance from graduate students, especially in the development years.

Middle school students were chosen to be the "explorers" for the pilot program because the program could complement many areas that the students were already studying: math, geography, history, computer science, and Earth science. KidSat could fit into a teacher's curriculum without inhibiting other areas of study. In fact, the program enhanced the other subject areas by associating them with an area of interest, space exploration, which encouraged students to want to learn. Initially, middle schools were selected on the basis of three criteria: urban location, proximity to one of the institutional partners, and/or previous involvement with a space shuttle mission. Later, schools associated with NASA centers across the country were brought into the program. The number of middle schools grew, starting with just three for STS-76 to 52 for STS-86.

## 1.8 KidSat Infrastructure

The overall command and data flow between the ground and the shuttle utilized the Internet and an existing infrastructure of NASA satellites. In the classrooms, students used the Internet, orbit maps, and atlases to develop commands that specified the times for photographing the Earth. These commands were sent to the KidSat Mission Control Gateway at UCSD, where they were integrated with similar commands from other classrooms into a single Camera Control File (CCF). This CCF was checked and sent via the Internet to NASA's Mission Control Center (MCC) at the Johnson Space Center (JSC) in Houston, Texas, where it was subsequently sent up to the shuttle using the onboard communication Ku-Com Adapter/Orbiter-Com Adapter (KCA/OCA) system via a link to the shuttle that included DOMSAT, White Sands, TDRSS, and the shuttle's $K_u$-band system. Once onboard, the CCF controlled the times when photographs were taken. These photographs were then downloaded, usually during the night side of each ninety-minute orbit, through the same TDRSS/White Sands/DOMSAT system to JSC. The images were then sent to KidSat at JPL in Pasadena, California, via the NASA Science Network (NSN). Once at JPL, the images were automatically processed and loaded into the KidSat Data System, and were available to the classrooms on the Internet only a few hours after capture and a few minutes after hitting the ground. The images were accessed in the classrooms during the mission for validation and annotation, and were studied and developed into post-mission explorations. The student-enhanced images were stored and are available on the Web so that students can share their discoveries via the Internet.

For more detailed information about how the KidSat project was started and organized, see Way et al., 1999.

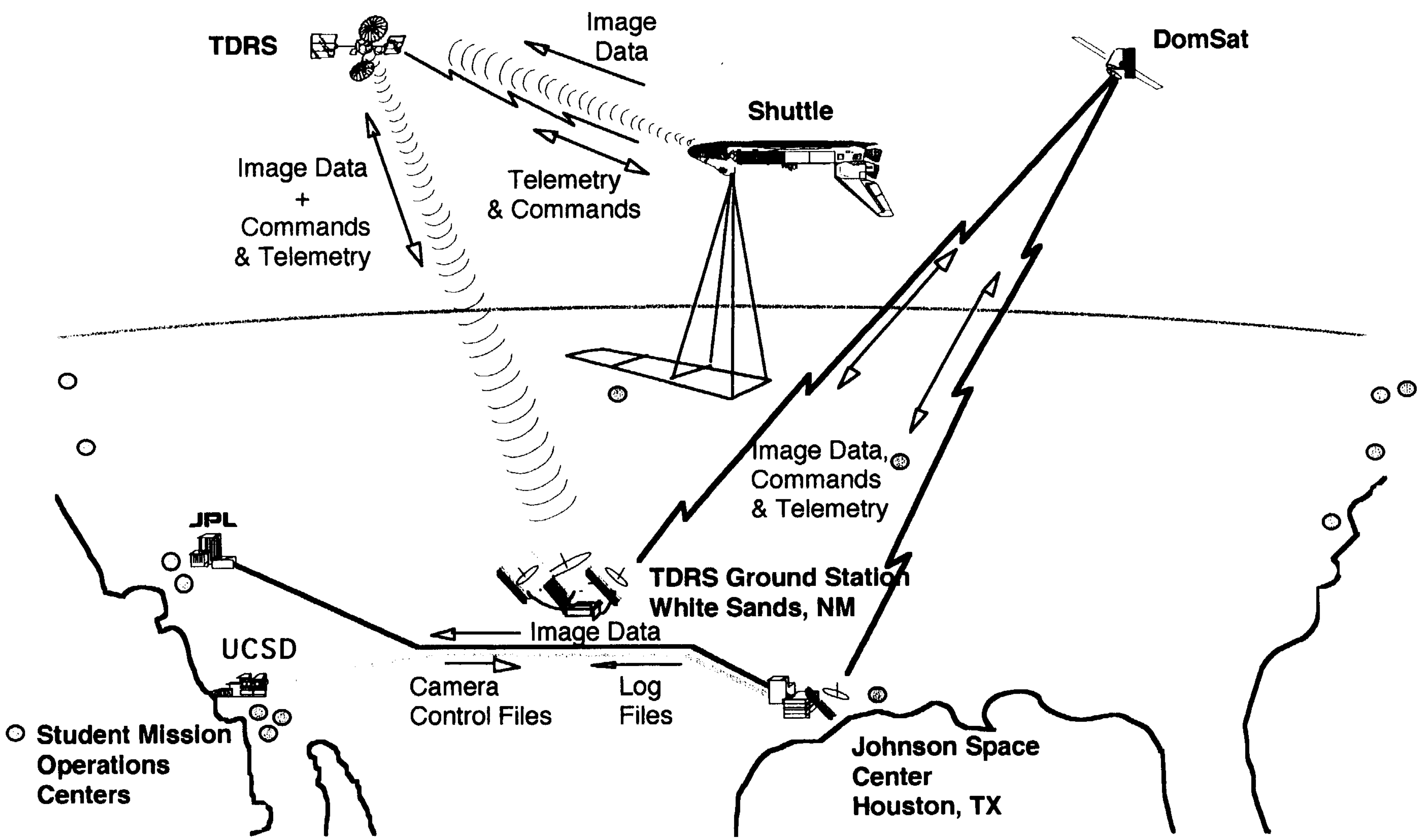


*Figure 4: KidSat's overall infrastructure, including links from the pilot classrooms to UCSD, JSC, and the shuttle via DOMSAT, White Sands, and TDRSS for commanding; and from the shuttle to JPL and the classrooms via TDRSS, White Sands, DOMSAT, JSC, and the Internet.*

## 1.9 KidSat Web Page

The KidSat project used the Internet both as an operational tool during the missions and as an interface to the data. The site remains on-line and is available for use by students (or adults). It consists of project descriptions and direct access to the images. Images are obtained from the KidSat Data System using a Web site that allows you to look at the images, find out where they were taken, and download them to your computer. On-line instructions for accessing and using the images are available from: **http://kidsat.jpl.nasa.gov/kidsat**.

The Web pages give access to the KidSat digital images; therefore, it is best if you have at least a 28.8Mbps modem connection.

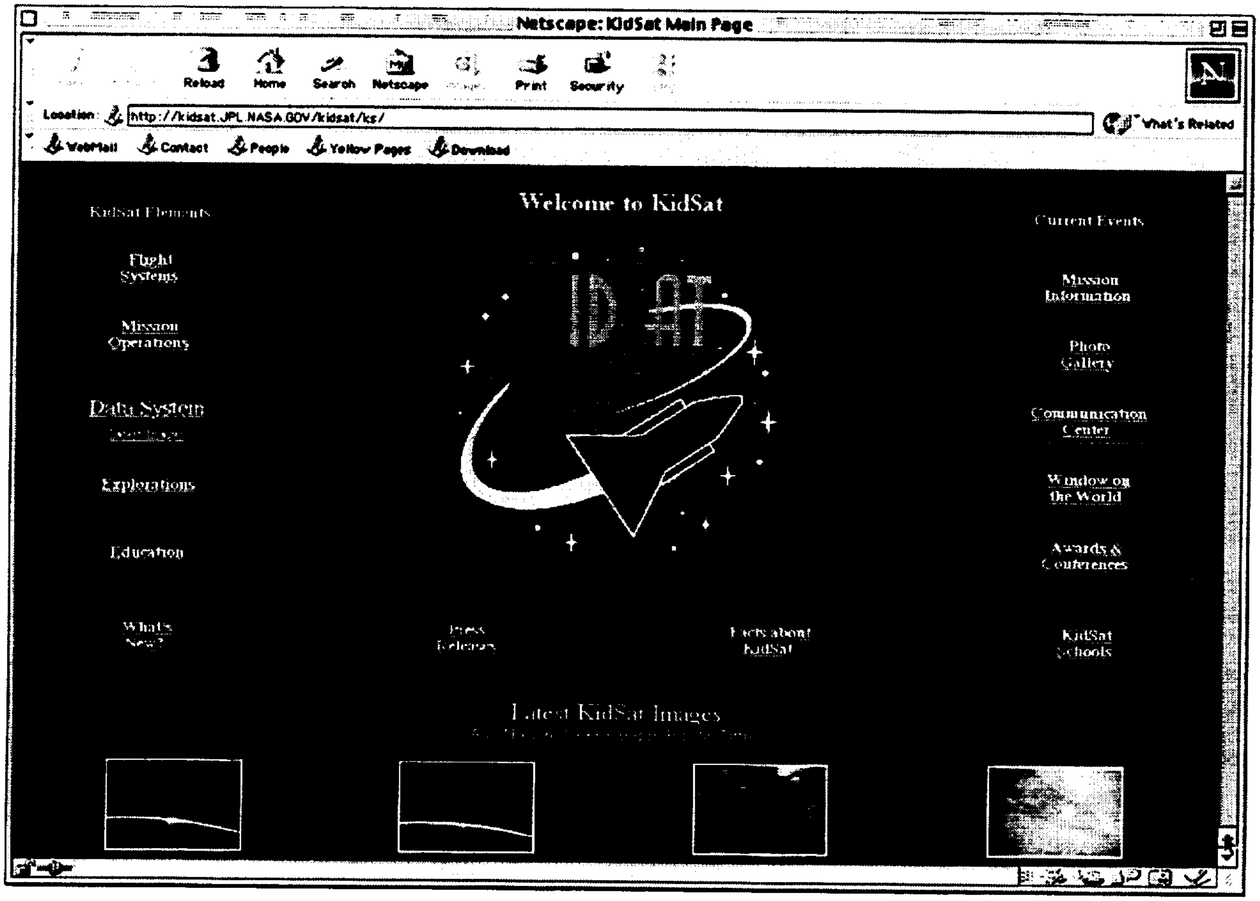


*Figure 5: KidSat Web page.*

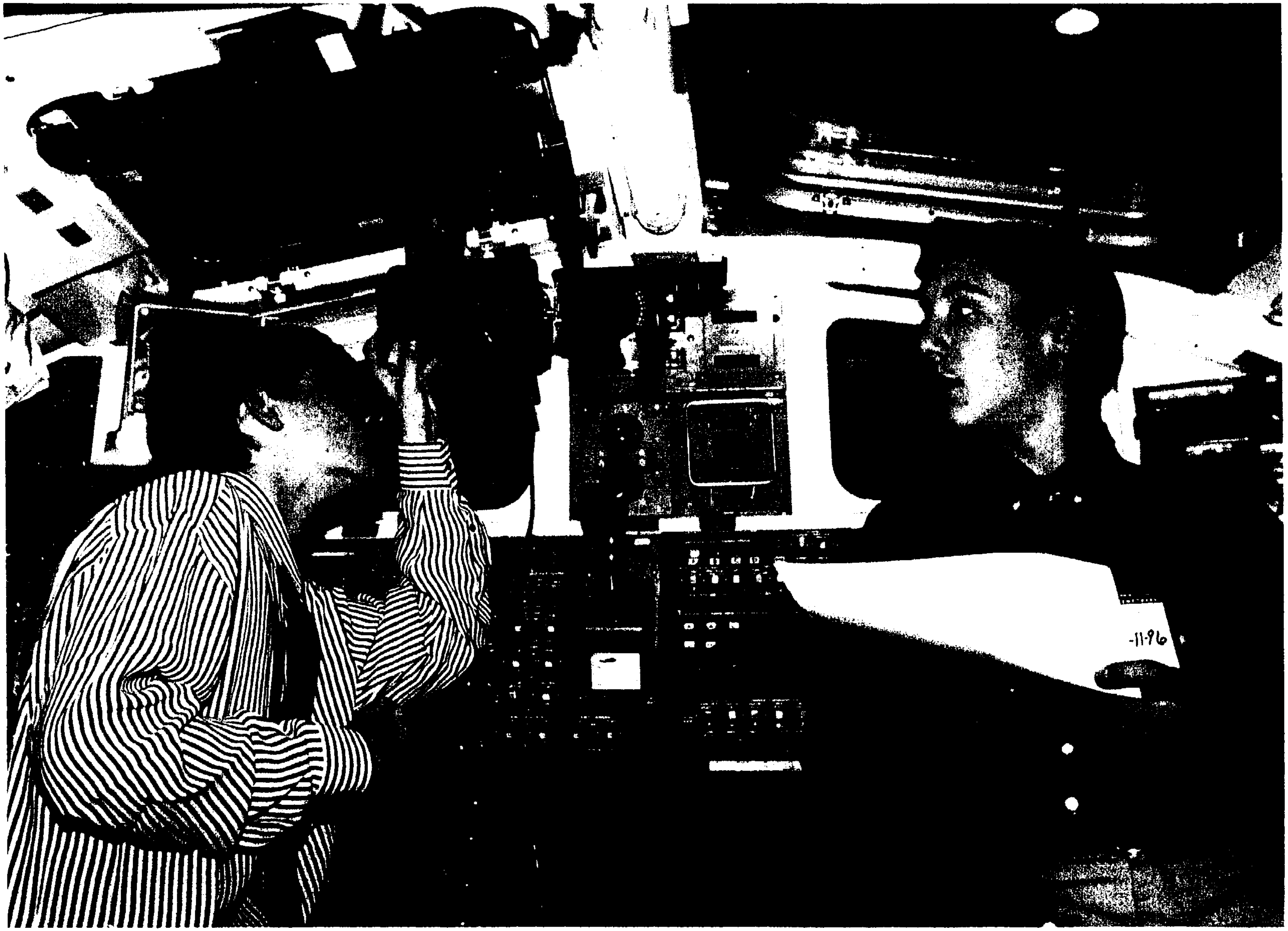


Figure 6: La Cañada High School students Josh Lane and Austin Leach test crew procedures and prepare to train the crew for STS-76 in the Orbiter simulator at JSC.

## 1.10 KidSat Logo

The name "KidSat" was made up by an adult. One of the first things students said about KidSat was that the name must be changed. The reasons were good: young people are not kids; KidSat is not a satellite, it flies on the shuttle; it is not an SAT test; and "we are not kidding." The renaming process started when a high school student, who was working on the project team, organized a logo and renaming contest. Lisa Min, from La Cañada High School, came up with a brochure inviting students to submit a name and a logo. The brochure included information on the names of other NASA missions, like Galileo, named after the scientist who discovered the Jovian moons; Magellan, named after the explorer who circled the Earth; Ulysses, named after the Greek mariner who went in search of uncharted tomorrows; and the shuttles Columbia, Challenger, Atlantis, Discovery, and Endeavor, all named after explorers' ships. Lisa received many suggestions from the middle school students in Charleston, Pasadena, and San Diego. She enlisted the help of several students from different KidSat teams and worked with two artists from France, Sally Holt and Jean-Max Albert to develop the final logo. The group got together, selected elements from many of the middle school students' logo designs and naming ideas, and came up with one integrated proposal. One key idea was to make the letter Y into a shuttle, and the letters E and S into land and water forms. The result was Project YES—Youth Enhancing Space. The keyword was "enhancing" which was just what students were doing for the space program. The resulting logo was used for STS-76 and a decal with the logo was flown on the shuttle for each school and student team.

However, there was concern that too many other projects were named YES and that more students should be involved in the logo contest. Based on recommendations from NASA Headquarters, KidSat would keep its names and the YES logo would be combined by the graphics department at JPL with a logo made by UCSD students. The result was the KidSat logo that flew on both STS-81 and STS-86. The interest generated by the process of creating a logo prompted educators to include in the curriculum the activity of making a logo for, and naming, each school's SMOC.


*Figure 7: KidSat/Youth Enhancing Space logo used for STS-76.*

*Figure 8: KidSat logo used for STS-81 and STS-86.*

## II. Flight System

The KidSat Flight System was designed to enable remote sensing from the space shuttle for educational purposes. The requirements for the Flight System were that it:

- acquire high-resolution color photographs of Earth similar to those obtained with hand-held cameras by the astronauts,
- be remotely operated using commands generated before and during the mission by students in middle school classrooms, and
- deliver the images in real-time to the ground KidSat Data System, which then made the images available to the classrooms during the missions.

The Flight System included a digital camera, a flight computer and its software, one of the four payload-bay video cameras, and the interfaces with the shuttle.

The payload was developed for a very low cost by using existing flight hardware provided by the NASA Space Shuttle Program. Custom software and cabling were developed to support the payload. For the KidSat pilot flights, a modified Kodak DCS-460C digital camera was used and an IBM Thinkpad was used for the flight computer. The digital camera used by the astronauts for in-cabin and hand-held Earth photography had flown in a hand-held configuration as the Electronic Still Camera (ESC) on previous shuttle flights. For KidSat, the camera was bracket-mounted in the shuttle's starboard overhead window. Bracket mounting provided a known pointing direction for the camera and eliminated unnecessary crew interaction. This combination of flight hardware was ideal for the pilot program flights because it used available hardware, needed only routine integration, and involved minimal development and testing.

The KidSat payload was developed by the Flight team and was made up of: students from La Cañada High School; undergraduates from a variety of universities including Stanford University, the University of Southern California (USC), the California Institute of Technology (Caltech) and Harvey Mudd College; and engineers from JPL and JSC under the leadership of John Baker from JPL. The team was responsible for:

- designating and obtaining the appropriate flight hardware,
- developing and testing the flight software,
- integrating and testing the hardware and software with the shuttle,
- performing astronaut training,
- monitoring the operation of the Flight System during the mission and handling any malfunctions, and
- assessing post-flight performance and making the necessary improvements for the next flight.

For more information about the KidSat Flight System, see Baker et al., 1999.

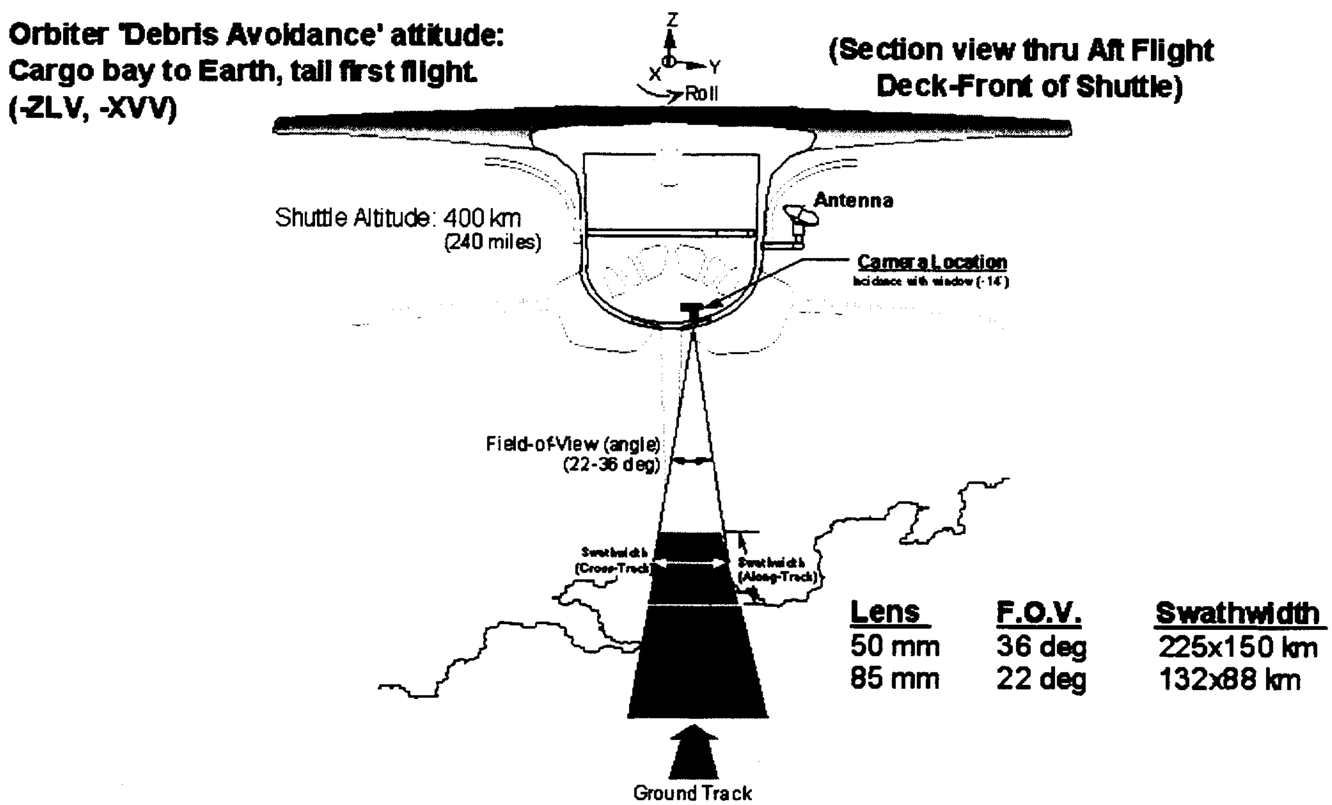


*Figure 9: Shuttle orientation and field of view with respect to the ground.*

Figure 10: Rick Searfoss with the KidSat camera and Thinkpad in orbit on STS-76.

Figure 11: KidSat in orbit on STS-76.

## 2.1 Flight Hardware

### *2.1.1 Digital Still Camera*

The Kodak DCS-460C includes a Nikon N90S body and a 18.4 × 27.6 mm Charge Coupled Device array in the focal plane, providing a 3060 × 2036 pixel image. The camera is 170 × 114 × 208 mm and weighs 1.7 kg. Three lenses were used, ranging from 50 to 180 mm; however, the 50-mm lens (36° field of view (FOV) or 225 × 150 km scene on the ground) and 85-mm lens (22° FOV and 132 × 188 km scene) were used for most of the KidSat photographs, due to the wide FOV. The 50-mm lens was used for the first portion of each mission and the 85-mm one for the second post-docking period. The camera generated color images by using color interpolation over a group of four pixels. The wavelength bands for each color are approximately 400–500, 500–600, and 600–700 nm for blue, green, and red, respectively.

The camera provided remote shutter operation and data transfer through a Small Computer Standard Interface (SCSI) port. When the camera took a picture, the raw image data were stored on a removable Personal Communications Module Computer Interface Adapter (PCMCIA) card. Unlike film cameras, the KidSat camera could store its images on the PCMCIA card and then download them to Earth during the mission, instead of using film that needs to be developed in a dark room after landing.

### *2.1.2 Payload General Support Computer*

The Payload General Support Computer (PGSC), a small computer used for crew operations, was a standard configuration IBM Thinkpad 755CS running Windows 3.1 (16-bit operating system) for the first flight, and then Windows 95 (32-bit operating system) for the last two flights. The commands and images were routed to and from the camera through the SCSI interface to an IBM Thinkpad 755CS computer with an 810MB hard drive. This in turn was connected to the $K_u$-band link using the Ku-Com Adapter (KCA) for the first mission, and was a precursor to the operational version of the Orbiter-Com Adapter (OCA) for STS-81 and STS-86. The KCA and OCA are devices that convert data produced on the shuttle into a suitable format for the $K_u$-band link to TDRSS. For STS-76, the KidSat Thinkpad was the same computer as the KCA/OCA computer. For STS-81, the OCA computer used another Thinkpad that was connected to the KidSat computer using a BNC-LAN connector. Data rates of 2 and 4Mbps were accommodated. Using the 2Mbps channel (Channel 2), 40 seconds were required to downlink an image; using the 4 Mbps channel (Channel 3), 20 seconds were required. As a typical operating scenario, KidSat used Channel 2 for KCA/OCA operations during the times when the crew was awake. Just prior to the crew pre-sleep period, they were asked to change the Payload Data Interface Panel (PDIP) digital camera rate switch from low to high, placing the KidSat downlink on Channel 3 to allow KidSat to empty their hard disk of images. At the last loss of signal (LOS) and prior to sleeping, the crew was asked to reconfigure KidSat to Channel 2, which allowed use of both the video on Channel 3 and the KCA on Channel 2 for KidSat downlinks during crew sleep.

### *2.1.3 Image Data*

The raw image files (KDK files) were 6.4MB in size. For STS-76, a 170MB PCMCIA card was used, allowing 26 images to be stored on the camera at a time. For STS-81 and STS-86, a larger 260MB PCMCIA card was used, allowing 40 images to be stored. Once on the Thinkpad, an 810MB hard drive was available, allowing more than 100 images to be stored before downloading was necessary. Once on the ground and interpolated, the images were 18MB in size. The final images were in TIFF file format and were 12-bit interpolated/calculated color. The average frame rate for the camera was one frame per 12–15 seconds with a burst rate of two frames in two seconds; the hard drive write speed was the limiting factor for the number of images that could be captured per orbit.

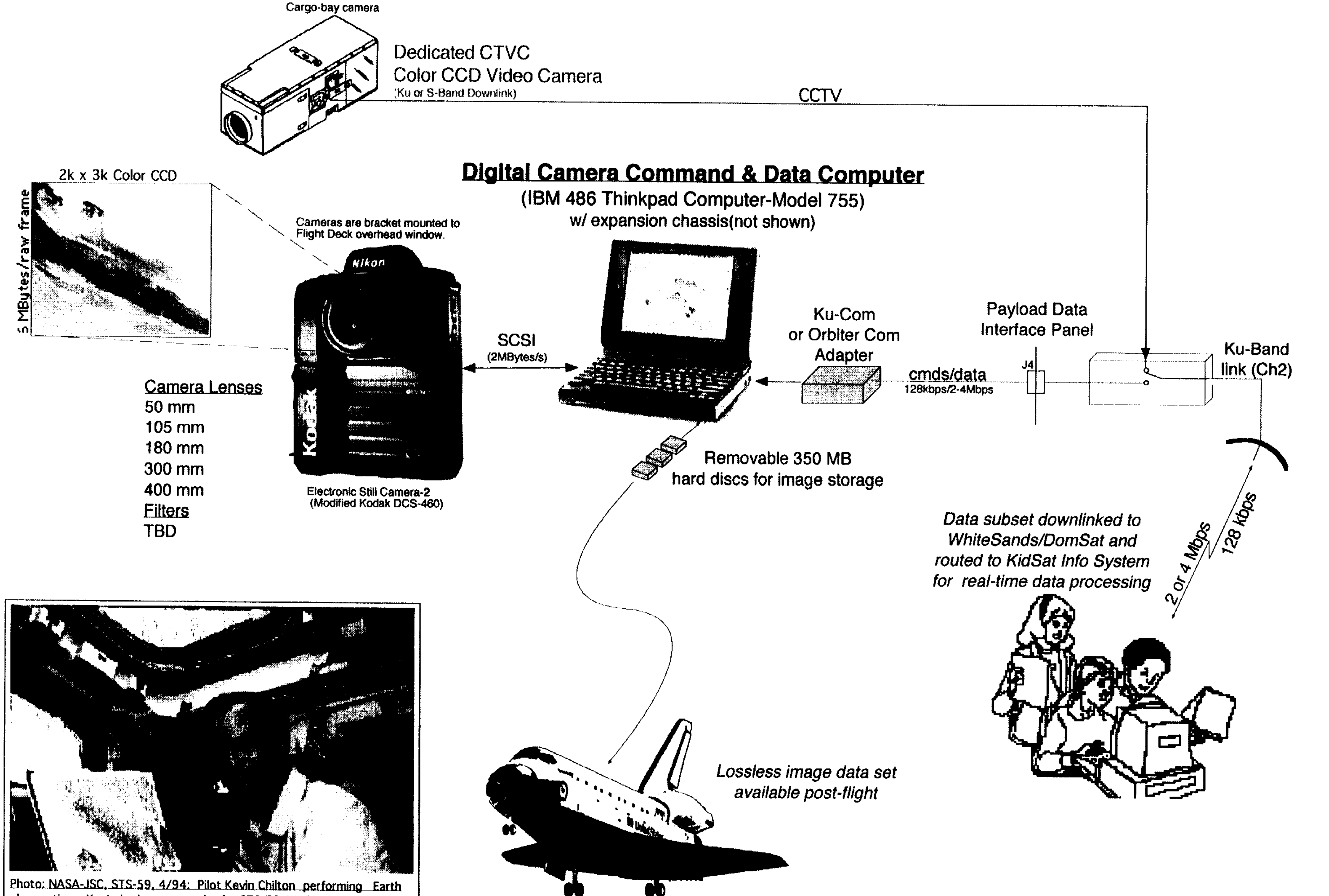


Photo: NASA-JSC, STS-59, 4/94: Pilot Kevin Chilton performing Earth observations. Kevin is the commander for STS-76, KidSat flt 1.

Figure 12: KidSat cameras, Thinkpad, and links to the shuttle as configured for STS-76.

### *2.1.4 Camera Bracket*

The bracket used to mount the camera to the window was developed initially for the Shuttle Radar Lab missions and was designed and built to hold a Linhof camera to the aft-starboard flight deck overhead window. The bracket used the window shade clamping system, but did not use a window shroud. It had a manually adjustable cross-track angle from nadir of +20 to –40°. The angle was set at 0° for all KidSat operational time with the exception of the pre-dock period during STS-86, when the shuttle was rolled, due to thermal constraints. The bracket and the KidSat hardware were all stored in lockers on the Shuttle's flight and middecks for access immediately following launch and to allow final storage just before landing.

### *2.1.5 Video Cameras*

The shuttle's solid-state color television camera (CTVC) has a standard Orbiter interface, and will be used on the International Space Station; these video cameras fly regularly in the Orbiter payload bay. The cameras are mounted on the payload-bay pan tilt units and use CCD arrays to provide color video. The sensor is a color separating prism with three 1/2-inch frame transfer CCDs, and a resolution of 400–625 Television Lines per Picture Height (TVL/PH). The camera weighs less than 18.9 pounds, is approximately 17 × 6 × 6 inches, and consumes a maximum of 24.8 W at 28 V. The focal length of the CTVC is from 5.5 mm to 47 mm, offering a field of view of 10.7° × 8.0° (horizontal × vertical FOV) to 75.3° × 60.1°. The *f*-stop range is *f*1.7 to *f*16. The camera's output is NTSC video. One of the CTVCs normally in the payload bay was designated for KidSat use during the nadir-viewing portion of the shuttle flights. KidSat was allocated periods when video data could be acquired and downlinked live to the ground for capture at the KidSat Data System and by the classrooms via NTV. The camera was operated by the Integrated Communications Officer (INCO) at the JSC Mission Control Center in a synchronized mode, in which onboard Greenwich Mean Time (GMT)/Mission Elapsed Time (MET) was embedded in the video signal. The GMT/MET time was decoded at JSC and the information was displayed on the final video product.

**Picture Size Cue Card**

**Orbit Altitude 211 Nautical Miles or 391 km**

| Camera Lens Focal Length | * Effective Focal Length (mm) | Picture Width (x-axis) | Picture Width (y-axis) | 10% Picture Overlap Time Interval (secs) | Pixel Size (m) |
|---|---|---|---|---|---|
| **50** | ***64*** | **204 km** (127) mi | **136 km** (85) mi | 23 | 67 |
| **85** | ***109*** | **120 km** (75) mi | **80 km** (50) mi | 14 | 39 |
| **180** | ***230*** | **57 km** (35) mi | **38 km** (24) mi | 6 | 19 |

* Compared to film camera

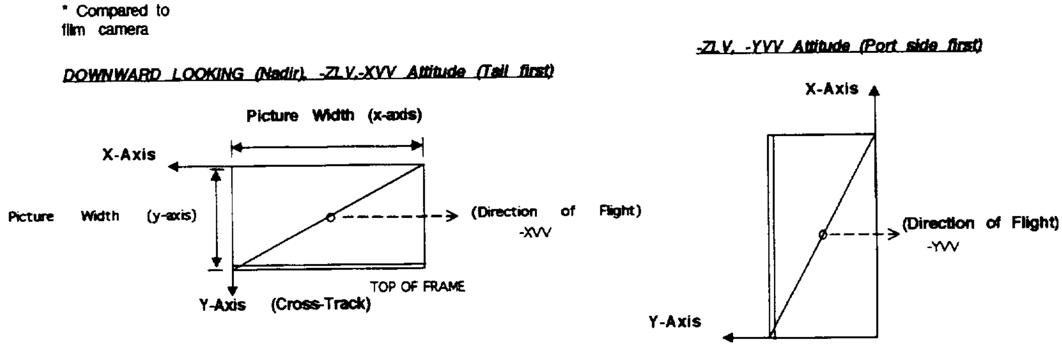


*Figure 13: Photograph parameter calculations for the Kodak DCS-460C for various lens focal lengths (FOVs, pixel size).*

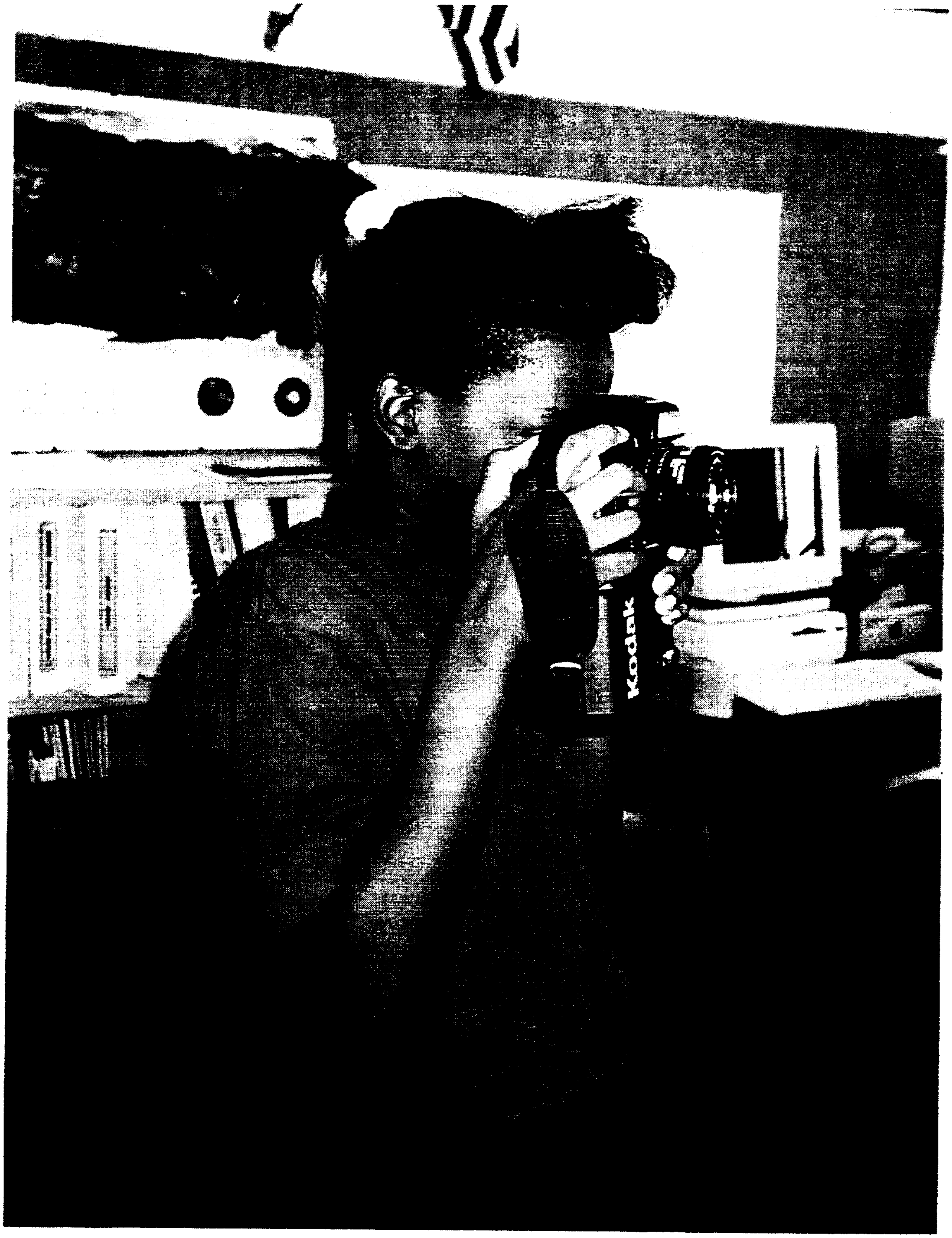


*Figure 14: A student at Buist holding a KidSat digital camera.*

## 2.2 Flight Software

Operation of the instrument was accomplished with the flight software running on a PGSC. The software was written around a scheduler routine that kept track of time and commanded activities on one-second intervals based on the MET clock. All commands, telemetry, and data were handled as files.

The first two versions of the software were 16-bit applications and used a custom camera driver provided by JSC. They were written with simple scheduling programs to read command files, take pictures, transfer images from the camera to the PGSC hard disk, and log the results. The last version of the flight software, flown on STS-86, had a significant number of modifications based on lessons learned from the first two flights to improve access and download, and was a 32-bit application. Improvements included:

- fault detection, alarming, and built-in malfunction procedures,
- loss-less image data compression (approximately 50 % using GZIP),
- improved camera status information and control,
- improved software performance,
- less CPU load and reduced image-file transfer time, and
- upgrades for network operation compatibility.

Built-in fault detection and assessment using a beeping alert was also included to minimize the time between a software or camera error and correction of that error by the crew. Once an alert sounded, the crew would evaluate and remedy the situation and notify the operations team on the ground of the situation.

Pictures were scheduled on board by ground commands in the Camera Control File (CCF) that specified the time for photographing Earth as an MET (dy/hr:min:sec). The following camera commands were all part of the flight software:

- take photographs based on the CCF,
- move the acquired photographs from the camera to the Thinkpad,
- compress the photographs and store them for downlink,
- monitor the condition of the camera,
- generate a log file that documented payload operation, including executed commands and errors,
- capture time from the Pulse Code Modulation Master Unit (PCMMU), and
- allow for astronaut interaction—the ability to schedule photographs, manually take photographs, inhibit operations, view a thumbnail of the last picture taken, and view the log file and command queue.

The CCF was read by the KidSat flight software, then sorted and ordered by MET into a command (CMD) file. The software monitored the MET and executed commands, including shutter commands, at times specified in the CCF. The flight software then retrieved the captured images from the camera PCMCIA card, sorted them on the Thinkpad hard drive, and deleted them from the camera hard disk.

Before every mission, the software was tested to check that it performed as required with the space shuttle flight-specific software load in the physical conditions of the shuttle, and that the different parts of the KidSat Flight System worked well with each other and with the systems onboard the shuttle and on the ground. Testing of the flight software and hardware was performed at JPL, JSC, and UCSD before and during mission simulations.

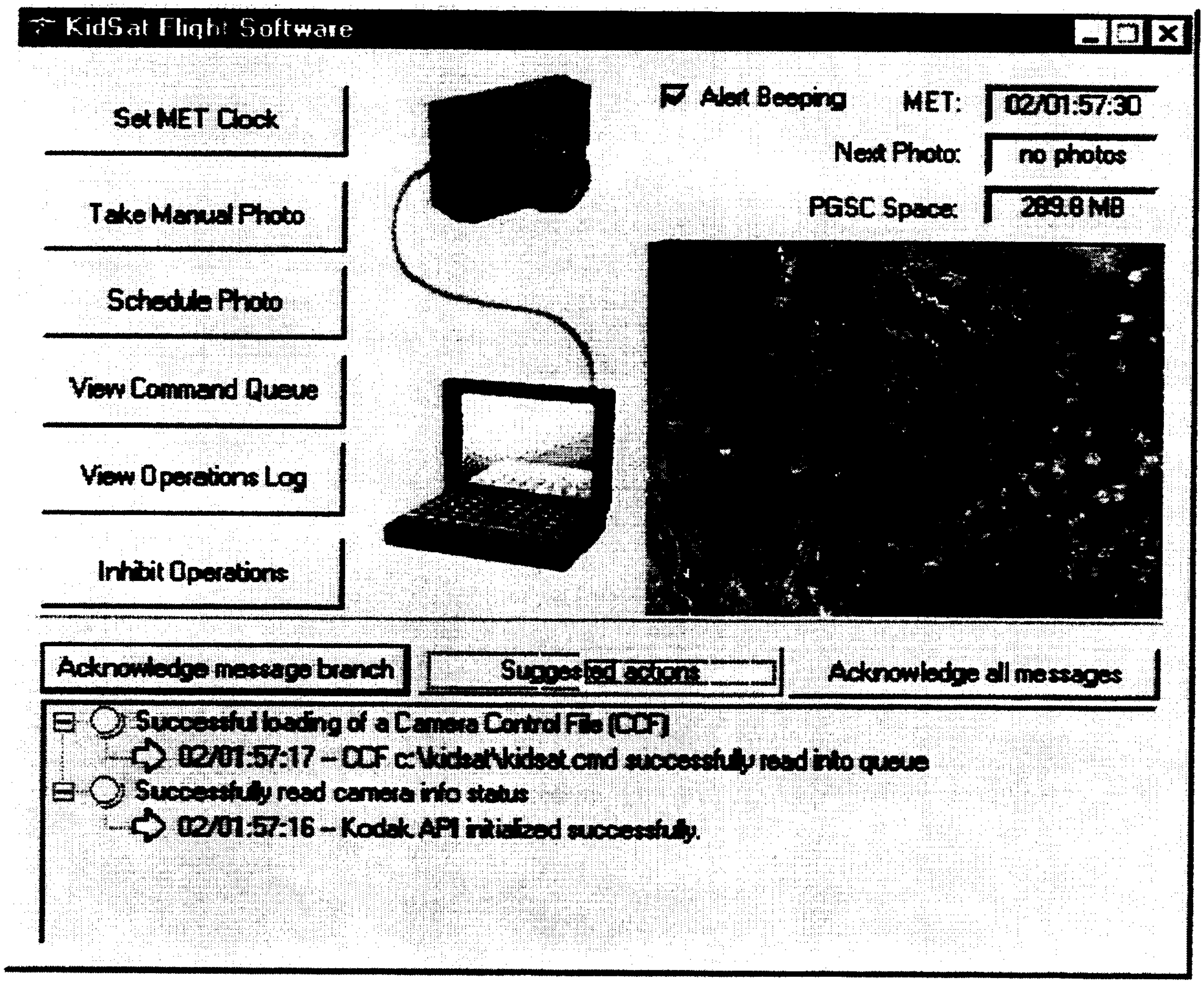


*Figure 15: Flight software interface for STS-86.*

P/TV09 KIDSAT

SCENE SYNOPSIS

Scene includes First Session (Pre-Docking) and Second Session (Post Separation)
Scene contains H/W setup for data collection and desired in-cabin photographic scenes
Document OPS w/orbiter ESC
KidSat lens changeout from 50mm to 85mm prior to Second Session (Post Separation)

FLIGHT PLAN CALLOUT: SETUP

1. ESC Unstow/Initial Batt Charge

a. Unstow ESC, AC/DC Pwr Converter, AC Pwr Cable, additional PCMCIA cards, lenses

ESC b. ✓ ESC Pwr – OFF
Connect AC/DC Pwr Converter ESC cable to J1 on ESC
Connect opposite end of AC/DC Pwr Converter to AC Pwr Cable

A15 c. ✓ AC UTIL PWR – OFF
Connect AC Pwr Cable to AC Util outlet

d. AC UTIL PWR – ON

NOTE

Batt will be fully charged in 30 min regardless of indication

ESC ✓ BATT segments – Flashing/sequencing

2. KidSat PGSC C/O

✓ KidSat PGSC setup per NETWORK SETUP DIAGRAM (ORB OPS, PGSC)

3. Install Camr Brkt

W7 a. Unstow, install ovhd brkt, tabs (two) to stbd, bolts (two) to port

b. Tighten brkt bolts (two)

c. Set brkt angle to 0° in roll (Nadir viewing)

*Figure 16: Procedures flown on the mission and used by the crew to set up and operate the KidSat system (1 of 5).*

P/TV09 KIDSAT (Continued)

FLIGHT PLAN CALLOUT: SETUP (Continued)

4. Config and C/O ESC 35mm

| | ESC |
|---|---|
| **KIDSAT ESC**<br>Lens – 50mm (First Session)<br>– 85mm (Second Session)<br>✓ PCMCIA Hard Disk installed<br>Camr Settings<br>Pwr – ON<br>LCD Illum – ON<br>Mode – S<br>ISO – 200<br>Drive – S<br>Flash – Single<br>Meter – Center<br>SS – 500<br>Exp Comp – 0<br>Focus – SPOT<br>Body Focus – M<br>f/stop – Min and locked<br>✓ SCSI pb – 5 | Take Test Image<br>Focus, Frame, Fire<br>✓ Normal Camr sound<br>✓ Card Busy Lt blinking (~15 sec)<br>✓ No blinking ISO on rear LCD<br>✓ Frames remaining – 39<br><br>Delete Test Image<br>Activate Camr<br>DELETE pb – Depress, hold 1 sec<br>✓ DEL displayed<br>DELETE pb – Depress, hold 1 sec<br>✓ Frames remaining – 40<br>ESC pwr – OFF<br><br>Mount ESC to brkt<br>✓ Camr focus visually – ∞ (Tape)<br>Eyepiece Shutter Lever – CL<br><br>CAUTION<br>ESC Camr Pwr – OFF prior to<br>SCSI cable installation to ESC<br><br>KidSat PGSC Pwr – OFF<br>If RS-232 Y Cable connected to KidSat PGSC COM 1/RS-232 serial port, disconnect<br>Connect Camr to PGSC<br>Config cable per KIDSAT DIAGRAM, FS 1-44<br>Connect SCSI Cable to J2 on ESC<br>Connect opposite end, w/slim PCMCIA–SCSI Card attached, to KidSat PGSC PCMCIA slot, green dot up<br>KidSat PGSC Pwr – ON<br>Select CANCEL when "New Hardware Found" window appears<br>Connect RS-232 Y Cable to KidSat PGSC COM 1/RS-232 serial port |

*Figure 16: Procedures flown on the mission and used by the crew to set up and operate the KidSat system (2 of 5).*

FLIGHT PLAN CALLOUT: SETUP (Continued)

## KIDSAT DIAGRAM

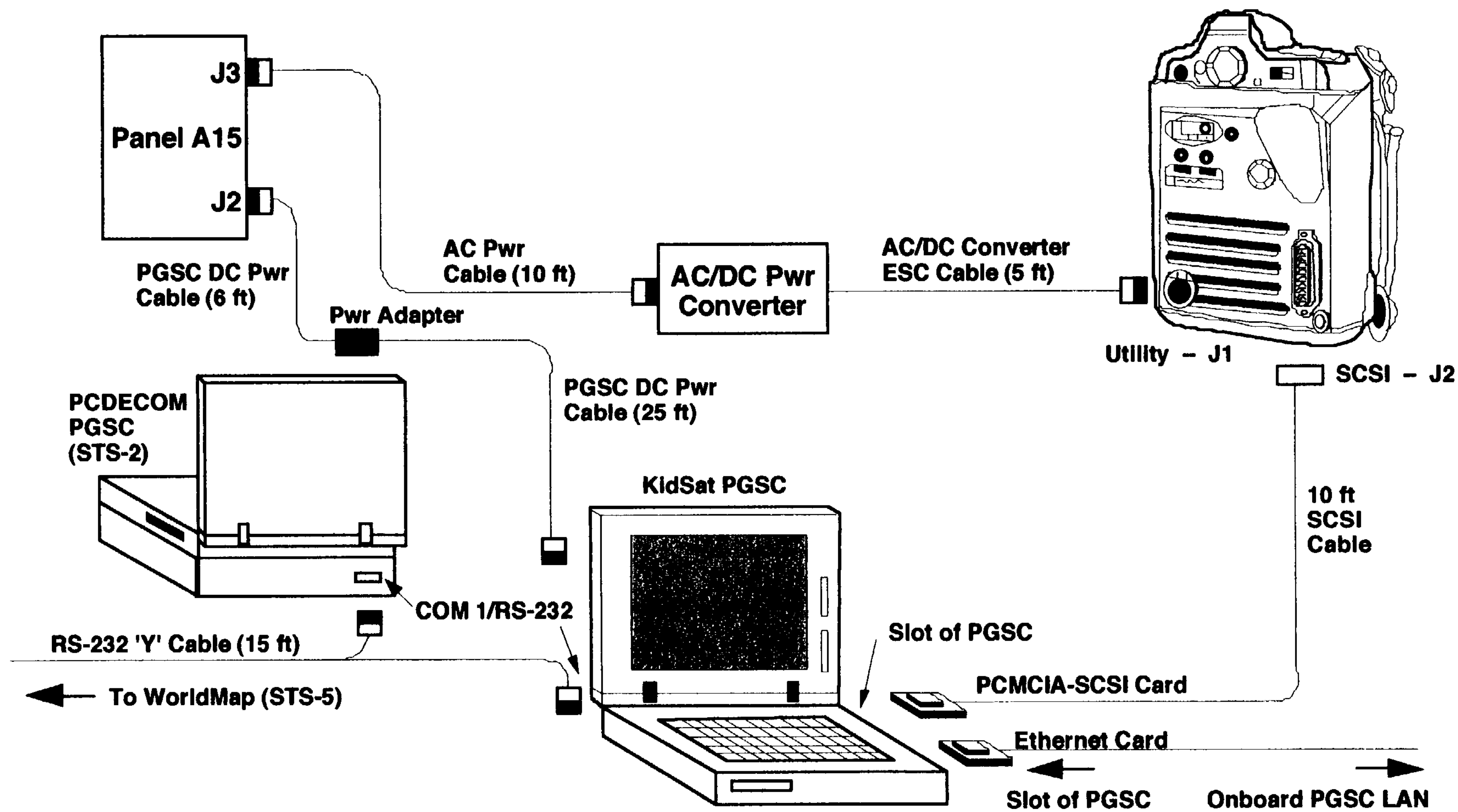


*Figure 16: Procedures flown on the mission and used by the crew to set up and operate the KidSat system (3 of 5).*

P/TV09 KIDSAT (Continued)

FLIGHT PLAN CALLOUT: SETUP (Concluded)

ESC 5. Turn on ESC
PGSC Double-click Shuttle Apps icon on desktop
Double-click KidSat icon
Click on SET MET CLOCK button
Enter orbiter MET in "Set Current MET" window
Click on SET TIME NOW button
✓ MET clock accurate within ±1 sec of orbiter MET
✓ Status window updating
If no error messages, click on "Acknowledge All Branches"
Click on TAKE A MANUAL PHOTO button – Answer YES
ESC ✓ Normal Camr sound
✓ Card Busy Lt – Blinking (~15 sec)
✓ No blinking ISO on rear LCD
✓ Frames remaining – 39
PGSC ✓ Status window [MET – Flt crew successfully initiated manual photo take]
✓ Status window [Image has been successfully transferred from Camr]
Notify MCC installation complete

FLIGHT PLAN CALLOUT: OPS

| ✓ | SUBJECT | CAMR | NOTES |
|---|---|---|---|
| | KidSat Camr Installed in Window | Orbiter ESC | Use 28mm lens |
| | PGSCs and Associated Cabling | Orbiter ESC | Use 28mm lens |
| | Individual Crewmembers (groups) w/KidSat Equipment in Background | Orbiter ESC | Use 28mm lens |

To Inhibit/Resume Ops

PGSC On KidSat Space Flight Software, select Inhibit (Resume) Operations as reqd

*Figure 16: Procedures flown on the mission and used by the crew to set up and operate the KidSat system (4 of 5).*

P/TV09 KIDSAT (Concluded)

FLIGHT PLAN CALLOUT: OPS (Concluded)

KidSat Ops w/Ku Band Antenna Stowed

NOTE

KidSat can continue to operate after stowage of Ku Band Antenna. Crew must verify available Hard Drive space on KidSat PGSC in “KidSat Spaceflight Software” window

PGSC 1. ✓ PGSC Hard Drive
2. If ≤500MB, remove & replace Hard Drive w/spare KidSat PGSC Hard Drive

DEACTIVATION

1. ✓ MCC

PGSC 2. Exit “KidSat Spaceflight Software” window

ESC 3. ESC Pwr – OFF
PGSC On Taskbar (next to displayed time), click PCMCIA icon
Click on “Stop Adapter APA-1460 SCSI Host Adapter”
Click OK when “Adapter APA-1460 SCSI Host Adapter” window displayed
Eject pb – Depress fully to eject SCSI card
A15 ✓ AC UTIL PWR – OFF
✓ Disconnect AC Pwr Cable from AC Util Outlet and AC/DC Pwr Converter
Disconnect AC/DC Pwr Converter ESC Cable from J1 on ESC
Disconnect SCSI Cable from J2 on ESC, and remove PCMCIA-SCSI Card from PGSC
Unmount Camr from brkt
ESC ✓ PCMCIA card installed in Camr
Stow ESC, AC/DC Pwr Converter, AC Pwr Cable, additional PCMCIA cards, lenses

W7 4. Remove photo brkt and disassemble
Window Stow brkt
Shade Bag

Figure 16: Procedures flown on the mission and used by the crew to set up and operate the KidSat system (5 of 5).

## 2.3 Astronaut Involvement and Training

Although the KidSat Flight System operated remotely and independently of the crew, the astronauts were required to set up and stow the Flight System before and after in-flight operations, and handle possible lens changes and software resets. As part of the setup, the astronauts:

- installed the camera and bracket in the overhead window,
- connected the power and data cables for the camera and Thinkpad,
- installed the selected lens,
- activated the camera and Thinkpad,
- initialized the flight software,
- set the MET clock, and
- set the bracket angle to 0° unless otherwise specified.

Training of the astronauts responsible for KidSat during the mission was performed by the KidSat Flight team with support from the KidSat Mission Operations team at JSC in the shuttle simulator. Training included a general orientation to KidSat, manual installation of the Flight System, and software operation and malfunction handling.

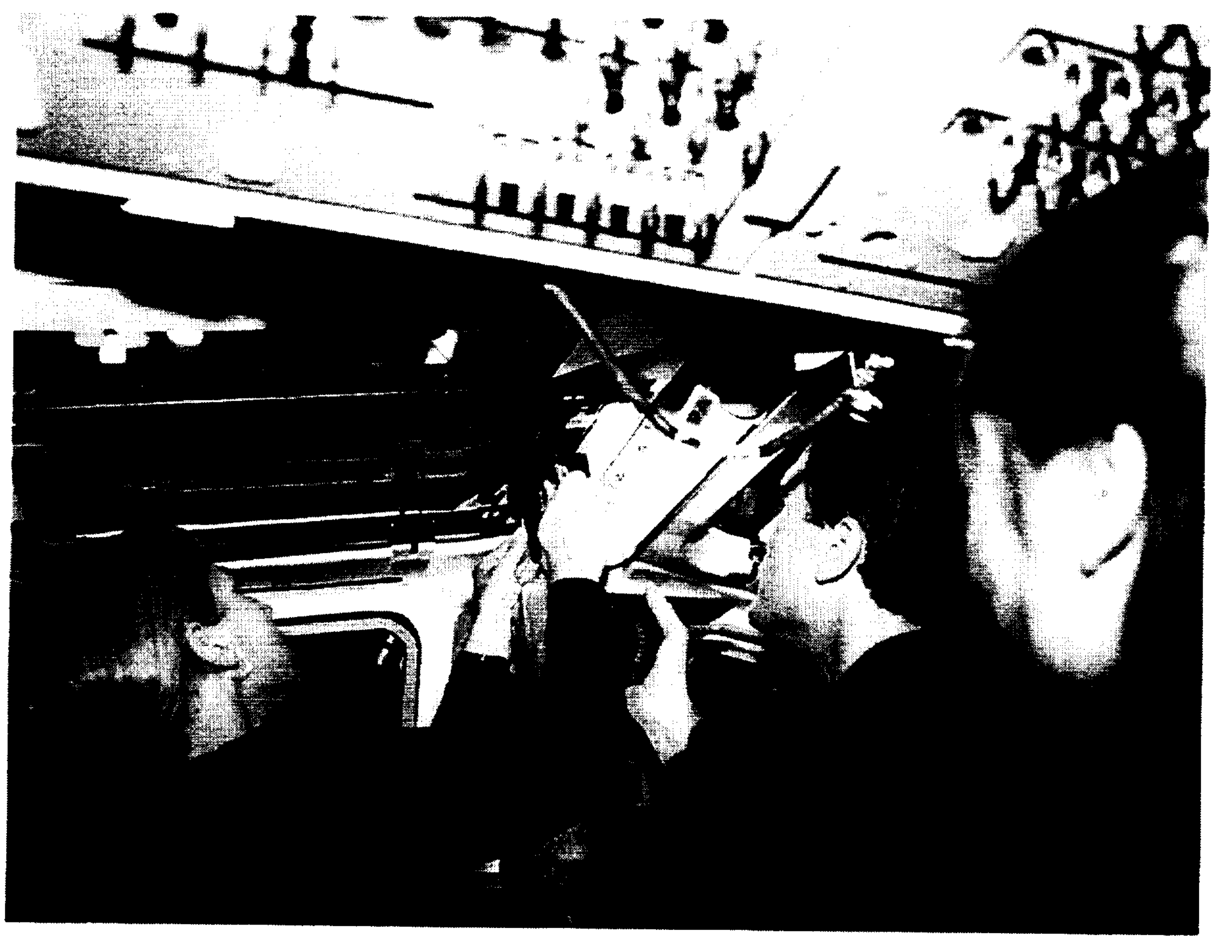

*Figure 17: Marsha Ivins and Jeff Wisoff practice installation of the bracket as a member of the KidSat Flight team looks on.*

## 2.4 NASA Television (NTV)

NTV (http://www.nasa.gov/ntv/) is a free TV channel operated by NASA. It begins as a satellite broadcast, then is redistributed in some areas by cable. For KidSat, NTV was used for viewing the Earth video live in the classrooms, KidSat-related press conferences, mission updates and mission status reports, and for watching the mission live (launch, Extra Vehicular Activities (EVAs), Mir docking, and landing). Outside of mission times, there are also many educational programs on NTV. A schedule is available on the Internet at http://www.nasa.gov/ntv/.

There are three options for receiving NTV:

- Local cable companies: Some cable companies show NTV regularly or during shuttle missions.
- NTV is broadcast on GE-2, transponder 9C, C-Band, located at 85 degrees West longitude. The frequency is 3880.0 MHz. Polarization is vertical and audio is monaural at 6.8 MHz.
- The Web: http://www.nasa.gov/ntv/ntvweb.html.

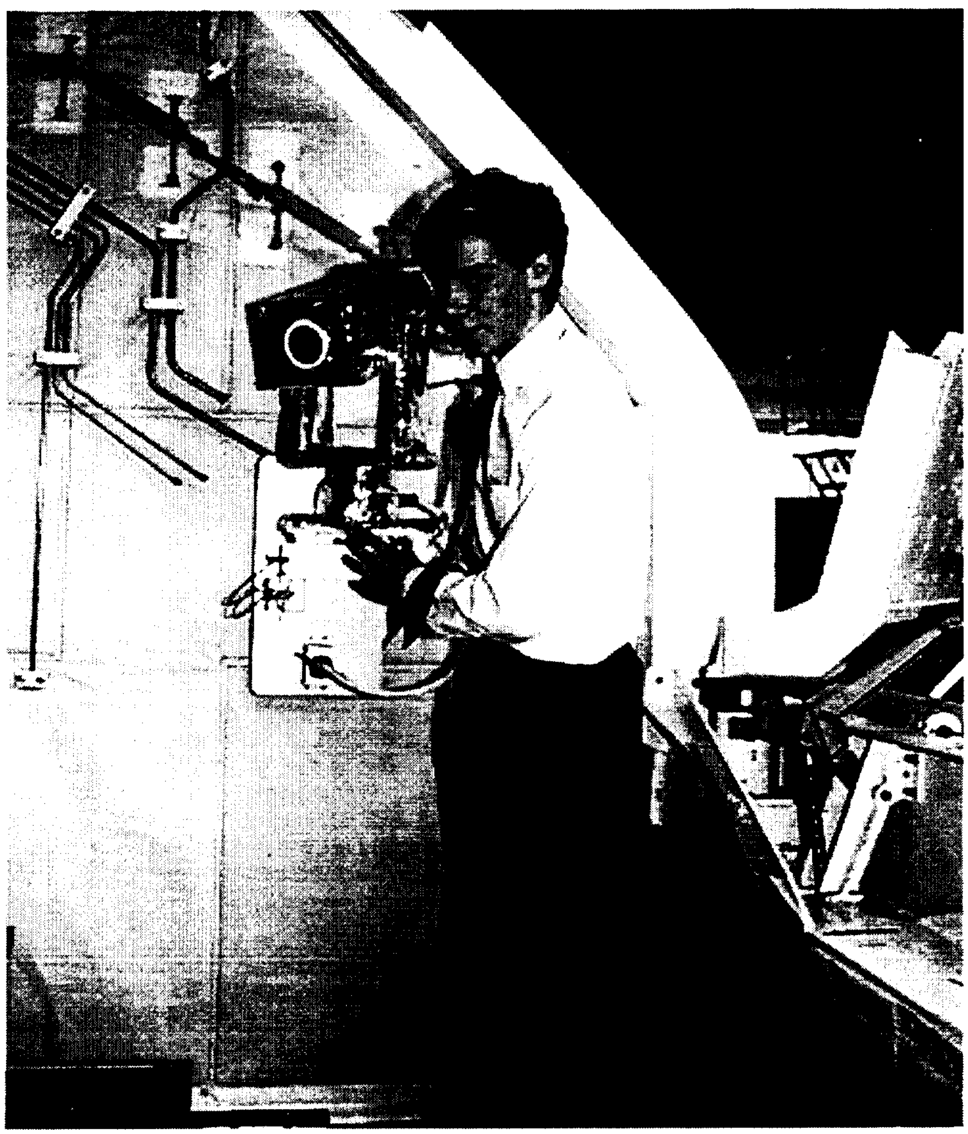

*Figure 18: Josh Lane with the Orbiter video camera.*

# III. Mission Operations

## 3.1 Mission Design

The orbits for the shuttle missions to the Mir Space Station were all circular low-Earth orbits and were specifically designed to dock the shuttle with Mir. The orbit for Mir is about 400 km altitude with a 51° inclination, therefore the shuttle needed to be in this same orbit for docking. After launching from Kennedy Space Center, approximately two days of orbiting and maneuvers were required before the shuttle's orbit could be matched with the Mir orbit.

While docked to Mir, the shuttle's windows faced the Mir station. Although looking at the Mir hardware might be interesting, the primary goal of the KidSat mission was to look at Earth. Therefore the time periods before and after docking, when the shuttle flew in a payload-bay-to-Earth, Z-axis Local Vertical (-ZLV) attitude, were of key interest.

For more information about KidSat operations, see Rackley, 1999.

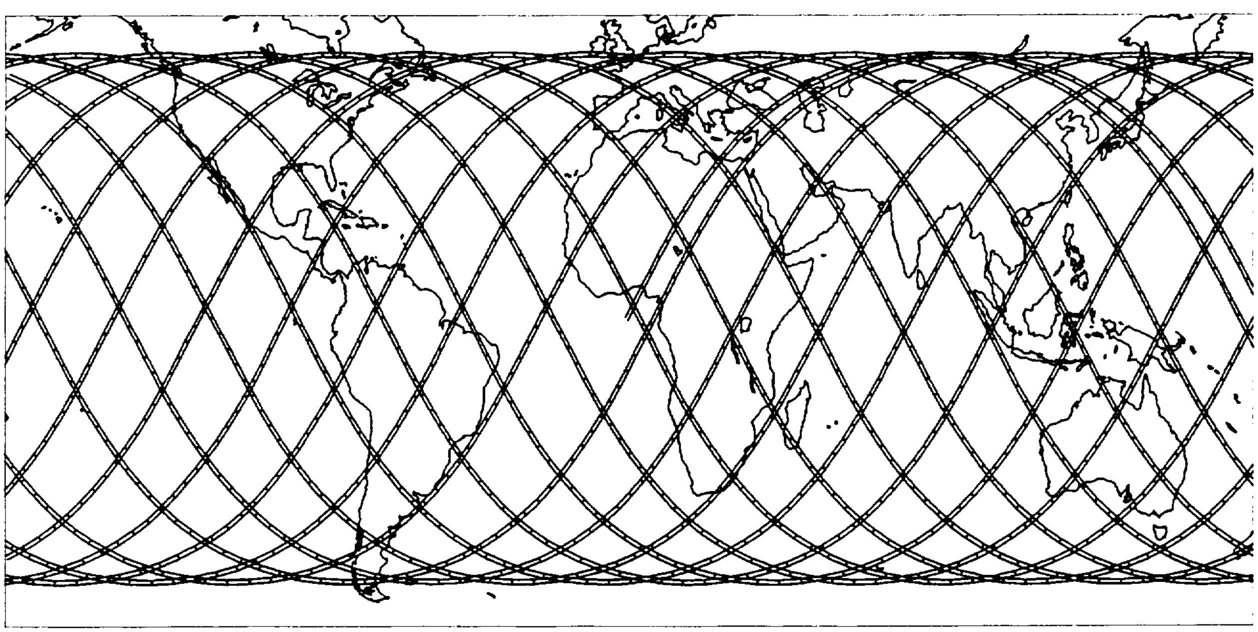

*Figure 19: Potential day coverage for the KidSat camera. Swath width is shown to be 100 km—actual options for KidSat were 40 to 225 km, depending on the lens and altitude at the time of imaging. The longitude of the ascending node of the orbit in this figure is 0.0°; this parameter changes from day to day and mission to mission, thus sliding the orbits to the left or right.*

*Figure 20: Sally Ride discusses a simulation with UCSD students.*

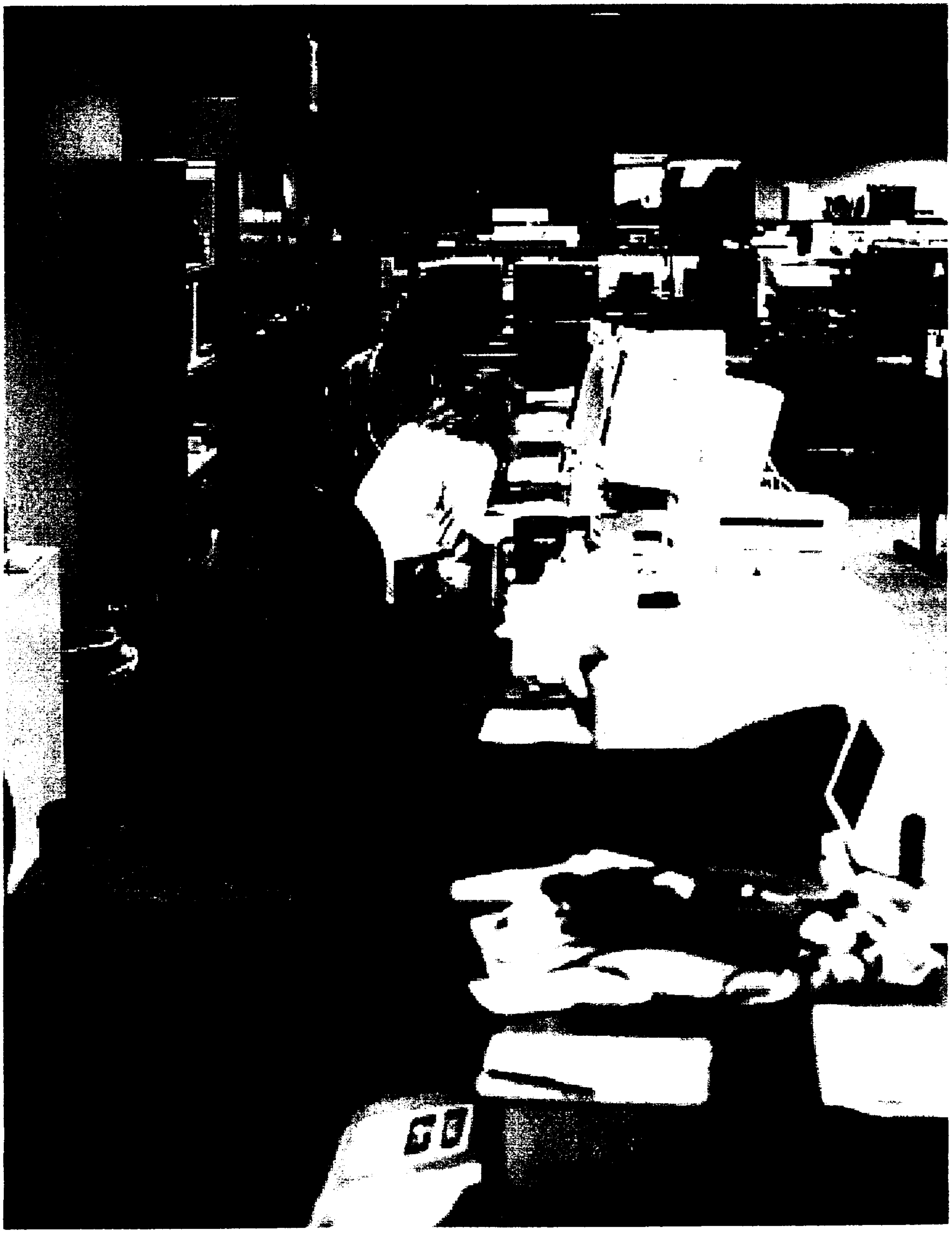

Figure 21: Johnson Space Center KidSat/ESC Payload Operations Control Center.

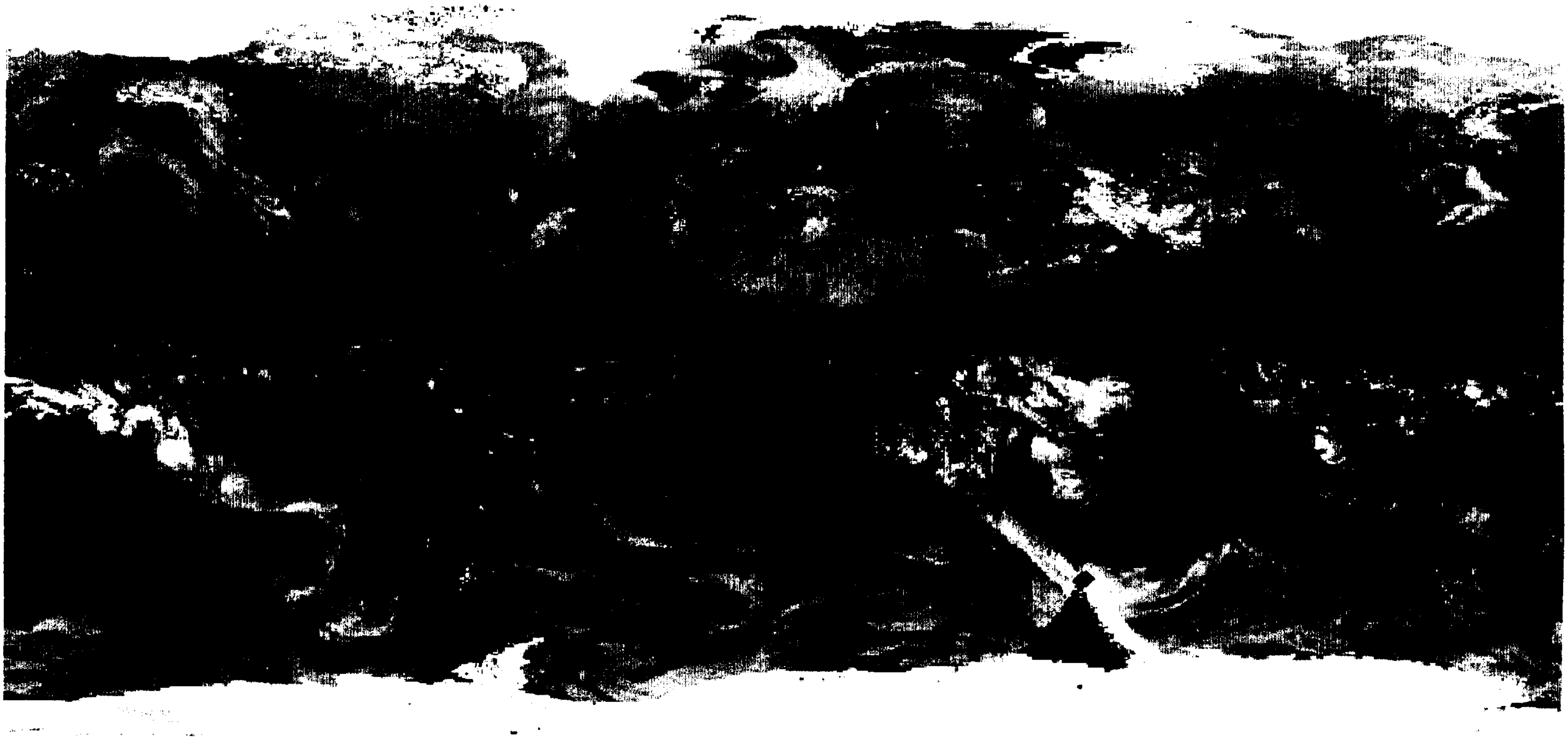

*Figure 22: Images taken on STS-86 during the course of one day. The images were overlaid in a global weather map generated from satellite data on flight day 2. This figure demonstrates the challenge in taking a cloud-free image.*

### 3.2 Mission Operations Element

The Mission Operations element of KidSat was responsible for executing the mission. In order for students to take pictures of the Earth, they were required to investigate aspects of the shuttle orbit, the mission timeline, and weather.

One key to the success of the KidSat project was the development of a mission operations scheme that could be scaled to allow many classrooms around the country to actively participate in the program. The Mission Operations component of KidSat was one of the elements that gave the students ownership and made them participants instead of observers. The Mission Operations tools allowed them to decide which pictures to take, to communicate their plan to the camera in space, and to monitor the camera while it executed their instructions. In discussions with teachers and students during the development phase of the project, it became clear that one of the compelling, exciting, and engaging aspects of the project was the involvement students had in the planning and execution of the flight.

The Mission Operations structure was designed to be interactive and dynamic. It consisted of:

- Student Mission Operations Centers (SMOCs) in the middle schools, where the initial planning took place both before and during the missions,
- links from the schools to a KidSat Mission Control Gateway at UCSD, where these observation plans were verified and coordinated, and
- links from the Gateway to the Mission Control Center (MCC) at JSC, where students' instructions were sent to the camera in orbit and other students in the Gateway accessed the latest shuttle orbit and timeline information.

The role of the Mission Operations Team was to develop the infrastructure, tools, and support for the SMOCs and the Gateway. The Mission Operations Team was made up primarily of undergraduate students from the University of California, San Diego. High School students from Merrill West High School in Tracy, California, and El Cajon Valley High School in El Cajon, California, as well as high school students from the KidSat Flight team, also participated during the missions. The team was led by Dr. Sally Ride, a professor of physics at UCSD.

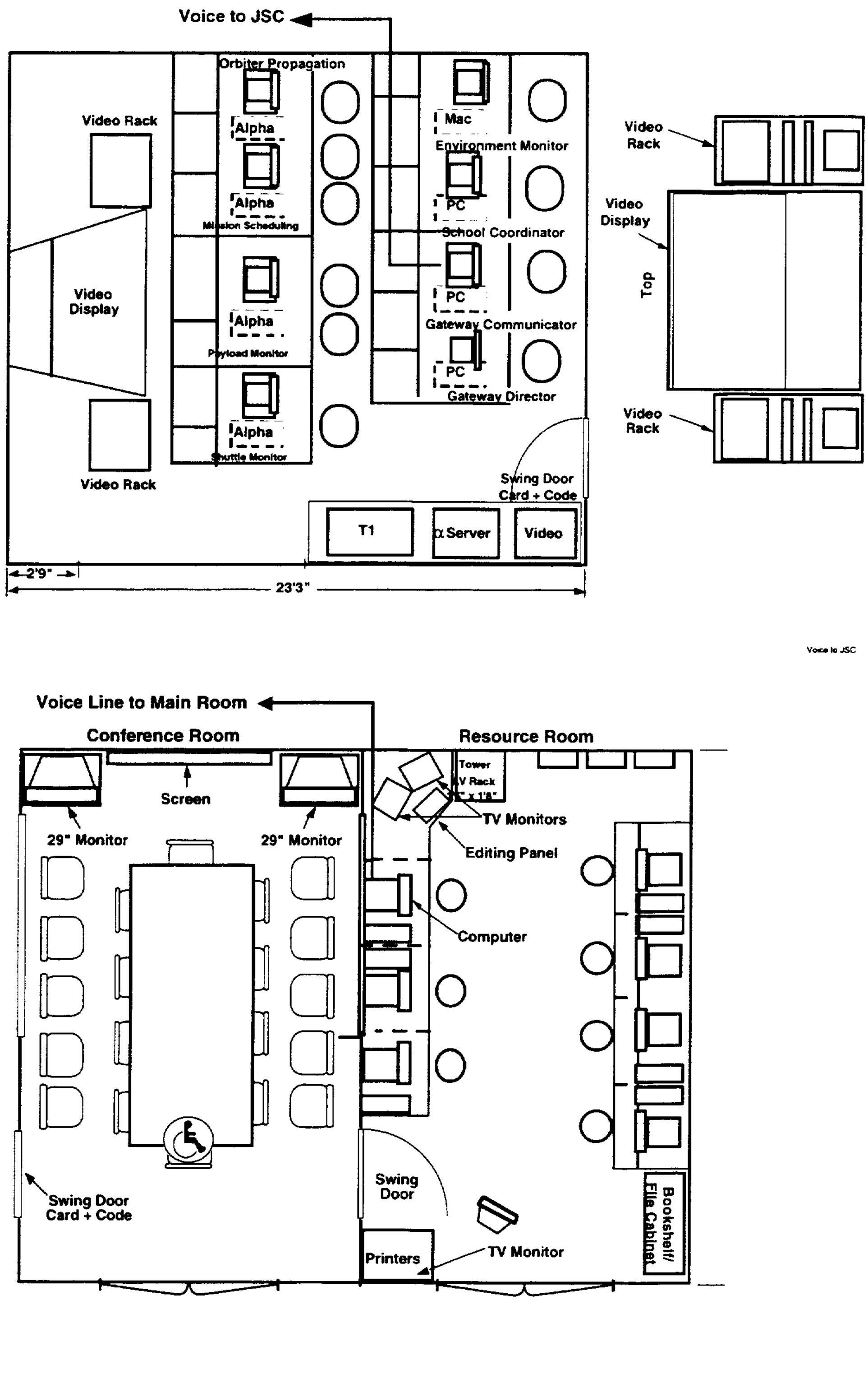


*Figure 23: Room layout for the Mission Control Gateway (top) and for the conference and resource rooms (bottom).*

### 3.3 Mission Control Gateway

The KidSat Mission Control Gateway (MCG) was the heart of the KidSat Mission Operations System. It functioned like a remote Payload Operations Control Center (POCC), connecting the investigators (in this case, the students in their classrooms) to their instrument, and was modeled after the new Space Station Mission Control Center at JSC. The KidSat MCG was designed by a team of undergraduate students. This team identified the functions of the Gateway, and from those functions defined the requirements for hardware, software, information, and resources such as TV monitors, headsets, etc. A prototype was developed based on this work, and the students' preliminary design was reviewed in the spring of 1995. The communications links were also designed and established by a team of undergraduates. This team identified the hardware and software requirements for the link between the Johnson Space Center MCC and San Diego's MCG, and links between the Gateway and the pilot schools.

The Gateway communicated with the ESC Payload Operations Control Center (POCC) at JSC via a dedicated T-1 line through eight voice loops and a high-speed data line. The Gateway's mission support functions and Internet interfaces were operated using software that was written by UCSD students. The voice loops provided students at the Gateway and at the Data System at JPL the ability to monitor the conversations of the crew—the Flight Director, ESC Coordinator, Integrated Communications Officer, and Payload Officer—and to communicate with the JSC POCC.

In preparation for the flight itself, the SMOCs and the Gateway developed a pre-flight timeline based on expected weather and lighting conditions, and the shuttle's orbit. They developed the tools needed to track the mission and update the potential coverage of the shuttle using Satellite Tool Kit (STK) software. During the weeks preceding the mission, simulations of the mission were run to refine procedures and give students practice for the real mission. During the flight, students at the pilot program schools were able to monitor the shuttle flight, the status of the KidSat instruments, and weather conditions around the world. This information was provided by the KidSat Gateway, which relayed telemetry, flight information, and weather information over the Internet in a format compatible with the computers at the SMOCs. This information gave the middle school students the ability to follow and participate in the flight, and to modify or update their scheduled observations.

*Figure 24: Mission Control Gateway at UCSD as configured for STS-76.*

### 3.4 Student Mission Operation Centers

Since students were the main focus of KidSat, emphasis was placed upon the Student Mission Operation Centers (SMOCs). Students in the SMOCs had the responsibility of determining where to take pictures and validating the information associated with their pictures. In the middle schools, small versions of JSC's Mission Control Center were set up so that students could perform mission operations tasks during the KidSat missions. Using the Internet and Web pages designed specifically for KidSat operations, students were able to:

- determine where they wanted to take pictures,
- determine the specific MET time to obtain these pictures,
- submit these times to the Gateway at UCSD,
- monitor the validity of their commands and modify them if necessary,
- monitor the progress of the mission,
- determine whether their photographs were successfully taken,
- download the photographs from the KidSat Data System as soon as they arrived at JPL, and
- validate their location and the associated information.

#### *3.4.1 SMOC Configuration*

There were a variety of SMOC configurations. Some schools involved only one class in a SMOC and some incorporated classes from many schools in their district. Some SMOCs were set up in classrooms and others in dedicated areas. Some SMOCs operated only during school hours while others included after-school or even all-night operations as the KidSat camera continued its operations 24 hours a day.

#### *3.4.2 Computers*

A minimum computer platform configuration was necessary to support SMOC activities. Mission operations activities included performing off-line and on-line mission planning, using real-time telemetry, sending and receiving e-mail, electronically submitting image requests, and accessing weather and other available information via the Internet. Thus, the minimum SMOC computer had to be capable of using Netscape browser software, accessing the KidSat Mission Control Gateway over the Internet, and viewing and using the information provided in various forms. Students at the Gateway determined that a minimum of three SMOC computers could perform all of the duties necessary for KidSat missions operations. The specifications for the computers are included in Table 1.

#### *3.4.3 Tools*

SMOCs also used a variety of other tools including atlases, clocks showing MET and local time, maps, and books. A key tool was a slider map that showed Earth and the current shuttle orbit. The position of the orbit was specified by the equatorial node crossing. These node crossings were supplied by the Gateway as part of the SMOC Web pages. In addition, a series of guides and handbooks were developed by the Mission Operations team to support teachers in the operation of their SMOCs.

#### *3.4.4 Positions*

All positions in the SMOCs were staffed by students, but the Missions Operations Director set the tone and pace for the center. Each SMOC had a slightly different set of positions. The positions for the Redwood SMOC and each position's responsibilities are shown in Table 2.

#### *3.4.5 Training*

Students and teachers worked with the KidSat curriculum to study the logistics of an upcoming mission. They learned the skills necessary to participate in the KidSat missions. These skills were reinforced through a series of simulations (SIMs) of the actual mission. These SIMs were designed by the Gateway to provide practice and experience for the SMOCs before the actual mission. The first part of the actual mission provided the best practice—in most cases, the SMOCs revised their operation scenario and target selections considerably during the time the shuttle was docked with Mir and KidSat was not in operation.

*Table 1: SMOC Computer Minimum Configuration*

Macintosh: Performa 500 or 600 PowerPC series

- 8MB RAM
- 500MB hard disk
- Mac OS System 7.1 or higher
- Ethernet port (included with CPU)
- 14-inch high-resolution color monitor with 256 colors
- Sound (included with CPU)
- CD-ROM (highly desirable)

PC: 486 processor (or faster) using Microsoft Windows

- 8MB RAM
- 500MB hard disk
- Microsoft Windows 3.1 or higher
- Ethernet port
- 14-inch SVGA color monitor with 256 colors
- Sound card
- CD-ROM (highly desirable)

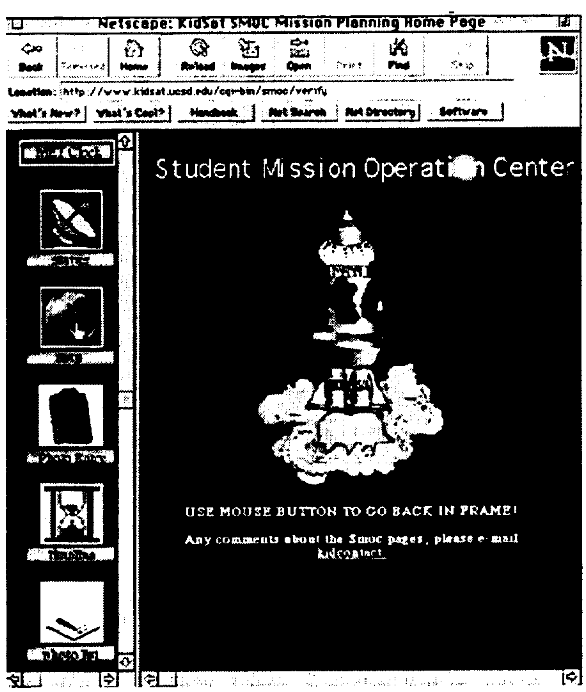


*Figure 25: The Mission Operations SMOC home page, generated by undergraduate students.*

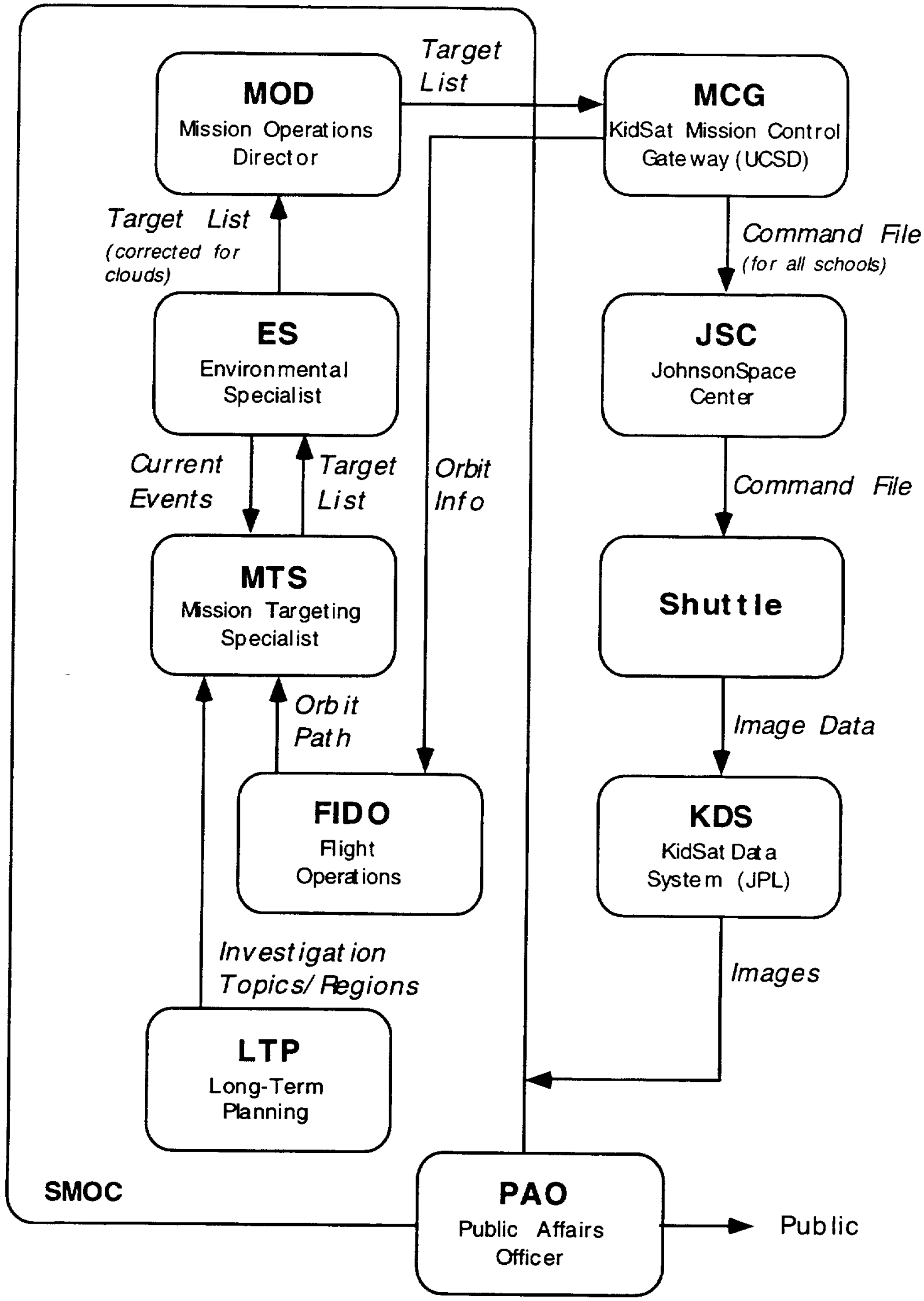


*Figure 26: Flow of information as organized by the Redwood SMOC.*

*Table 2: SMOC Positions (Redwood SMOC)*

MOD: Mission Operations Director

- Oversees all SMOC activities
- Directs all briefing sessions
- Maintains constant contact with all team members on shift
- Inputs data from completed Mission Target Planning forms to Gateway
- Updates target status on whiteboard
- Updates binder containing Mission Target Planning forms
- Reviews MOD journal from prior shifts
- Records shift information in MOD journal

FIDO: Flight Dynamics Officer

- Monitors KidSat Web pages
- Records: orbit numbers, descending nodes, and day/night terminators
- Reports working orbits, present orbits, and target due times
- Reads and interprets orbital maps as needed
- Reads and evaluates Crew Timeline, and relates to photo opportunities
- Reviews target sheets for day/night availability, camera availability, and shuttle position
- Gives targets to SMOC commanders for assigned code words, or returns them to Mission Targeting Specialist (MTS) for retargeting with reason
- Operates land phones, facsimile, and e-mail communication as necessary
- Reviews FIDO journal from previous shift
- Records all shift information in FIDO journal
- Participates in debriefing and briefing activities

LTP: Long-Term Planner

- Develops preflight list of targets based on PI/class investigations
- Predicts upcoming photo opportunities of PI/class site from chart list
- Utilizes slider map to predict possible targets to support PI/class
- Completes appropriate LTP form
- Informs MTS of latitude and longitude of proposed targets on MTS form
- Retargets appropriate orbit according to priority list of PI/class investigations
- Checks mission images; flags them for future PI/class investigations
- Keeps the PI/class investigations chart updated
- Reviews LTP journal from previous shift
- Records all shift information in LTP journal
- Participates in debriefing and briefing activities

*Table 2: SMOC Positions (Redwood SMOC) (cont.)*

MTS: Mission Targeting Specialist

- Checks accuracy of LTP forms
  - Determines photograph availability of LTP targets
  - When targets cannot be replanned, returns rejected forms to LTPs
- Researches new targets using computers and slider maps
  - Fills out top section of Mission Target Planning forms
  - Clips LTP sheets to back of Mission Target Planning forms
- Gives both sheets to environmental specialist (ES)
- Reviews journal from prior shifts
- Records shift information in the MTS journal
- Participates in briefing and debriefing sessions

ES: Environmental Specialist

- Monitors environmental status
- Maintains a record of upcoming environmental and weather conditions
- Informs MTS of any changes which may affect mission plan
- Is responsible for weather data on targets
- Is responsible for current event computer—news Web sites
- Posts pertinent anomalies which may affect targeting plan
- Is responsible for use of slider maps and other materials to predict weather
- Maintains computer connection with a variety of environmental sites.
- Reviews ES journal from previous shift
- Records all shift information in ES journal
- Participates in debriefing and briefing activities

IP: Image Processor

- Masters the use of NIH Image
- Utilizes the KidSat macros
- Establishes the geographic locale of image
- Validates the orientation of image with placement of compass rose
- Identifies landforms and other features
- Sets scale and verifies image dimensions
- Validates image and submits to Data System
- Maintains communication with NIH Image technicians

*Table 2: SMOC Positions (Redwood SMOC) (cont.)*

| |
|---|
| PAO: Public Affairs Officer<br>• Keeps track of key SMOC events<br>• Speaks to press, other media, and local community organizations<br>• Welcomes and directs SMOC guests<br>• Prepares press briefs and daily bulletins<br>• Follows important events on NTV<br>• Notifies SMOC of upcoming mission events<br>• Reviews PAO journal from previous shift<br>• Records shift information in PAO journal<br>• Participates in briefing and debriefing activities |

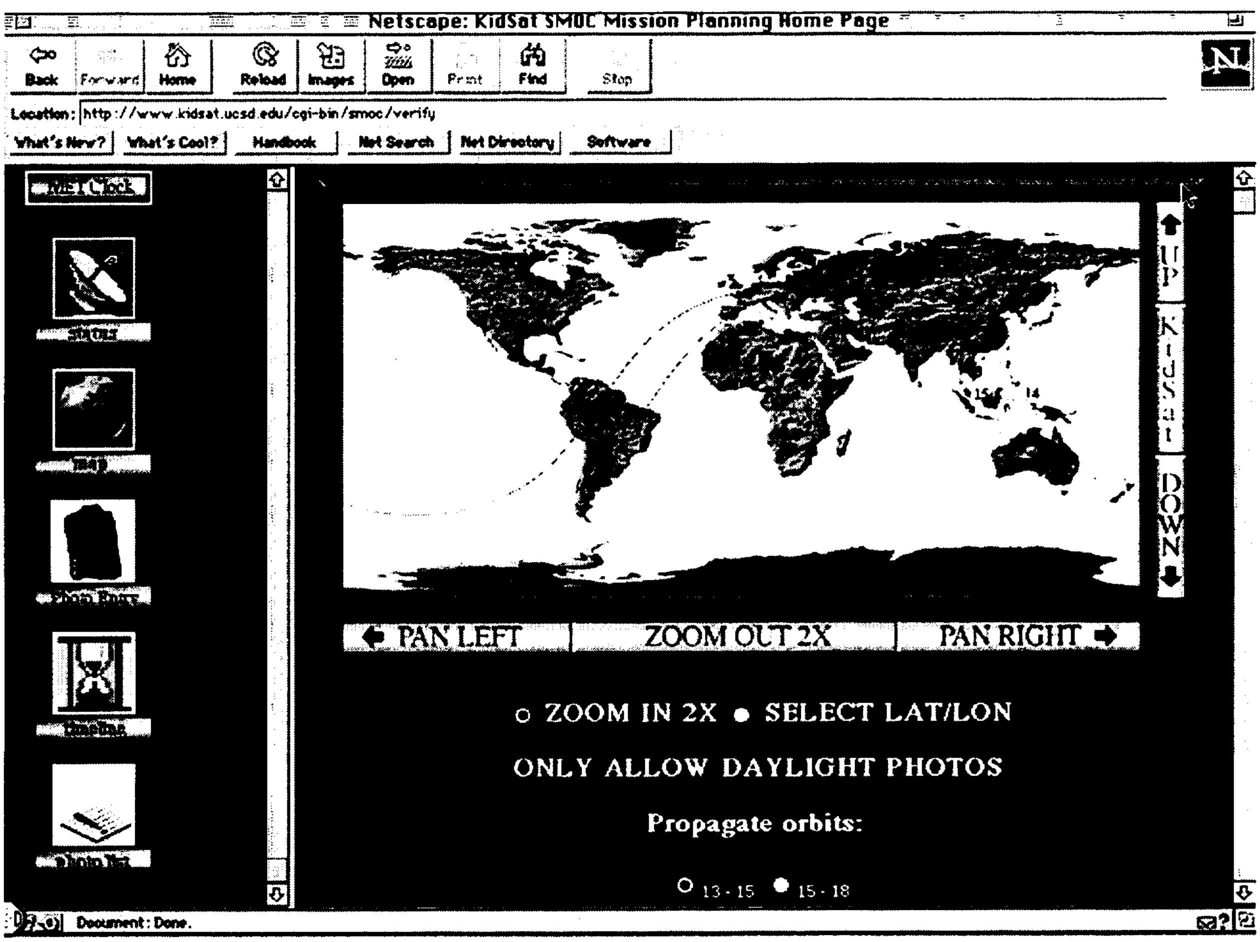


*Figure 27: Orbital map on the Mission Operations Web page, showing the orbit tracks for a portion of the mission.*

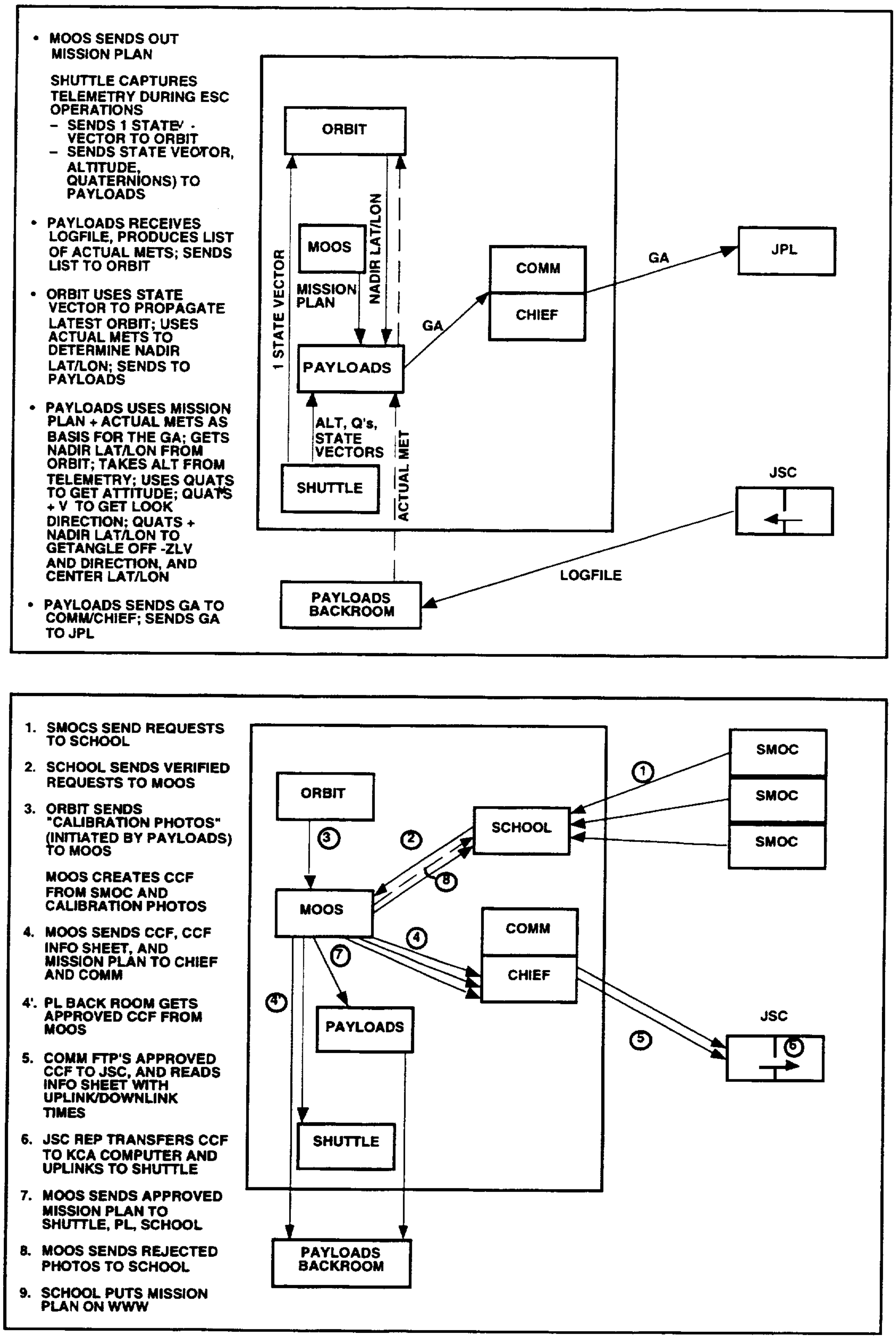


*Figure 28: KidSat flow of information in the Gateway for GA generation (top) and photograph selection (bottom).*

## 3.5 Mission Operations Scenario

Before each mission, the Gateway acquired orbit parameters from JSC, based on the best planning information. A set of maps was generated that showed the orbit tracks for times during the mission when the KidSat camera would acquire photographs. These maps were put on-line for access by the SMOCs. The teams in the SMOCs selected the times they wanted to take pictures, based on the locations of the orbit tracks on Earth during the daylight portion of the orbit. These student requests formed the pre-mission plan that was launched with the shuttle as a backup CCF.

After launch, a new set of orbit parameters was distributed periodically from JSC, based on the latest predictions for the orbit. These new parameters were used to update the orbit maps on-line. The SMOCs revised and added to their selections, based on the updated tracks and the development of actual weather conditions or events taking place on Earth during the mission.

The Gateway accepted new photograph requests from the SMOCs until ninety minutes before the orbit on which the photographs would be taken. Photograph requests from all schools were compiled and verified. Improper requests were returned to the SMOCs where they were either deleted or resolved and requested again. Each request included a priority which helped the Gateway determine which image would be acquired when a conflict between two or more schools occurred.

The verified set of requests formed the CCF and was sent to JSC. Then the CCF was relayed to the shuttle on the night side of the orbit immediately preceding the daylight photograph period. Once the photographs were taken, the images were downlinked on the night side of the orbit following the image acquisitions. The images were immediately sent by the KidSat POCC to JPL and UCSD. The images were placed on the Web at JPL and checked for engineering problems at UCSD. A Generated Annotation (GA) file was made at the Gateway, based on each orbit's photograph requests, and sent to the Data System. This file was used to document the location, requesting school(s), and preliminary image-content information for each acquired photograph.

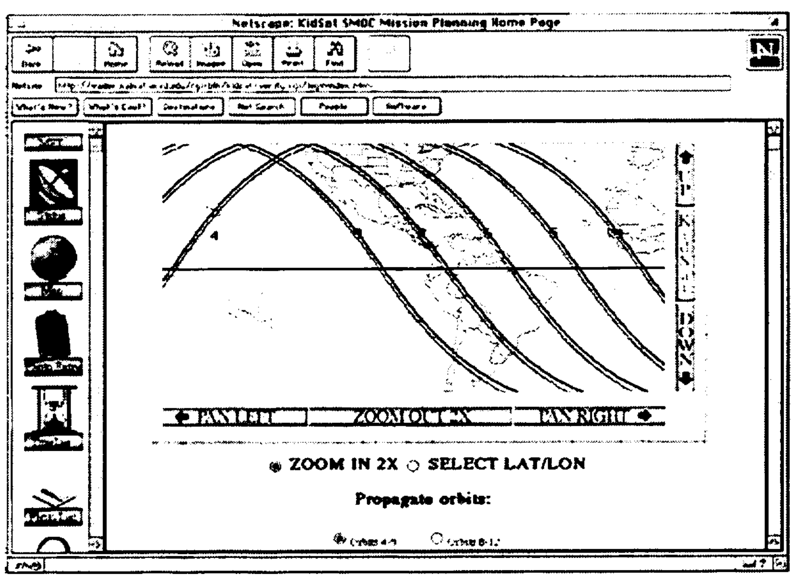


*Figure 29: A detailed orbit map from the Mission Operations Web page.*

# IV. Data System

The KidSat Data System was responsible for acquiring, making accessible, and archiving the KidSat images once they reached the ground. Additionally, the Data System was responsible for providing KidSat students with the image processing and scientific visualization tools to analyze the data. Finally, the Data System was responsible for providing the technical assistance required by the middle schools.

The Data System was developed to take full advantage of existing information systems technologies while being flexible enough to benefit from new technologies as they emerged. The Data System transferred the image data from JSC to JPL using the NASA Science Network (NSN), processed the images from their raw 6.4MB format to their full 18MB file and placed the images on-line in one format. This format was easy to view and search by students using computers and Internet connections that were typically found in middle schools, along with tools to analyze the images quantitatively (including NIH Image). In addition, some of the images were manipulated at JPL's Digital Image Animation Lab (DIAL) into a variety of visually interesting products as preparation for future activities in the classrooms. Additional information provided as part of the Data System consisted of:

- satellite weather maps,
- digital Jet Navigation Chart (JNC) maps,
- data describing the shuttle orientation and location, and
- links to other remote sensing data, especially photographs from other shuttle missions.

The Data System team was centered in the DIAL at JPL and was supported by the Solar System Visualization Team. The Data System team's goal was to deliver the images to the schools in the most exciting ways that were technically possible while using formats appropriate for school computers. In addition, the team excelled in accommodating requests from teachers and students for improving the system to make it more usable in classroom environments. The team was made up of students from La Cañada High School, La Cañada Flintridge Preparatory School, undergraduates from Harvey Mudd College, USC, the California State Polytechnic University in Pomona, and the University of Nebraska; and engineers from JPL's Cartographic Application Group, Multiple-Image Processing Lab (MIPL), and DIAL. Weather data were obtained from the University of Wisconsin. The Data System team was led by Paul Andres, an engineer at JPL. For more information about the KidSat data system, see Andres et al., 1999.

*Figure 30: Students at WALC use the Internet to download images from the KidSat Data System, with the assistance of the JPL Data System team leader, Paul Andres.*

Figure 31: Roger Kassebaum and Casey Kirchner, at the Johnson Space Center POCC, assist with the transfer of the images from the MCC to JPL, during STS-76.

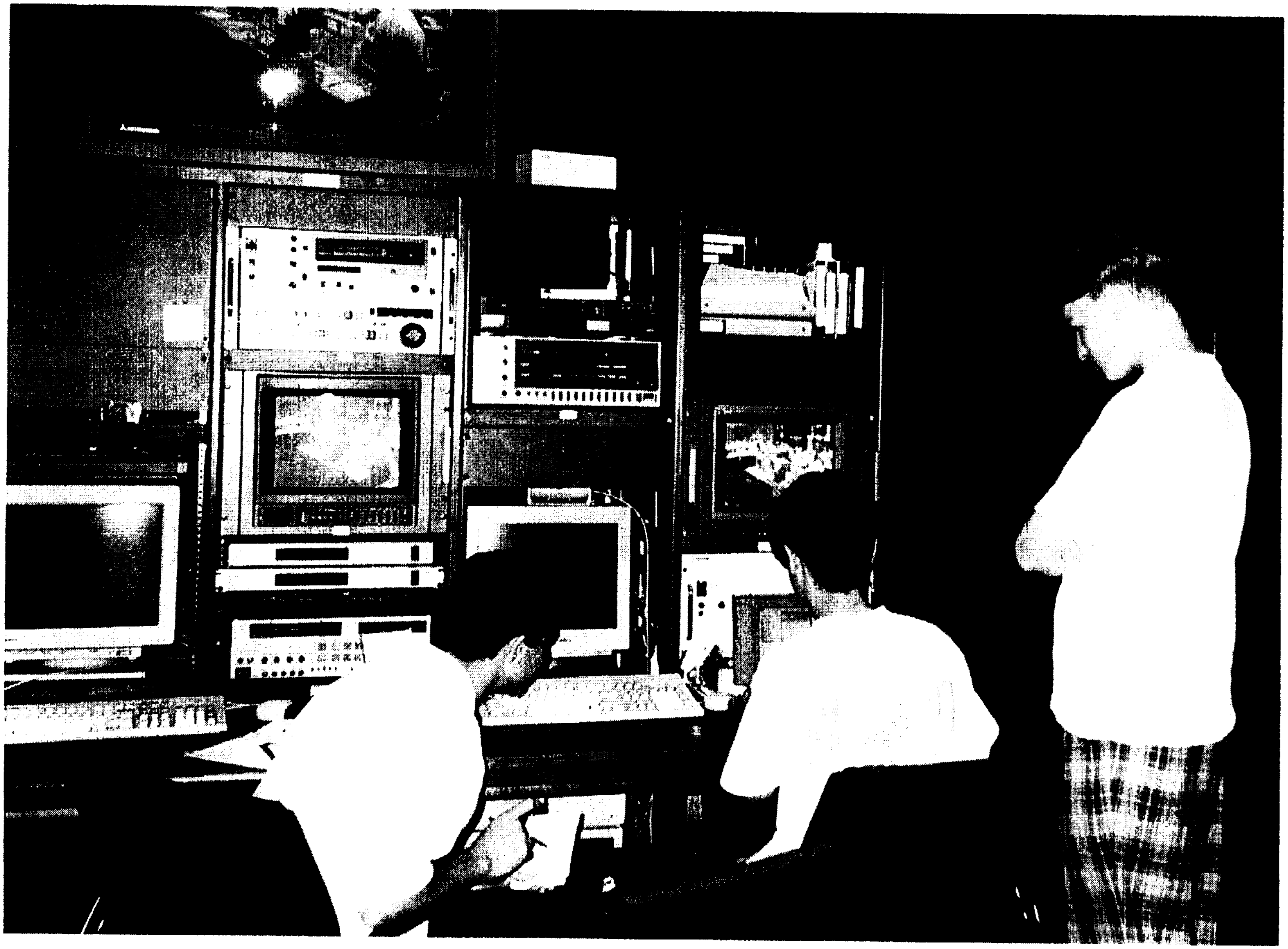

Figure 32: La Cañada High School students capture data at the KidSat Data System, located at the JPL Digital Image Animation Lab, during the STS-76 mission.

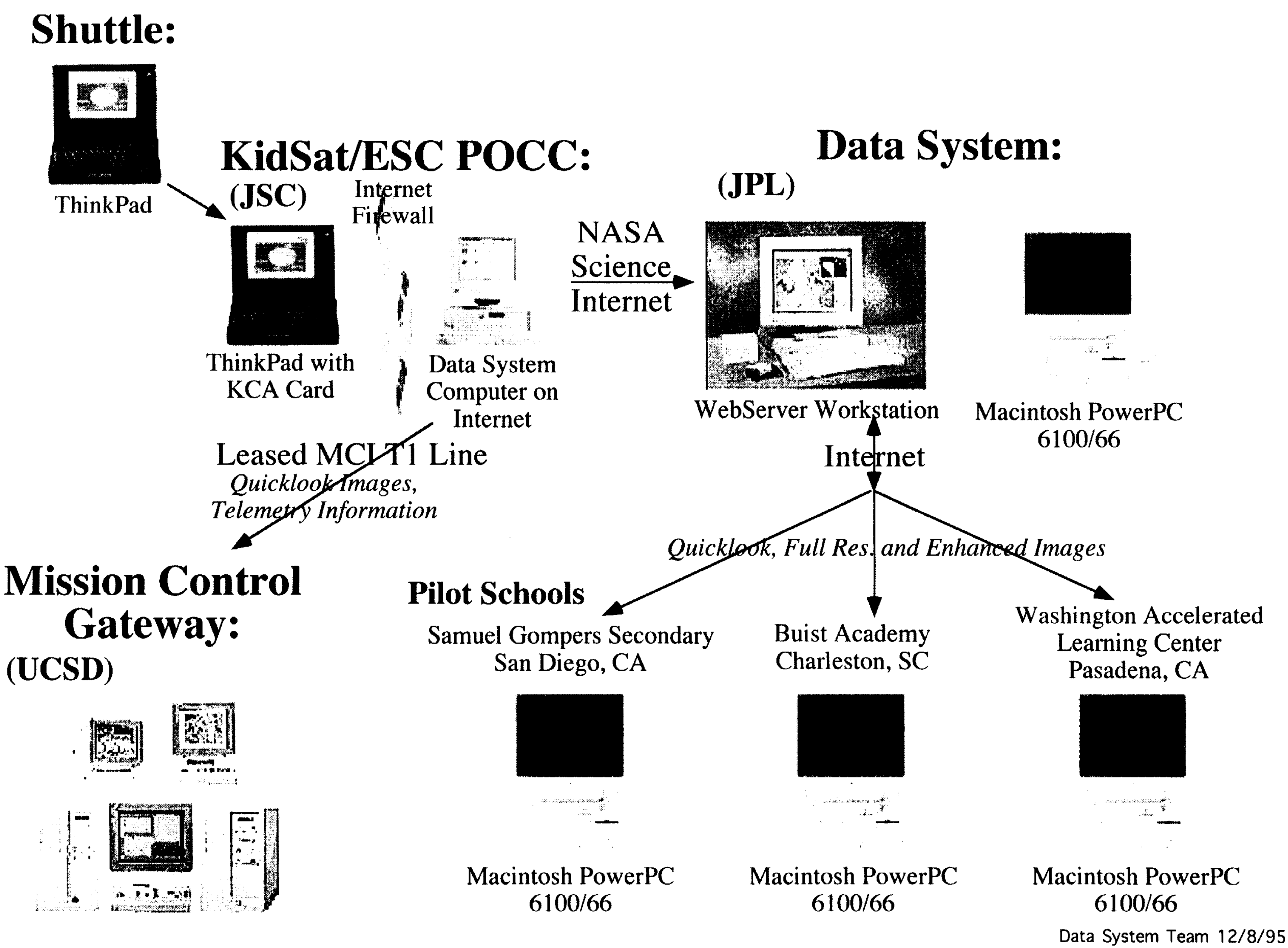


Figure 33: KidSat Data System flow diagram.

## 4.1 Data System Design and Image Flow

The overall design for the KidSat Data System focused on the use of the Internet to link students in classrooms to the images. The images were transferred from the shuttle to JSC using the TDRS system and the KCA/OCA capabilities. The KCA/OCA computers at JSC were protected from outside manipulation and therefore were not connected to any outside computers. Because of this, students on the Data System team in the JSC POCC manually transferred the image files to a floppy disk, then to a computer that was connected to the Internet. In other words, they transferred the images by "Sneaker Net." From there, the files were transferred using the NASA Science Network, a dedicated NASA Internet connection, to JPL. For the second and third flights, an electronic firewall was set up between the OCA computer and a File Transfer Protocol (FTP) computer linked to the Internet. By the third flight, the files were automatically transferred to JPL using a program that "watched" for new files on the FTP computer, then automatically pulled those files to the Data System via FTP. Once they arrived at JPL they were processed, contrast enhanced, and placed on the Web so that they were immediately accessible. The ancillary data that describe the image location, and information from the requesting classrooms were received via FTP from the Gateway and were developed using shuttle telemetry data and the requests input from the classrooms.

In the classrooms, students used computers linked to the Internet to download the images for analysis and to upload annotated images and explorations. The characteristics of the classroom computers were specified to ensure low cost to the schools and enough power to allow easy manipulation of the images and timely downloads from the Internet.

*Table 3: Specifications for School Computers for Interfacing with the KidSat Data System*

| |
|---|
| Power Macintosh 6100/66 AV |
| 1MB video RAM |
| 16MB memory |
| 17-inch MultiSync color monitor |
| CD-ROM (double-speed) |
| 1 GB hard disk |
| Extended keyboard |
| Ethernet connection |
| Apple Color LaserWriter 2400 (double-speed) or Hewlett-Packard 660C |

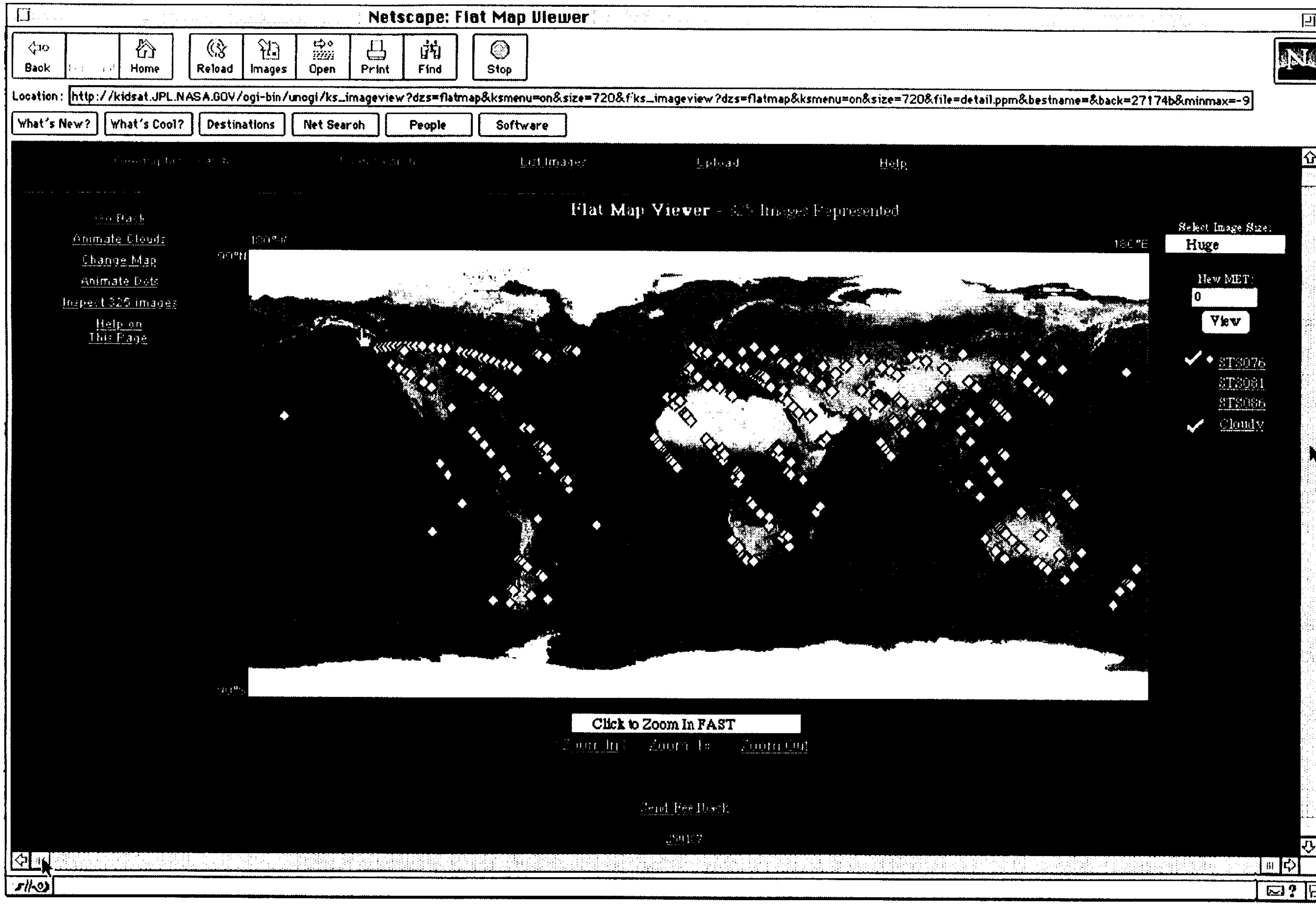


Figure 34: Data System Geographic Search page.

## 4.2 Image Formats

Each KidSat image is 18MB in its full processed standard TIFF form (3060 × 2036 pixels) and displays an area of 100 to 200 km on a side depending on the lens used to take the photograph. As part of the processing, the image file formats were converted to generic raw pixels and the images were sized down to include one fourth the resolution of the original image. These images were stretched, based on the maximum and minimum intensity of values of the green band and placed on the Web so that each image could be displayed as the full image, scaled to 720 × 479 pixels (1.011MB), or reduced so that a smaller portion of the image could be seen. Each zoom step reduced the size of the image by a factor of four. The image or the zoomed region could then be downloaded in a variety of image formats (GIF, JPEG, TIFF, PICT) and sizes (see Table 4).

*Table 4: Image Download Options*

| Image Resolution | Pixel Size | Data Download Size (kB) |
|---|---|---|
| Very High | 3060 × 2036 | 1624 |
| High | 1530 × 1018 | 406 |
| Moderate | 765 × 509 | 101 |
| Low | 382 × 254 | 25 |

## 4.3 Data System Interface

The Data System Web pages allow students to find, view, verify, and analyze the images in multiple ways. Three search options are available from the Data System page. The Latest Image Search engine presents the images in reverse time order, with the first image page displaying the latest images to arrive at the Data System. This option was most useful during the mission because students viewed the images for the first time as they were downloaded from space to the classrooms. The images are presented in thumbnail format with each image displayed as a 96 × 64 pixel (18kB) image. The Image Viewer function is accessed by clicking on the image of interest.

The Geographic Search option allows students to search any geographic area of interest by pointing and clicking on a map of the world. There are four types of maps that can be used as a search basis:

- an image map derived from a global mosaic of optical satellite images from the Advanced Very High Resolution Radiometer (AVHRR) instrument,
- a political map,
- a topographic map, and
- a weather map (also very useful during the mission to determine where to take a picture.)

Available images are shown on the map as colored, diamond-shaped icons with a different color for each KidSat mission. Students zoom in on the map or view a particular image by selecting the Inspect Images icon.

The last method for finding a particular image or set of images is the Form Search, which allows students to find an image by MET, by an attribute of the image, or by viewing a list of image names or thumbnails. Links at the top of this page provide helpful hints and a short tutorial on how to effectively use the Form Search. Searches by geographical content (e.g., images with rivers) are based only on the student validations—i.e., the students are responsible for providing the Data System with the image content.

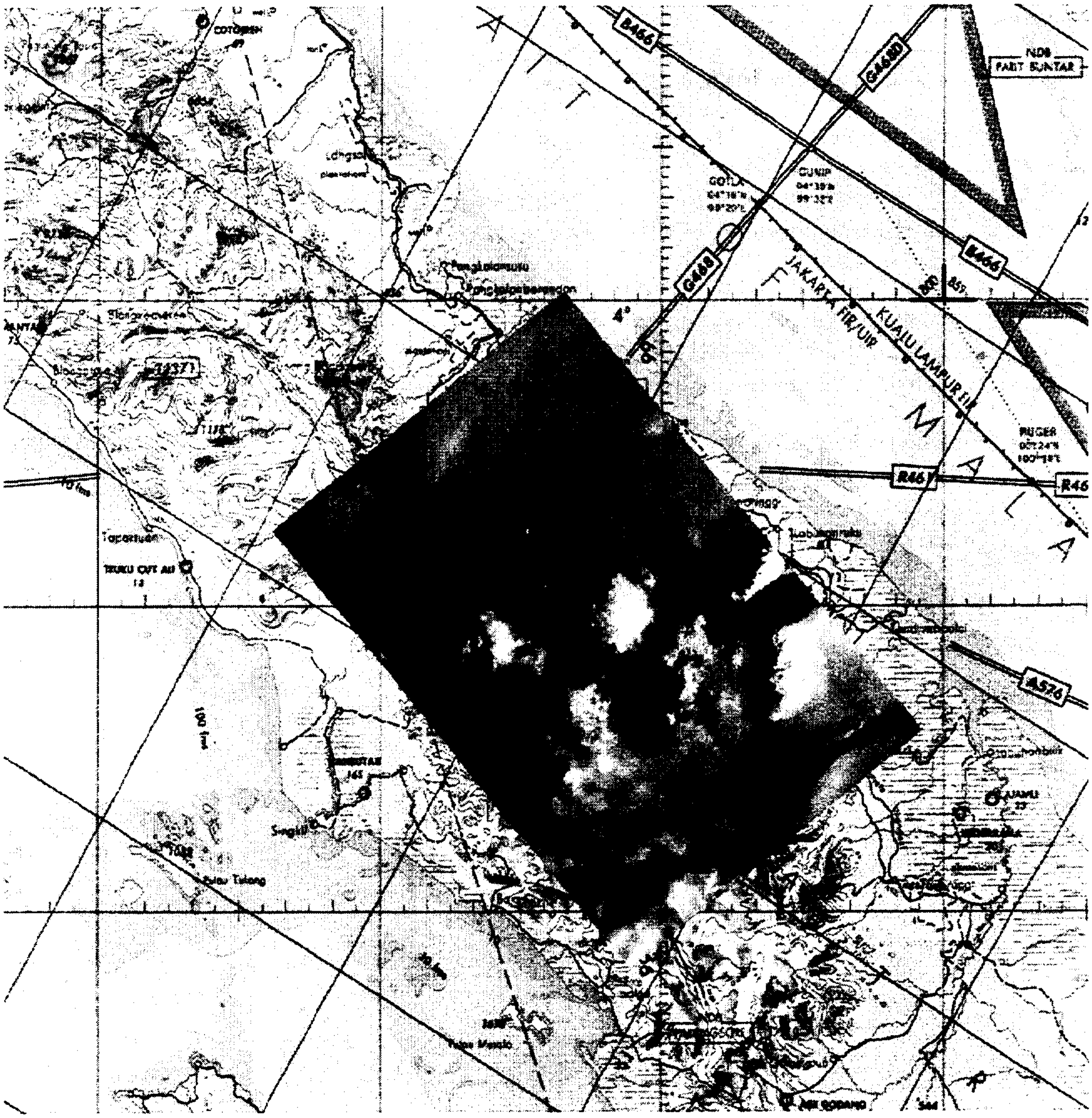


*Figure 35: Overlay of images of clouds on a JNC map of Sumatra. The overlay is a capability available from the KidSat Data System.*

Image Viewer is Web-based software that allows the KidSat user to view and download the image in various sizes, resolutions, and in four different data formats—PICT, TIFF, GIF, or JPEG. The viewer allows students to see the entire image at low resolution (720 × 479 pixels) or zoom in on a particular area of interest by pointing and clicking on the image. It also allows students to manipulate the image (rotate or flip it) using the KidSat Image Composer, which is accessible from Image Viewer. From this page, other viewing options are available:

- a 400 × 400 km digital Jet Navigation Chart (JNC) map (placed on-line as a 1024 × 1024 pixel image file) of the area surrounding the image,
- an animated replication of the weather at the time of KidSat image acquisition derived from 8 km/pixel global weather mosaics from Geosynchronous Operational Environmental Satellites GOES8 and GOES9, MeteoSat, and Geostationary Meteorological Satellite GMS-5,
- a detailed catalog of image information, and
- annotated images and image explorations created by students using each image.

After the last shuttle flight, a 1 km/pixel digital satellite map and a 1 km/pixel elevation map covering the same area as the JNC map were also made available.

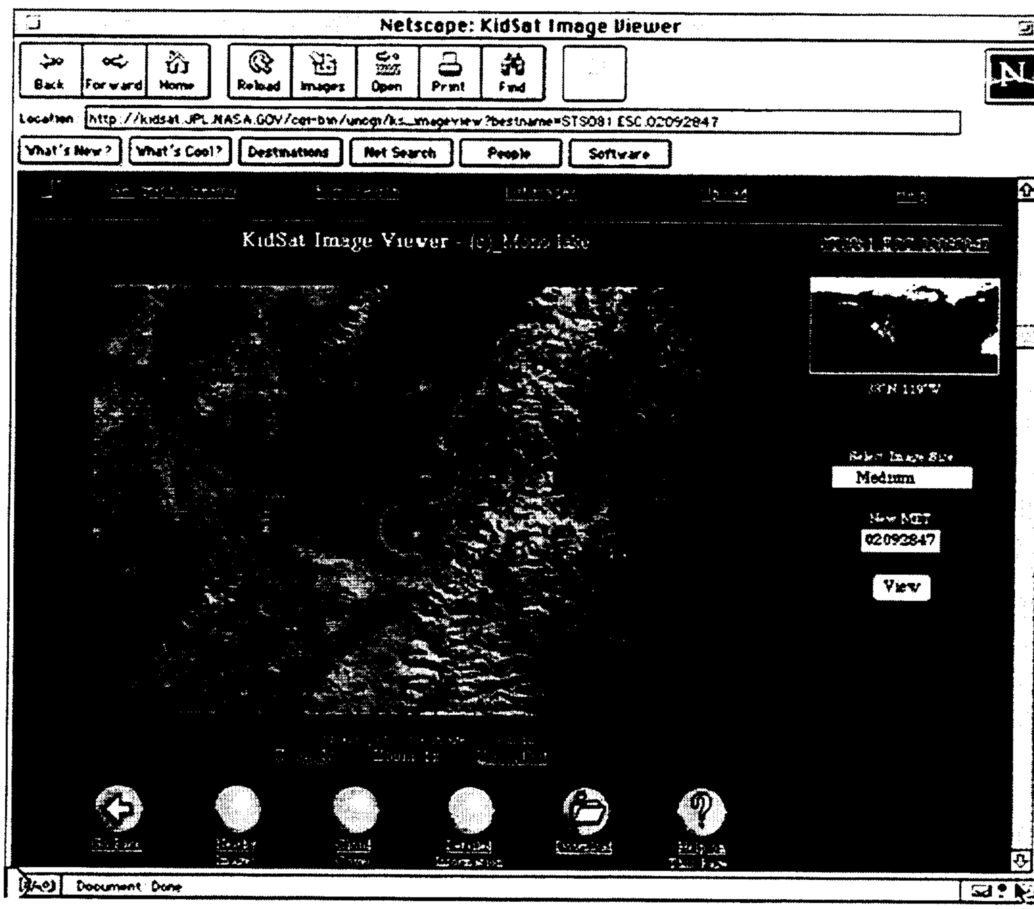


*Figure 36: Data System Web page showing the image as displayed to the students. Images may be downloaded from this page at a variety of resolutions and formats depending on the Internet capabilities of the schools.*

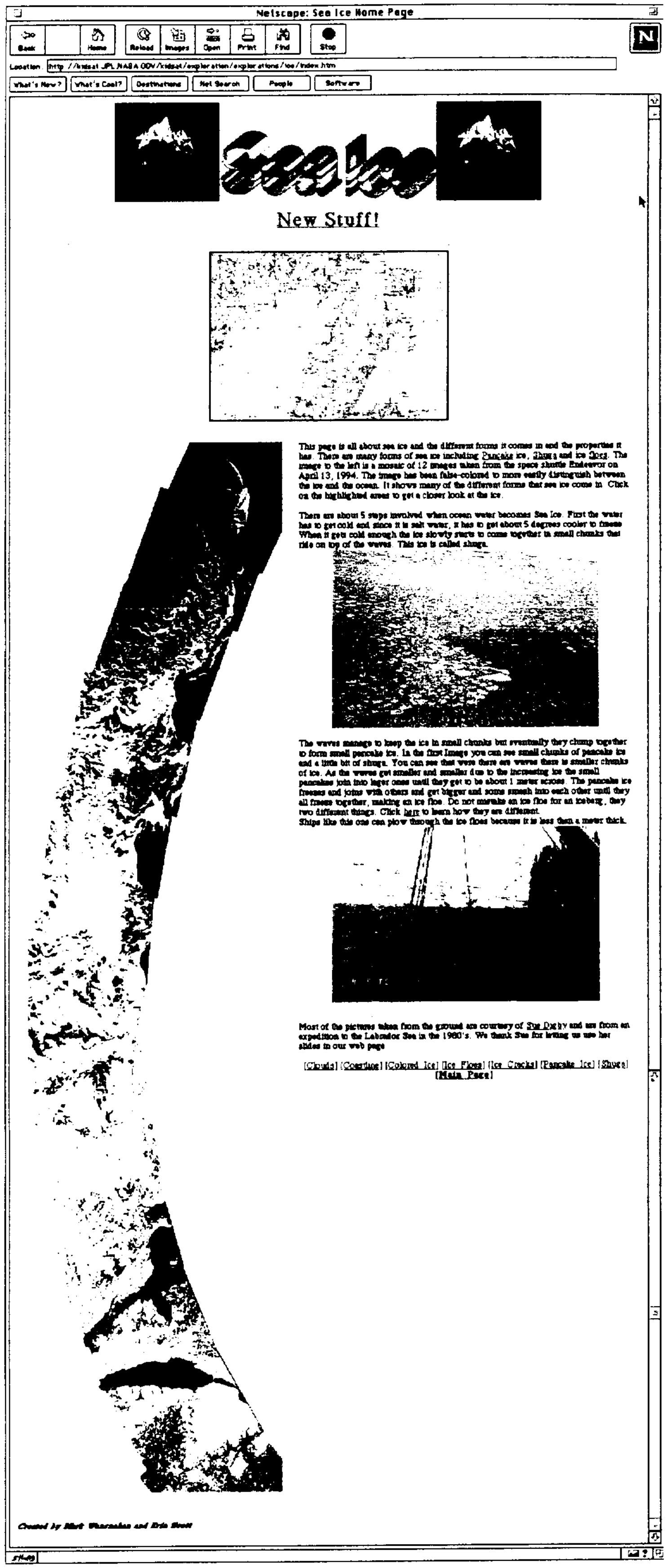


*Figure 37: Example of an Exploration on ocean ice generated by the KidSat Exploration team.*

## 4.4 Analysis of Images

Once students found the image they requested, there were several steps to pursue in the analysis. The first step, image validation, was required by the student who requested that image. The next two steps, annotation and exploration, could be carried out by any student or school for any of the KidSat images. Annotation and exploration were tailored to each classroom, depending on the teacher's curriculum decisions.

Validation was the process of verifying that the camera took the requested image and that the associated information was correct. In addition, validation provided information about the content of the image. This was used to find images in the Form Search option. The primary element of the validation procedure was to check that the assigned center latitude and longitude, orientation, and name were correct and to submit corrections when necessary.

Annotation involved determining image content, such as political or geographic information—the names of the mountains, rivers, cities, and borders. Annotation was the first step in researching the images. Political and geographic names were written directly on the images, and the images were submitted to the Data System for others to view. The primary tool used for image annotation was NIH Image. This program was selected for its ability to analyze images and because it is free and available on the Web (through a link on the KidSat Data System page).

Exploration, the most exciting step in analyzing an image, goes beyond naming the features in the image. Students were encouraged to find out what the images exposed about Earth's history, science, and geography. Explorations incorporated maps, weather data, books, the Internet, and other authorities. The discoveries made in exploring the images were compiled and submitted to the Data System for viewing by other students.

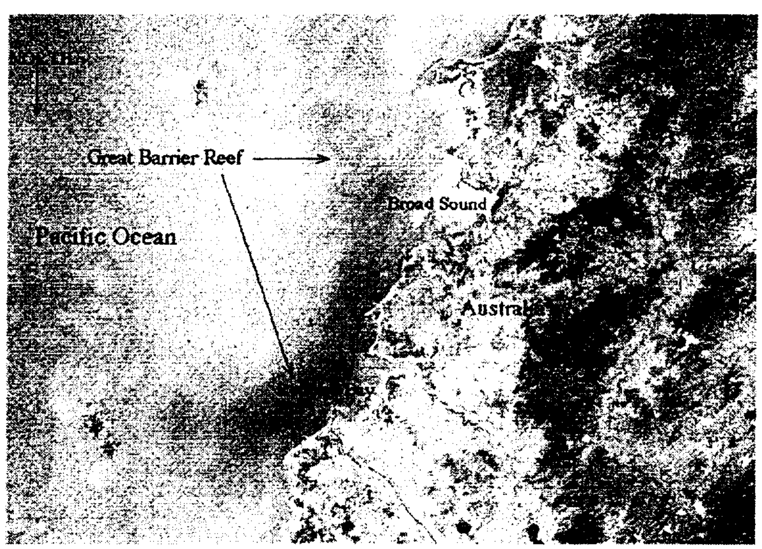


*Figure 38: Example of an annotated image from STS-86 taken at MET 08/02:36:38, annotated by Olive Pierce School. The caption reads: "On the left is the coast of Australia. On the right is the Pacific Ocean. The lower bay that you see is called the Broad Sound. The upper bay is called Repulse Bay. The Great Barrier Reef is not visible, but it is there in the dark of the water. The islands in the photograph are called Northumberland Islands. The river is called Bowen River."*

## 4.5 Image Visualization

In addition to analyzing a single image, combinations of images were used to provide a broader view of the Earth. In some cases, several overlapping images were acquired. These series of images were pieced together to show a swath crossing a broad region, which revealed borders, terrain changes, and coastal crossings. In some cases, the overlap is sufficient for a stereo pair to be viewed, creating a three-dimensional effect. Students could manipulate images into series and stereo pairs in their classrooms using NIH Image (see Sections 9.4 and 9.6 for more on series and stereo pairs).

A more exotic way of viewing an image is to "fly" over and around it. The Digital Image Animation Lab (DIAL) has a visualization tool that uses topographical data and a KidSat image to create an animation or "flyby" of a specific area of the picture (see Appendix C to obtain a copy of the video). Students working with the DIAL produced videotapes of the flybys for a few selected images. In the future, it may be possible for any student to interactively explore KidSat images and videos through self-directed flybys.

Before the first flight, the Data System team produced two flybys using existing shuttle photographs. These flybys were along paths requested by the Core Curriculum Design Team for use in the "Impact of Water on Earth" curriculum module. For the first flight, a flyby using a KidSat image of Saudi Arabia was generated and released to the classrooms and the world, using NTV. This volcanic region in Saudi Arabia was selected because it was the only image containing interesting topography that was cloud-free.

*Figure 39: Student exploration reports on the walls in John McGuire's classroom at Pacific Union School.*

# V. Exploration

Images from space can provide a much larger perspective of the world. For example, one may see geographical features that would not be easily discernible if viewed from the ground. Explorations incorporated KidSat images in investigating different aspects of Earth. Explorations would focus on history, art, science, math, society, and other academic subjects. Explorations were documented like scientific journals—the reports scientists write on a discovery. To write these "scientific journals," students used a variety of resources including atlases, encyclopedias, and the Internet. The explorations were used as reports, projects, or, for those people who felt a thirst for knowledge about the world around them, simply for their intrinsic value. Some of the explorations were posted on the Exploration home page.

The image data allowed students to "discover" and "rediscover" Earth. In rediscovering Earth, the images gave students a new perspective on current studies. For example, a student's home area could be studied to learn about the geographic and historical significance of the location. Students could gain a new, more enthusiastic insight into history, geography, current events, and dynamic changes on Earth by relating them to the images. In discovering Earth, students learned of previously unknown information with images of dynamic events such as fires. They found hidden places such as impact craters and searched for cities like the "Lost City of Ubar" (Blom 1992 and Fisher and Fisher 1999).

An exploration team, formed as part of the KidSat project, modeled such explorations by creating examples with the ideas and experiences of scientists from NASA and universities. The KidSat Exploration team was composed primarily of students from La Cañada High School with the participation of students from Arcadia High School and Leicester University. The team was led by Dr. JoBea Way of JPL with support from Marguerite Syvertson for STS-81.

*Figure 40: Students from the Exploration and Data System teams along with Eric DeJong from JPL determine image location in preparation for creating a flyby of Saudi Arabia.*

## 5.1 Viewing Earth from the Shuttle–Insights by the Astronauts

***James Wetherbee, Commander, STS-86***

*Commander Wetherbee discusses his past experiences viewing the Earth during the crew familiarization briefing given by the KidSat students to the STS-86 crew.*

You may have heard a lot of stories about astronauts who come back and talk about the lack of borders. You get up into space and don't see borders and that gives you a sense that we are all in this together—we are all really one people and need to take care of the planet. I heard that so many times but I find it more interesting to go up and look for places where you do see borders. There are some places where you can see that, but it doesn't happen very often.

Some obvious areas are where the land meets the water, of course. I find it interesting, for example, to look at the peninsula of Florida and find out that the cartographers did a very good job when they drew the maps. That's an easy example, but there are others: where you see straight lines—in some of the states in Africa, for example. I can imagine there is a long fence or road that goes for hundreds of miles where the folks many years ago said, "Okay, you take the mountains and we'll take the plains"—and that's the border of the state. You can see it on maps—these long straight lines that are borders.

Others occur because of land formations—a similar situation where people said, "All right, we got the mountains, you take the plains, and you take the forests." You can see those long divisions between states. I find that more interesting than coming back and saying you can't see borders in space. You can see a lot of human structures. You can see all the big cities, of course, which look gray in color in contrast to the browns or the greens of the Earth. You can see runways, all over the world, big ones, even little ones. You can see long interstates. You can't see any cars and trucks—they are a little bit too small—but you can see long roads in between cities. So I find it very interesting to look at the Earth from the point of view of what it would look like to someone who suddenly zipped down here and took some video. How would they tell whether or not there were people on the planet or anything living? I have not seen the Great Wall of China—mostly because I haven't looked for it. I'll try to look for it in this next flight. You can see an awful lot of campfires when you are flying over at night in some areas of the world. It's a pretty spectacular sight to see all the fires.

I'll talk briefly about weather patterns. You have done a very good job of analyzing the photographs of weather patterns that you already have. Those are interesting to see; especially some of the large thunderstorms. Mesoscale lightning—the kind where, all of a sudden, lightning is triggered on one side and then you see a whole bunch of lightning strikes very quickly on a very large mesoscale of two, three, four hundred miles across. All of a sudden lightning is bursting, then there is a period of quiet for several seconds, and then you see more lightning. It looks like it's all connected. Obviously, hurricanes are very easy to see and very spectacular. If you see hurricanes that have a very well-defined eye, that's pretty spectacular from space.

Some of the things that are very difficult to take pictures of are really pretty spectacular. I'm sort of jumping ahead to your last question, "Which pictures would you choose to take from space?" Some of the things that are pretty spectacular are very difficult to take pictures of. The one that comes to mind is the atmospheric glow that you see on the nighttime side of Earth. Not many people realize that the atmosphere actually glows. You can be on the complete dark side of Earth—thousands of miles away from any human light—and the atmosphere glows. It exists because of a phenomenon where it gets heated during the day by the sun. The molecules and atoms of oxygen in the upper atmosphere get heated and jump up to a higher energy state. Then, on the night-side of the orbit, they cool, drop down to a lower energy state and give off photons. What you see is a glowing atmosphere. It's like a parking lot at night that's foggy and maybe has street lights illuminating the fog. That's about the intensity of the glow you see. But that would be very difficult to take pictures of with your camera unless you had the proper film and an exposure setting that allowed you to take it. As Space Shuttle Orbiter Atlantis flies through the upper part of the atmosphere, it will glow also. You'll see—not the individual molecules, of course—but the effects of molecules that smash into Orbiter, get excited into a higher energy state, and grow. Again, that would be difficult to take pictures of. Finally, let me say that we don't only look at the Earth.

There are tremendously interesting views of the stars at night, especially in the Southern Hemisphere, when you look at the large and small Magellanic clouds. The incredible number of stars that you can see with the naked eye will just blow your mind. It's just incredible. If you could take some pictures of things other than the Earth, that might be nice. If we are in an attitude that doesn't support taking pictures of the Earth, all is not lost.

I guess I will close by saying I would encourage you, after our flight, to see if we can get together again and have another teleconference like this. We can talk about some of the pictures we saw and what we recorded. Mike Bloomfield can give you some of his impressions as a rookie. I'm sure he is going to be as enthusiastic as you all are to see the images, because he will be seeing them for his first time up in space and you will be seeing the pictures along with him for the first time.

And by the way, good job on all the work here. This is great. I really didn't expect all of this—this is a real project. You have done a fine job and we are really impressed with all the work that you have done—so keep up the good work.

## 5.2 Discovery from the Shuttle

***Tom Jones, Mission Specialist, STS-59 and STS-68***

*Dr. Jones discusses his experiences in discovering a crater while viewing the Earth from the shuttle on missions STS-59 and STS-68.*

I've been interested in planets, asteroids, meteorites, and craters since I was in elementary school. After taking a lot of science courses in college, and then flying for the U.S. Air Force, I went back to school to study the space sciences very seriously. I worked hard to become a planetary scientist, and was able to work with NASA studying how asteroids were formed, and what they're made of.

Since craters on Earth and other planets tell us much about the size and composition of asteroids, comets and meteorites, I approached my first space flight with the idea of looking carefully at Earth for traces of these scars from extraterrestrial impacts. I wanted to see the famous, well-known craters, but I planned to keep an eye out for unusual geological features as well. What good is a planetary scientist in orbit if she/he is not doing some exploring?

On my first mission I did see many of the impact craters and volcanoes I'd hoped to see, but nothing that I thought would qualify as new. However, in looking at our 12,000 photographs of Earth after the Space Radar Lab 1 mission in April 1994, I noticed a striking circular feature in a picture of Korea. No one had mentioned seeing it as they took the picture—in fact, we don't know who took that photograph. The green ring sure looked to me like a crater, and big enough to study from orbit. Surprisingly, it wasn't listed in any of the crater catalogues I checked. So, I made a note to look for it again on my second flight on Space Radar Lab 2, in October 1994.

Sure enough, when I passed, camera in hand, over Korea early in the mission, I spotted the green ring of the crater easily. Snapping away, I caught the crater (if that's really what it is) peeking through the cloud cover below. A few days later I was scanning the ground in Siberia, east of the huge freshwater lake Baikal, when I saw another crater-like formation dusted with early winter snow. That may also prove to be an undiscovered impact feature. Other scientists are working with me now to see if either of these features has been studied before, and to go after the evidence that will prove these circular scars were created by cosmic impacts. I'm sure there are many similar surprises waiting to be revealed by those who keep a keen eye on our planet's surface.

This suspected Seoul impact structure is located about 32 km north of Seoul, the capital of South Korea. The crater location is 37° 49' North, 127° 03' East. This feature, while not proven to be caused by an asteroid or comet impact, appears similar to many other impact craters on Earth, the Moon, Venus, and Mars. The suspected crater has a sharply elevated rim, a flat floor, and an uplifted set of hills at the center. The shuttle photographs also show a roughly circular region of forested hills surrounding the sharp rim; the impact that formed the crater may have also influenced this area's appearance through fracturing of the surrounding rock.

The crater's rim lies just at the outer reaches of Seoul's suburbs. Urban development—roads and buildings—reaches to the southern rim of the structure, but the crater floor is mostly farmland. The rim ridges are rugged and forested; this contrast of the green, circular rim with the fields on the crater floor was what caught the eye of the astronaut photographers on STS-59 and STS-68. The town of Tongducheon is just north of the rim, near the demilitarized zone, and the small village of Tokchong is nested in the central uplift. The town of Uijongbu lies outside the southern rim along a major north-south highway. This road was the axis along which North Korean forces advanced during the June 1950 invasion of South Korea. The ridges of the Seoul impact structure saw heavy fighting during the see-saw campaigns back and forth across the demilitarized zone from 1950–1953.

Now that our suspicions have been aroused, planetary scientists must visit the area and obtain rocks for study from the rim and central uplift. Those rocks should tell us whether the structure is, in fact, a true impact crater, and when the impact explosion occurred. Other circular features in Korea are visible in space photographs, some very similar to the Seoul feature. Are they all impacts, or is there something about Korean rocks that produces circular uplifts throughout the peninsula? The answers are not known. The few samples we've obtained from our friends in Korea do not show the shocked quartz crystals within the rocks that prove an impact shook the bedrock here. Another field trip to the site will be necessary to confirm our suspicions and tell us more about the history of the feature. Judging from our space images, erosion has operated on the suspected crater structure for millions of years. A visit to study the geology of the site will tell us much about the formation and subsequent history of this feature. The Seoul feature reminds us that Earth's surface still holds undiscovered secrets about the history of our planet. Space-based observations of Earth will give us the global view we need to understand Earth's violent past, the present state of its surface, and dramatic natural and human-induced changes to our environment.

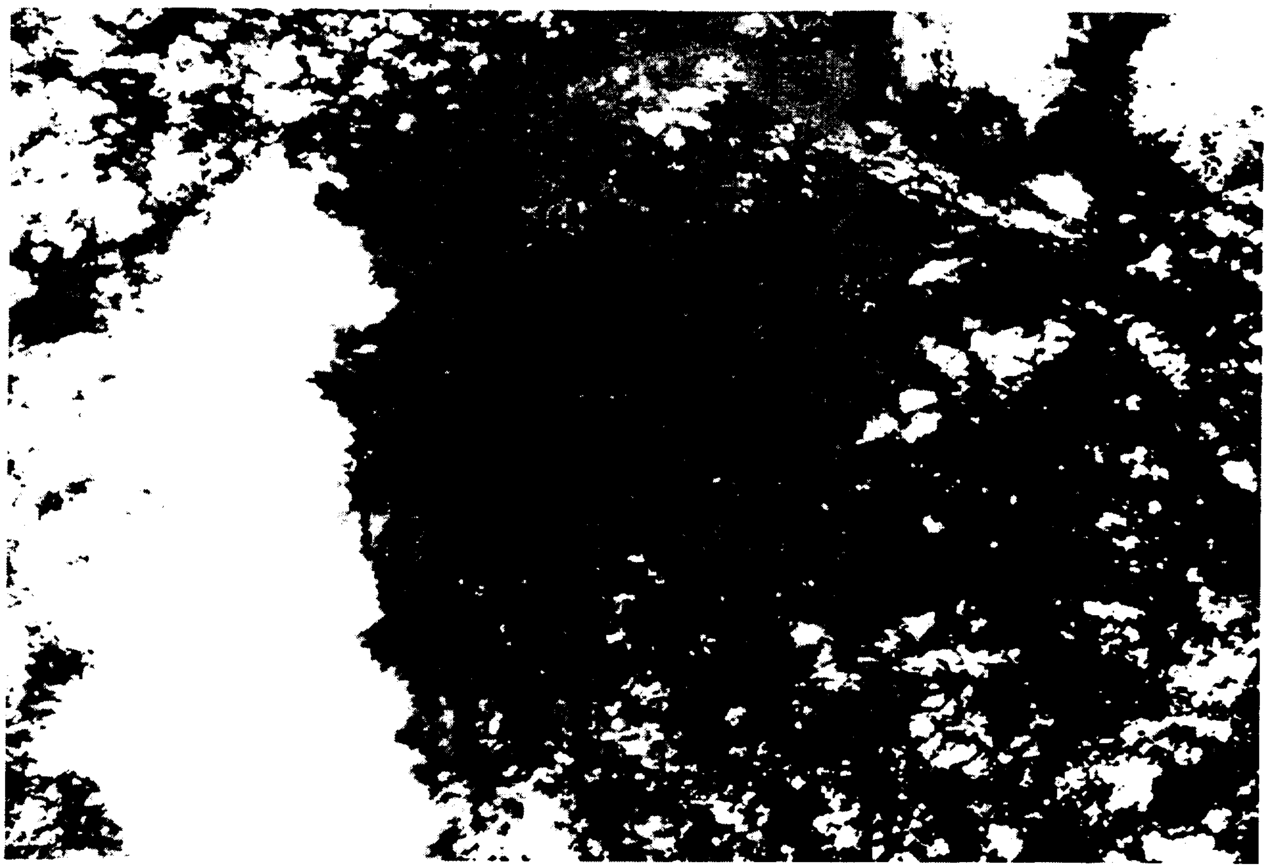

*Figure 41: Image of Seoul impact crater taken on STS-68, Roll 165, Frame 20.*

## 5.3 Science Telecons

Science telecons were conferences in which scientists discussed images and Earth science with teachers in a telecon format. Several of these telecons were held for each mission. Often, the scientists used other images in combination with KidSat data to emphasize a study of interest. Teachers were able to download images prior to the telecon and ask questions about the subject matter in advance. The scientists then discussed the images during the telecon. The Exploration team documented the telecons and included them as explorations on the Exploration team's Web page.

## 5.4 Exploration Plan

The Exploration plan was written by the Exploration team. The plan served the KidSat project and the KidSat students in several ways. First, it established the overall KidSat exploration objectives, requirements, and priorities for the missions. Second, it served as a guide for long-term exploration planning. The team responsible for the contents of the Exploration plan consisted of students, teachers and scientists. The Exploration plan is available on-line as part of the Exploration Web site.

*Table 5: Science Telecons*

| Scientist | Institution | Topic |
|---|---|---|
| Ben Holt | JPL, Oceanography | Waves and Ice |
| Ronald Blom | JPL, Geology | Lost Cities and Center Pivot Irrigation |
| Cindy Evans | JSC, Earth Observation Lab | The Aral and Caspian Seas |
| Adriana Ocampo | JPL, Geology | Impact Craters |
| Paul DiGiacamo | University of California, Los Angeles, Oceanography | The Motion of the Ocean |
| Mark Wensnahan | JPL, Oceanography | Exploration of Ice |
| William Patzert | JPL, Oceanography | Fires in Indonesia and El Niño |
| Compton Tucker | Goddard Space Flight Center, Ecosystem Science | Deforestation in the Amazon |
| JoBea Way | JPL, Earth Science | Stereo Imaging |

## 5.5 Questions about Earth

Students in the middle schools had many questions about Earth. They had an opportunity to ask the astronauts these questions, as part of the Crew Familiarization Briefing (see Section 6.2). The questions provide some insight into the kinds of explorations the students might undertake with the KidSat images.

### *5.5.1 Questions from Washington Accelerated Learning Center:*

1. Have you seen significant changes in any of the biomes that you observe from orbit compared to previous missions?
2. What areas of Earth are easiest to see at night? Are there any advantages of taking photographs at night? What do you learn from looking at night photographs?
3. Are you readily able to recognize earthquake fault patterns in California, Japan, and Africa?

### *5.5.2 Questions from Buist Academy:*

1. What is the most obvious example of humans' negative effect on the environment as seen from the shuttle? How about positive?
2. Can you see signs of pollution? This is in relation to nuclear accidents, ocean dumping, and oil spills like the one that occurred recently in England.
3. Is there an observable difference in the destruction of forests from space? We are concerned that everyone says to collect money for the Brazilian rainforest or Central American rainforest and have heard that the clear-cutting is very bad in Southeast Asia and were concerned about comparing images of rainforests and destruction.
4. Where in the world have you been able to observe water currents from the shuttle? I would like to know specifically about the Florida Keys, the sea of Okhotsk, the southern tip of India, and the southern tip of the Red Sea.
5. What is the most amazing observation of Earth phenomena you have made from space?

### *5.5.3 Questions from Gompers Secondary School:*

1. Are there any landforms or human structures that you always look for and why?
2. Have you seen the Great Wall of China from space?
3. If you could choose any picture to take from space, what picture would you choose and why?
4. Can you tell the difference between regular clouds and storm clouds?
5. When you view a hurricane, are you able to detect movement?

Several KidSat explorations were turned into scientific journal papers. See Barr et al., 1999, Tseng et al., 1999, and Fisher and Fisher, 1999.

# VI. KidSat and Education

The education of middle school students in fifth to eighth grade was the foremost aim of the KidSat project. This was achieved through the enhancement of middle school disciplines such as science, math, social studies, language arts, and art. The Education element of KidSat was designed by Johns Hopkins University's Institute for the Academic Advancement of Youth (IAAY). IAAY has an office in Glendale, California, providing proximity to JPL and UCSD. IAAY's primary responsibilities were to create a flexible and content-rich curriculum for educators, conduct educator training workshops with follow-up support, provide a quantitative assessment of the value of KidSat in middle school education, and provide mission support.

The goal of the Education element was to develop multidisciplinary, hands-on curricular modules that both respect students' individual academic needs and encourage them to maximize their intellectual potential. The implementation of the KidSat curriculum assisted educators to advance learning, knowledge, and inquiry of students through the use of science and space technology. High academic expectations in students were fostered and promoted through the curriculum.

To meet these responsibilities, IAAY provided educators with resources that met individual student needs and that addressed district, state, and national standards:

- developed an infrastructure and curriculum that fostered student intellectual exploration and discovery
- designed teacher training and follow-up support
- provided continuous evaluation and improvement of the curriculum as needed.

The Education team was led by Johns Hopkins University and IAAY and included the Core Curriculum Design Team made up primarily of teachers. The team was led by Elizabeth Jones Stork of IAAY. For more information on KidSat education, see Stork et al., 1999.


Figure 42: Core Curriculum Design Team and STS-76 pilot program teachers (top row, from left: Jackie Hunt, Dan Barstow, John McGuire, Kathy Rackley, Mark Jones, Paul Bixler, Roger Kassebaum; bottom row, from left: Cynthia Brammer, Rich Anderson and Rie Cowan.)

## 6.1 Curriculum Design

The Core Curriculum Design Team (CCDT), comprised of teachers, scientists, engineers and IAAY facilitators, was conceived to design and deliver the KidSat curriculum. The team created three education modules which supplemented existing middle school curriculum. The CCDT was also responsible for the training of KidSat pilot teachers. Based upon their own unique models of teacher training and staff development, the CCDT trained seventy teachers to implement the modules in their classrooms starting with the STS-76 KidSat mission. The CCDT also contributed to project assessment through the evaluation of instructors and students. Quarterly meetings were held for curriculum design development and revision as well as the planning of teacher training.

In the spring of 1994, five teachers were selected as initial CCDT members. They served through the completion of the pilot phase of the project. These teachers represented the pilot program schools and were recognized for their excellence in instruction and for possessing expertise in particular subject areas. The CCDT worked together with scientists and engineers to develop interdisciplinary lessons which integrated computer technology with middle school subject areas. The space science and engineering expertise was provided by scientists and engineers from NASA and various universities. Specifically, NASA scientists were selected by the lead scientist for education designated by the Office of Mission to Planet Earth at each NASA center.

The KidSat curriculum was designed for middle school students. The targeting of this age group stems from several educational principles. The existing middle school curriculum is flexible enough to incorporate a project like KidSat and matches the disciplines encountered in performing a KidSat mission, such as physical and life sciences, math, language arts, and social studies. The curriculum, modeled after skills used by scientists, emphasizes team building, problem solving, and research. The modules contain background information, lesson plans, teacher guides, and suggestions for hands-on activities that incorporate the use of images.

Three important principles, collectively known as the "optimal match," serve as the foundation of the KidSat curricular design. The Optimal Match Theory involves flexibility in teaching, respect for each student's individual learning pace, and a recognition that learning occurs everywhere and at any time. The modules advance learning by allowing students to determine a basic direction of discovery. After an introduction and rudimentary support for content topics, followed by fundamental instruction of scientific information and skills, students devise questions determining a course of inquiry. The module then describes a general topic for discovery and several subtopics. For instance, after viewing a video of a flyby generated by combining images and topographical data, student interest may focus on how such an image was produced. This may lead to activities and discussion on light, lenses, and cameras, which are all elements of the "Observing Earth from Space" unit.

The curriculum is currently available through the Johns Hopkins University IAAY, Western Regional Office, Glendale, California.

*Table 6: Core Curriculum Design Team Members*

| |
|---|
| Kathy Rackley (Buist Academy, South Carolina)<br><br>Kathy Rackley is a fifth grade teacher in Charleston, South Carolina. Mrs. Rackley received her undergraduate degree from the College of Charleston and her Master's from the University of Charleston. She is a member of the Can Do Team of the Charleston County School District. She teaches hands-on science and math, and organizes district-wide Space Days. |
| Bruce Fisher (Fortuna Elementary School, California)<br><br>Bruce Fisher is an elementary school teacher at the Fortuna School. Mr. Fisher has 15 years of experience in teaching an inquiry-based science curriculum that stresses hands-on exploration. He has received numerous honors and awards, including the National Educator Award, California Teacher of the Year, Favorite Teacher Award, and the NEWEST Award. |
| Daniel Barstow (Technical Education Research Center (TERC), Massachusetts)<br><br>TERC is a nonprofit research and development company, specializing in science and math curricula and innovative uses of educational technology. Daniel Barstow is a Principal Investigator for a group of projects focusing on effective educational use of remote sensing and geographic information systems. These projects include: Visualizing Earth; the education component of GLOBE; Global Lab; Mars Education Program; and Mapping Our City. |
| John McGuire (Pacific Union School District, California)<br><br>John McGuire is a middle school math instructor at Pacific Union Elementary School in Arcata, California. He is also a math and science lecturer at Humboldt State University and a member of the Sarah D. Barder Learning Center Faculty for Johns Hopkins University. Mr. McGuire has been a mentor teacher in mathematics and technology as well as being honored as a Sarah D. Barder Fellow, Presidential Excellence in Teaching Mathematics nominee, California Math Council Distinguished Teacher, and 1996 California State Teacher of the Year. His professional involvement includes: past president of CMCN, Redwood Area Math Project, RRCPD, Johns Hopkins Public Policy Institute, and editor of the CMCN newsletter, *Infinity*. |
| Roger Kassebaum (Millard North High School, Nebraska)<br><br>Roger Kassebaum has an educational background in aerospace, physics, and science education. He received his Master's in science education in 1979 from the University of Northern Colorado. Since 1974, Mr. Kassebaum has taught secondary school science in Nebraska, including physics, life science, chemistry, and math. Mr. Kassebaum is a member of the National Science Teachers' Association (NSTA), the Nebraska Association of Physics Teachers, and the National Education Association. He has been a consultant for the NASA Earth Observations Program and a recipient of the 1990 U. S. WEST Nebraska Teacher of the Year. Mr. Kassebaum has received numerous grants for the development of innovative curricula, including the Red Planet and was director for the NSTA/NASA NEWMAST Honors Aerospace Workshop at JSC. |
| Paul Bixler (Gompers Secondary School, California)<br><br>Paul Bixler holds a Master of Arts degree in education from the University of California, San Diego, and teaches mathematics (from pre-algebra to calculus) at Samuel Gompers Secondary School, Center for Science, Math and Computer Technology in San Diego. Previously, he served in the United States Navy for 22 years. During that time he served a tour of duty as a mathematics instructor (calculus and differential equations) at the U.S. Naval Academy in Annapolis, Maryland. For his Master's thesis, Mr. Bixler developed a senior-level robotics curriculum based on mathematics, computer design, and computer simulation. |

## 6.2 Outline of Curriculum Modules

| | | |
|---|---|---|
| **Viewing Earth from Space** | | |
| Unit 1 | Going to Space from Earth | |
| | 1.1 | History of Piloted Space Exploration |
| | 1.2 | Shuttle/Piloted Platform |
| Unit 2 | Looking at Images of Space | |
| | 2.1 | Familiar Places and Patterns |
| | 2.2 | Viewing Images of Weather |
| Unit 3 | Accessing Images from Space | |
| | 3.1 | Introduction to KidSat Data System |
| | 3.2 | KidSat NIH Image Tutorial |
| | 3.3 | Annotating KidSat Images |
| Unit 4 | Introduction to Mission Operations | |
| | 4.1 | Orbital Mechanics |
| | 4.2 | Communications |
| | 4.3 | What Can We See from Space? |
| | 4.4 | Student Mission Operations Center |
| | 4.5 | Pre-Mission Relations |
| | 4.6 | Mission Public Relations |
| **The Impact of Water on Earth** | | |
| Unit 1 | Weather | |
| | 1.1 | Investigating Weather |
| | 1.2 | What Can Clouds Tell Us? |
| | 1.3 | Clouds and Land Investigation |
| | 1.4 | Clouds and Storm Systems |
| | 1.5 | Weather Around the World |
| Unit 2 | Landscapes | |
| | 2.1 | Landforms Shaped by Water 1 |
| | 2.2 | Landforms Shaped by Water 2 |
| | 2.3 | Namib Desert Investigations |
| Unit 3 | Ice and Glaciers | |
| | 3.1 | Ice on Land |
| | 3.2 | Fractals in Ice and Snow |
| Unit 4 | Ecosystems | |
| | 4.1 | Biomes from Space |
| **Explorations** | | |
| Unit 1 | Image Explorations | |
| | 1.1 | Far Out, Man! |
| Unit 2 | Water and Land Explorations | |
| | 2.1 | The Properties of Water—Relating to Water Color |
| | 2.2 | Oceanographic Feathers and Sun Glint |
| | 2.3 | Exploring Islands |
| | 2.4 | Waterworld—Great Floods of 1993 |
| Unit 3 | Math Explorations | |
| | 3.1 | Properties, Scale, and Measurement |
| | 3.2 | Positions and Speed |
| | 3.3 | Percent |

*Figure 43: UCLA graduate student Paul DiGiacamo discusses ocean waves with teachers at the 1996 Summer Teacher Training Institute.*

### *6.2.1 Module 1: Viewing Earth from Space*

"Viewing Earth from Space" was the first KidSat module. This module introduces students to the basic skills needed in acquiring, interpreting, and using images to conduct explorations. "Viewing Earth from Space" includes "Going to Space from Earth" (focusing on the piloted platforms), "Looking at Images from Space," "Accessing Images from Space," and "Introduction to Mission Operations." Students apply fundamental concepts in science, mathematics, and technology that are relevant to the use of Earth-viewing instruments in low Earth orbit.

In the "Introduction to Mission Operations" unit, students discover how to request the images for their sites of interest. This entails studying the concepts involved in the acquisition of images from an instrument in space and basic mission operations techniques. Subtopics of this unit include targeting, team building, flight operations, weather, current events, and communications. Upon the completion of this unit, students were able to locate a site on a world map, predict when the shuttle would be over that site in the proper attitude, and determine if weather conditions would be favorable for a photograph. Students also learned how to set up and operate a SMOC.

### *6.2.2 Module 2: The Impact of Water on Earth*

"The Impact of Water on Earth" is the first student exploration module. The focus on water relates uniquely to our planet and is an integral part of the middle school science curriculum. Populations, natural resources, and environments—all intricately related to water on this planet—were studied using KidSat images in this module. Natural hazards related to water provided exciting imaging opportunities for the mission. Some students and teachers chose to use images of water to trace the movement of humans along waterways and research patterns of human migration. Subtopics include "Weather," "Landscapes," "Ice and Glaciers," and "Ecosystems." Activities in this module include the water routes of explorers, water resources in cities (ports, rivers, oceans, lakes), local water-related environmental issues, how we see water with remote sensing instruments, scales of water from space, early exploration and development of civilizations along rivers, and natural and human disasters (floods and oil spills).

### *6.2.3 Module 3: Explorations*

The "Explorations" module was designed to allow students to conduct image-based investigations on both individual and group levels. General topics were first introduced to the class as a whole. After general subject instruction and class-based investigations, students were encouraged to pursue independent investigations. The resources for this module were both text-based and located on the Internet. Research skills were emphasized and reinforced throughout this module. "Explorations" consists of three units: "Image Explorations," "Water and Land Explorations," and "Math Explorations." In this module, students created and analyzed three-dimensional images, investigated the great floods of 1993, and calculated environmental changes in images over a period of time.

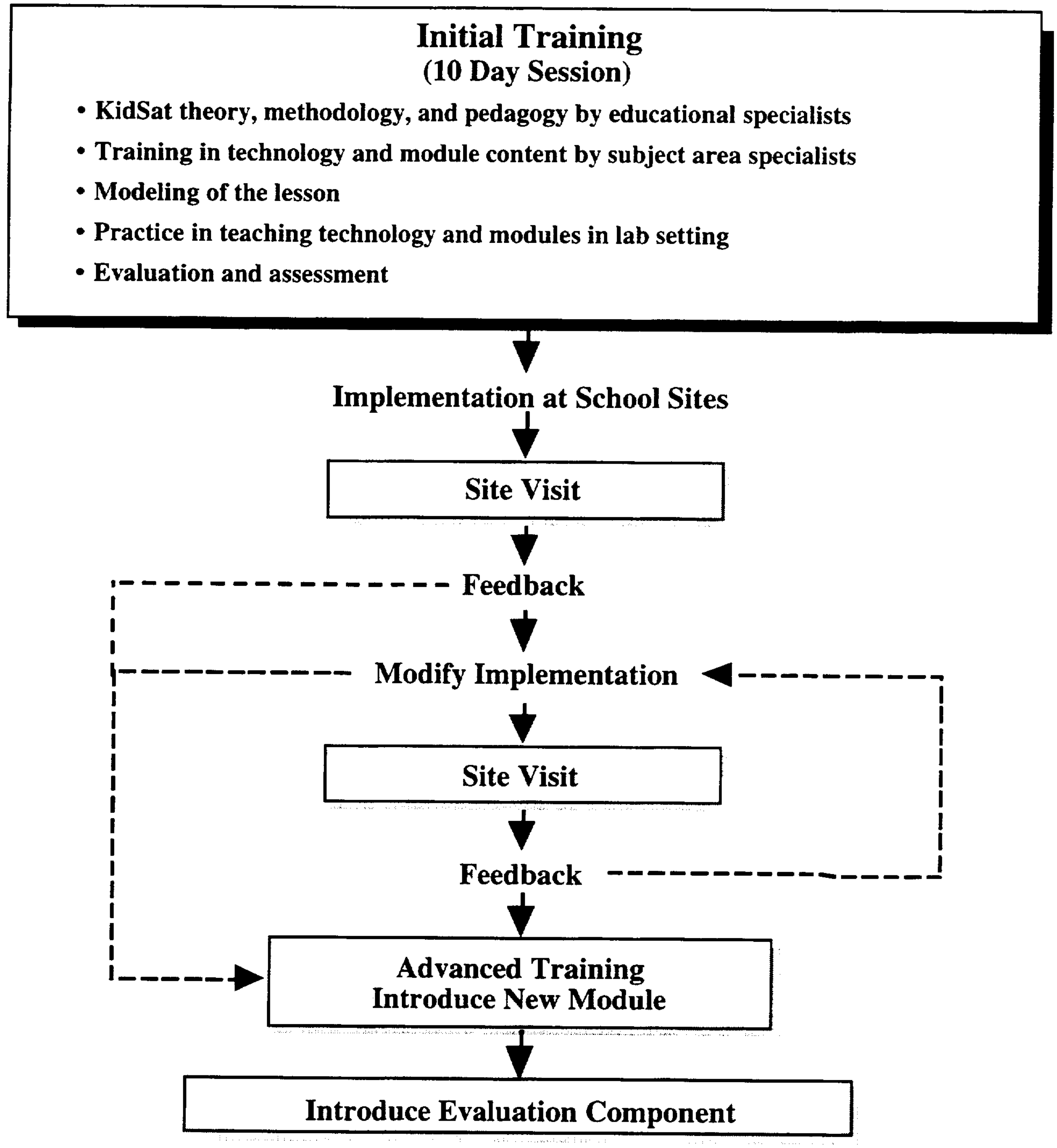


*Figure 44: Teacher training flowchart.*

## 6.3 Teacher Training

The KidSat Summer Teacher Training Institute is held during two weeks in July for teachers implementing the KidSat curriculum. IAAY brought together pilot teachers with the Core Curriculum Design Team (CCDT), scientists, engineers, and school district curriculum specialists. Teachers participated in lessons from the modules taught by the CCDT and scientists from JPL, NASA centers, and UCSD. They were immersed in the KidSat curriculum much like the students. Teachers were given the opportunity to work with the technology, annotate images, and participate in mission simulations. This hands-on experience enabled teachers to return to their classrooms, excited and prepared to guide students through the experience of KidSat.

The first KidSat Summer Teacher Training Institute took place in 1995 at JPL. Three middle school teachers representing school districts in San Diego, California; Pasadena, California; and Charleston, South Carolina attended the institute. These pilot program teachers implemented the KidSat curriculum during the 1995–1996 school year with the STS-76 mission in March 1996. The 1996–1997 school year saw the addition of another district in Omaha, Nebraska, a school in the Charleston County School District, and several schools already associated with NASA centers. The number of KidSat schools then totaled 17. Twelve middle school teachers attended the teacher training held at Caltech in Pasadena, California. Training emphasized incorporating the KidSat curriculum into all middle school disciplines. In 1997, two Institutes were held, one in Omaha, Nebraska, and the other in Charleston, South Carolina. Fifty teachers from 19 schools attended the two weeks of training. KidSat now included four schools in North Carolina, five in South Carolina, six in California, six in Nebraska, along with 31 schools associated with NASA centers. The 50 teachers who attended the institute formed interdisciplinary teams from their respective schools. Media and technology specialists from participating schools also attended to build stronger support at the schools. Pilot teachers from STS-81 supported the institute instructors, including the CCDT and local scientists from the University of Charleston, the South Carolina Space Grant Consortium, and the University of Nebraska.

*Figure 45: Elizabeth Jones Stork discusses images with teachers at the 1996 Summer Teacher Training Institute.*

*Table 7: 1997 Summer Teacher Training Institute Agenda*

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**Monday, July 14**

- Welcome
- Introductions

**KidSat Overview**
- Video: Buist SMOC
- Hands-on goals and purpose of the project
- Role of JPL, UCSD, JHU
- IAAY education philosophy
- Pilot program teacher expectations
- Institute responsibilities and YOU
- Video: KidSat Introduction
- Pre-test for teachers

**Field Study**
- Travel to Goose Creek: Biomes
- Demonstrate how the local area will provide hands-on activities
- Use the digital camera at the field site
- Read over Biomes Lesson in the evening

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**Tuesday, July 15**

**Curriculum**
- KidSat unit: Biomes
- Post the Charleston images on the wall and label them
- Apply the information from the field study to the KidSat lesson
- Biome Lesson: Model a lesson from the KidSat material:
  - Science content
  - Presentation
  - Assessment
  - Incorporation into classroom
- Images: Applying lessons to space images

**Images and Mission Operations**
- How do we get images?
- Shuttle, orbital mechanics, nadir views, camera footprint
- Planning to meet the needs of the curriculum
- Create long-term plan for targets

**SMOC Introduction**
- SMOC Web pages
- SMOC positions and layout
- Open computer time Wednesday evening

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**Wednesday, July 16**

**Review SMOC Information**
- How to set up a SMOC
- Teacher contact
- Slider maps and orbital tracks
- Atlases
- Roles of SMOC and integration of positions
- Folders designating each role

**SMOC Configuration**
- Technology
- Computers, memory, Zip drives, Netscape, NIH Image, modems
- How a SMOC works
- Using the technology
- A sequence for information and checks for the SMOC
- Computer Room
  - Each teacher in two different SMOC roles
  - SMOC Web pages

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**Thursday, July 17**

**SMOC**
- Why and what is a SIM?
- Do I really have time to do a SIM? YES!
- Mission SIM
  - SMOC: Teachers have one role for forty minutes, then switch and have another role

**Landforms Lesson**
- Images
  - Annotating the hard copy
  - Maps and atlas resources
  - Practice and presentation
- How to save an image
  - Get the image on disk
  - Data System (retrieve only)
  - Examples of images and annotations
  - Students' presentations
  - Annotated KidSat images on your desktop as examples
  - Validating an image

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**Friday, July 18**

**Technology**
- KidSat and UCSD lessons on the Internet
- Download images into NIH Image
- Annotating an image
- Data system pages:
  - Validation
  - Annotation
- Examples of student work

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**Saturday, July 19**

**Folley Beach Park**
- Guest speakers about Barrier Islands as an example of a field study

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*Table 7: 1997 Summer Teacher Training Institute Agenda (continued)*

**Monday, July 21**

**Technology**
- Digital images and space images
- Data System
- NIH Image upload and validate (provide image)
- Scanners
- Where are data and help
- Examples of Laing and Buist student work

**Tuesday, July 22**

**Viewing Earth From Space**
- Using Scientists as resources:
  - Guest experts
  - Community resources
- Plate tectonics and volcanoes: Bob Nusbaum
- Africa and landform image interpretation: Bob Nusbaum
- Practice what you teach:
  - Developing a focus area
  - Examples of students' work
- NIH Image training
- Assessment

**Wednesday, July 23**

**Lesson Models**
- Exploration lessons:
  - Water World or Island
  - Exploration or Namib Lesson
  - Evaluation, rubrics: Where does it fit in?
- Follow up from Tuesday:
  - Africa and landform image interpretation: Bob Nusbaum
  - Water—rivers and coastlines: Cass Coombs
  - NIH Image training continues

**Thursday, July 24**

**Lesson Models**
- Weather and Earth systems
- Cross curriculum fit and ties
- Break into school teams
- "Viewing Earth from Space" or "Water" Modules
  - Data System: Paul Andres
    - How it works
    - Mission protocol

**Friday, July 25**

**Testing (done at end of school year)**
- Data System: Paul Andres
  - How it works
  - Mission protocol

**Institute responsibilities (after workshop)**
- Data System SIMs
- SMOC: organize a timeline
- Telecon timelines
- Develop a rough plan
  - SMOC training
  - Image research
  - Atlas and map training
  - Parent and school roles
  - Letter to parents
- Press opportunities and communication
- Where is my support?
  - In the school
  - In the district
  - KidSat
  - Universities
  - NASA Centers
  - Community
- Thematic image use
- District curriculum integration

**Closing**


*Figure 46: Students in Kathy Rackley's 4th grade class prepare for STS-76.*

## 6.4 Addressing State and National Goals and Standards

KidSat is a multifaceted initiative and approaches learning in the full spirit of the comprehensive Goals 2000 as set forth by the U.S. Department of Education. Accordingly, KidSat challenges all teachers and students to seek high standards, high expectations, demanding course work, and new approaches to learning and teaching. The acquisition of advanced skills in science, mathematics, and technology by every student is essential to KidSat and supports not only the national objectives of Goals 2000, but also those of the National Council of Teachers of Math (NCTM) and the National Science Teachers Association (NSTA). Further, KidSat uses space technology and data as unifying elements of the curriculum in science, mathematics, and technology. KidSat is unique in encompassing the arts and humanities in its scope. The modules are designed to build skills and knowledge consistent with national and state standard frameworks for mathematics, science, technology, geography, language arts, and art. KidSat supports the current curricular objectives set forth in national math and science standards, the California Framework, and the curricular goals of the local school districts identified by the pilot program.

In the development of the curriculum modules and the teacher training, we emphasize teacher preparation and enhancement through the Summer Teacher Training Institute and long-term support, provide support for students, and emphasize educational technology in the development and implementation of KidSat.

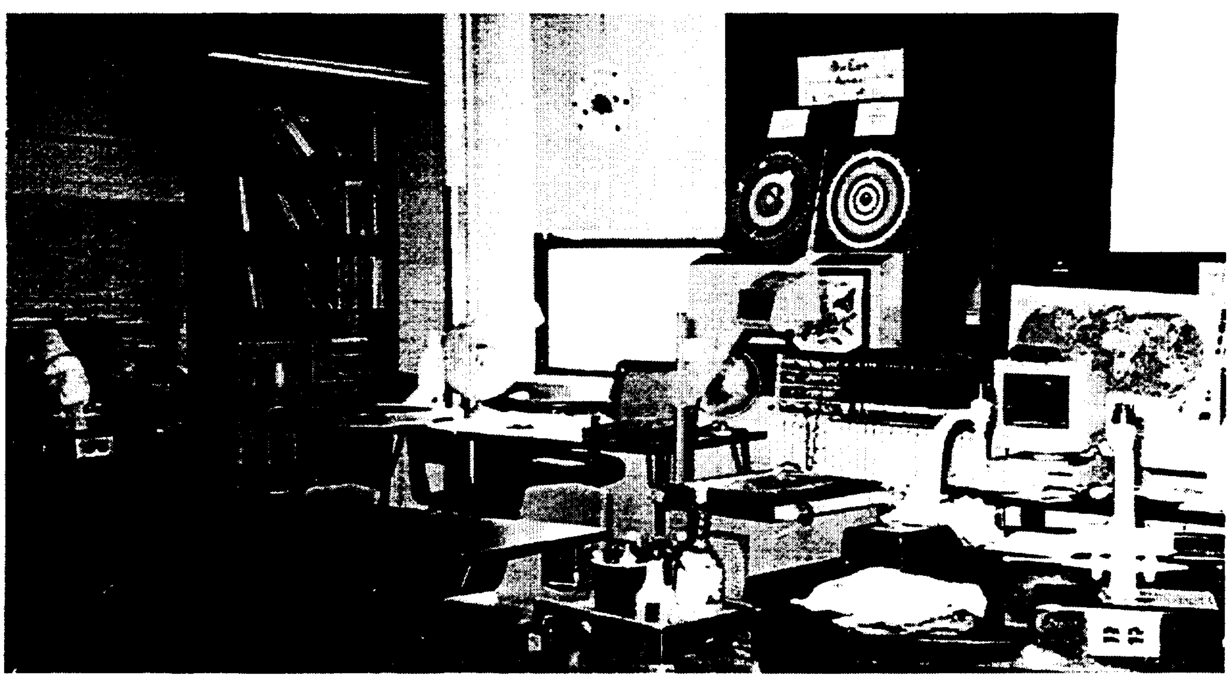


*Figure 47: Setup for STS-76 in a Buist classroom.*

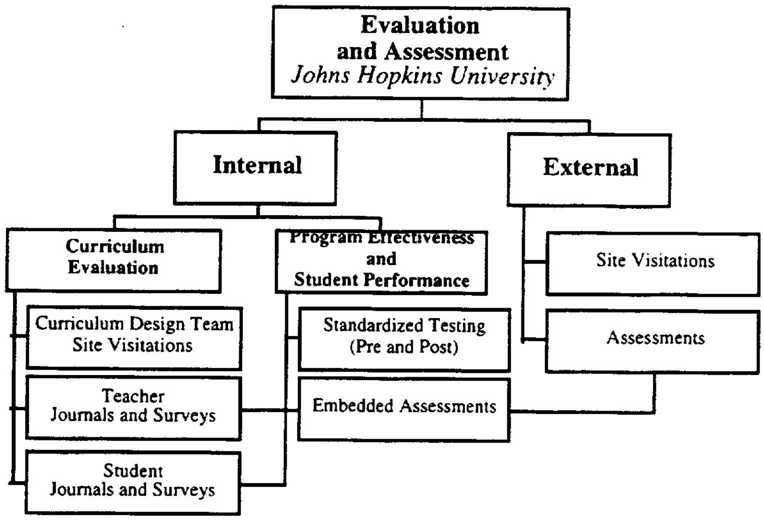



*Figure 48: Assessment overview.*

### *Performance Standards for Student Work*

| LEVEL | Standard to be Achieved for Performance at Specific Level |
|---|---|
| 6 | **Fully achieves the purpose of the task, while insightfully interpreting, extending beyond the task, or raising provocative questions.**<br>Demonstrates an in-depth understanding of concepts and content.<br>Communicates effectively and clearly to various audiences, using dynamic and diverse means. |
| 5 | **Accomplishes the purpose of the task.**<br>Shows clear understanding of concepts.<br>Communicates effectively. |
| 4 | **Substantially completes purpose of the task.**<br>Displays understanding of major concepts, even though some less important ideas may be missing.<br>Communicates successfully. |
| 3 | **Purpose of the task not fully achieved or needs elaboration; some strategies selected are ineffectual or not appropriate; assumptions about the purpose are flowed.**<br>Gaps in conceptual understanding are evident.<br>Communication limited to some important ideas; results are incomplete or not clearly presented. |
| 2 | **Important parts of the purpose or task not achieved; work needs redirection; approach to task leads away from completion.**<br>Understanding of concepts is fragmented, results are incomplete or arguments are weak.<br>Communication of purpose is attempted. |
| 1 | **Purpose of the task not accomplished.**<br>Shows little evidence of appropriate reasoning.<br>Does not successfully communicate relevant ideas, presents extraneous information. |
| 0 | **No attempt to engage in the activity, nor to address the purpose.** |

*Figure 49: Performance standards for student work.*

## 6.5 Assessment of KidSat: An Education Experiment

***Shawn Sakamoto***

Since the primary aim of the KidSat project was to improve education in middle schools, the success of the project was ultimately determined by whether there was a measured improvement in student learning. The evaluation encompassed two main forms of assessment: embedded and standardized. Teachers from the pilot program schools were instructed on the use of the measure during the KidSat Summer Teacher Training Institute.

The first form of assessment consisted of activities that were incorporated into the curriculum and that had prescribed skill expectations in order to evaluate students' understanding and progress. These activities were unique to each lesson and were based on the lesson design. Teachers developed pre- and post-tests to determine qualitative changes in students' abilities to read, analyze, and interpret images. These skills were imperative to the success of the KidSat curriculum and to successful learning outcomes. One of the opening activities to KidSat lessons was a questionnaire that was given to all students. The teachers were given multiple copies of the images that were to be used in this assessment exercise. The rationale for the embedded assessment was that it provided a diagnostic opportunity. Specifically, it documented student skill mastery, created a student portfolio, offered a formal evaluation of student performance, provided avenues for individual student choices and accomplishments, provided feedback to gauge teaching effectiveness, and allowed for qualitative assessment of a hands-on curriculum.

The second form of assessment used by KidSat was the Educational Record Bureau's (ERB) Comprehensive Testing Program (CTP) III. This nationally normed form of assessment was presented as a paper-and-pencil test requiring answers in a multiple choice format. The CTP III tested skills in writing, mathematics, and verbal and quantitative reasoning. The test was administered before the implementation of the curriculum and at the end of the program instruction, which coincided respectively with the beginning and the end of the school term. This assessment was also administered to a matched group of students. Gains on these sub-tests of the ERB were then compared to those of the students who did not participate in the program intervention.

All data from the pre-tests in the pilot phase were analyzed and reported for both the participating KidSat students and the matched group. Students from both groups took the ERB post-test at the end of 1996-1997 school year. Because studies on technology-based programs in schools have focused almost exclusively on software evaluation, results from our standardized testing provided interesting information on the impact of KidSat on measurable ability and aptitude. It is wise to note an important caveat in the interpretation of standardized tests or any other testing instrument: they measure only a single facet of learning outcomes: only a pixel in a picture, if you will.

# VII. Preparation for the Missions

Before each mission, there was a series of preparation processes carried out by the KidSat team in order to ensure the mission would be successful. These included a series of design reviews, crew familiarization briefings, crew training, and mission simulations.

## 7.1 Design Reviews

Preceding the first mission, a series of design reviews took place to ensure the overall design would be successful and the interfaces between each system were valid. The first set were Preliminary Design Reviews (PDRs), which included reviews of each individual element of the project as well as a review of the overall system. Students and teachers made the presentations for all of the KidSat reviews. The Education Element was included as an integral part of each review, which was a first for NASA. Following the PDRs for STS-76, a similar series of Critical Design Reviews (CDRs) were held. These were intended to focus on the final configuration of KidSat.

For STS-81, a single, integrated, "delta" CDR was held that involved all elements of the project. For STS-86, a relatively short review via teleconference followed the Crew Familiarization Briefing. Since the overall system was essentially the same for the two previous missions, the teleconference was brief.

## 7.2 Crew Familiarization Briefings

About six weeks before each mission, the KidSat teams held a Crew Familiarization Briefing. The objective of the briefing was to educate the flight crew and Mission Operations personnel about the payload, including:

- goals and objectives,
- payload systems and interfaces with Orbiter,
- operational aspects of the payload, and
- roles and responsibilities of the flight crews and Mission Control Center (MCC) flight controllers.

The briefings familiarized the entire crew with the payload. The briefing was conducted by the students using videoteleconference facilities at JPL and JSC. The briefing provided detailed and overview information for the crew and members of the Mission Operations teams at JSC. KidSat team members outlined how the program was developed and implemented for the shuttle crew to provide a background of the project. Each of the KidSat teams presented their part of the project.

## 7.3 Crew Training

Two months prior to the mission, the Flight team provided technical training for the shuttle crew members who would oversee the installation, maintenance, and stowing of the KidSat flight hardware. The training took place at JSC and usually involved three to five of the KidSat Flight team members with support from students from the Mission Operations team.

## 7.4 Mission Simulations

Simulations (SIMs) of the missions took place starting about five weeks before each flight to provide practice for all involved in the mission and to test and evaluate interfaces and procedures. The SIMs were based at the Mission Control Gateway and involved JSC, JPL and the SMOCs.

# VIII. The Three Missions

The KidSat pilot program consisted of three missions on the shuttle, part of three of the nine shuttle missions that flew to the Russian Mir Space Station. These missions were selected because the orbit inclinations of 51° provided a view of most of the United States. There was also a significant amount of time before and after docking with Mir when the shuttle was flying in the Z-axis Local Vertical (-ZLV) attitude during which the KidSat camera could see Earth.

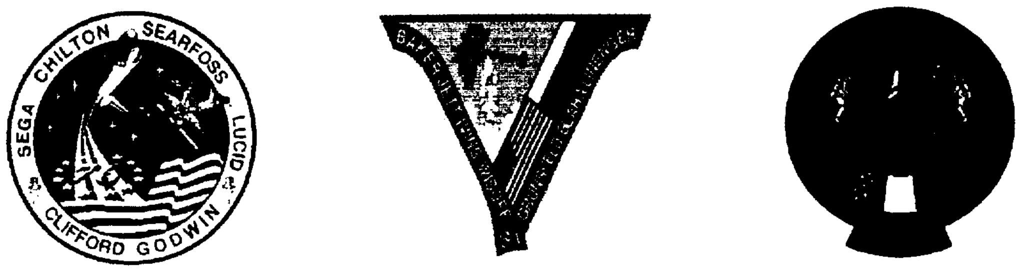



*Figure 50: Logos for STS-76 (left), STS-81 (center), and STS-86 (right).*

*Table 8: Summary of Missions*

| STS-76 | | Crew | Mission Goals |
|---|---|---|---|
| **Launch Date** | March 22, 1996 | Kevin Chilton | Third Mir docking, |
| **Landing Date** | March 31, 1996 | Richard Searfoss | crew delivered Lucid |
| **Duration (days)** | 9.22 | Ronald Sega | |
| **No. Orbs** | 144 | Richard Clifford | |
| **Hours Op.*** | 37 | Linda Godwin** | |
| **No. Schools** | 3 | Shannon Lucid | |
| **No. Students** | ~380 | | |
| **No. Photos** | 326 | | |
| **STS-81** | | **Crew** | **Mission Goals** |
| **Launch Date** | January 12, 1997 | Mike Baker | Fifth Mir docking, |
| **Landing Date** | January 22, 1997 | Brent Jett | crew exchange |
| **Duration (days)** | 10.21 | Jeff Wisoff | (Linenger/Blaha) |
| **No. Orbs** | 160 | John Grunsfeld | |
| **Hours Op.*** | 72 | Marsha Ivins** | |
| **No. Schools** | 17 | Jerry Linenger | |
| **No. Students** | ~3000 | John Blaha | |
| **No. Photos** | 540 | | |
| **STS-86** | | **Crew** | **Mission Goals** |
| **Launch Date** | September 25, 1997 | James Wetherbee | Seventh Mir docking, |
| **Landing Date** | October 6, 1997 | Mike Bloomfield** | crew exchange |
| **Duration (days)** | 10.80 | Scott Parazynski | (Foale/Wolf) |
| **No. Orbs** | 169 | Vladimir Titov | |
| **Hours Op.*** | 38 | Jean-Loup Chrétien | |
| **No. Schools** | 52 | David Wolf | |
| **No. Students** | ~6000 | Michael Foale | |
| **No. Photos** | 656 | | |

* Total hours of operation for the KidSat camera
**KidSat Payload Officer

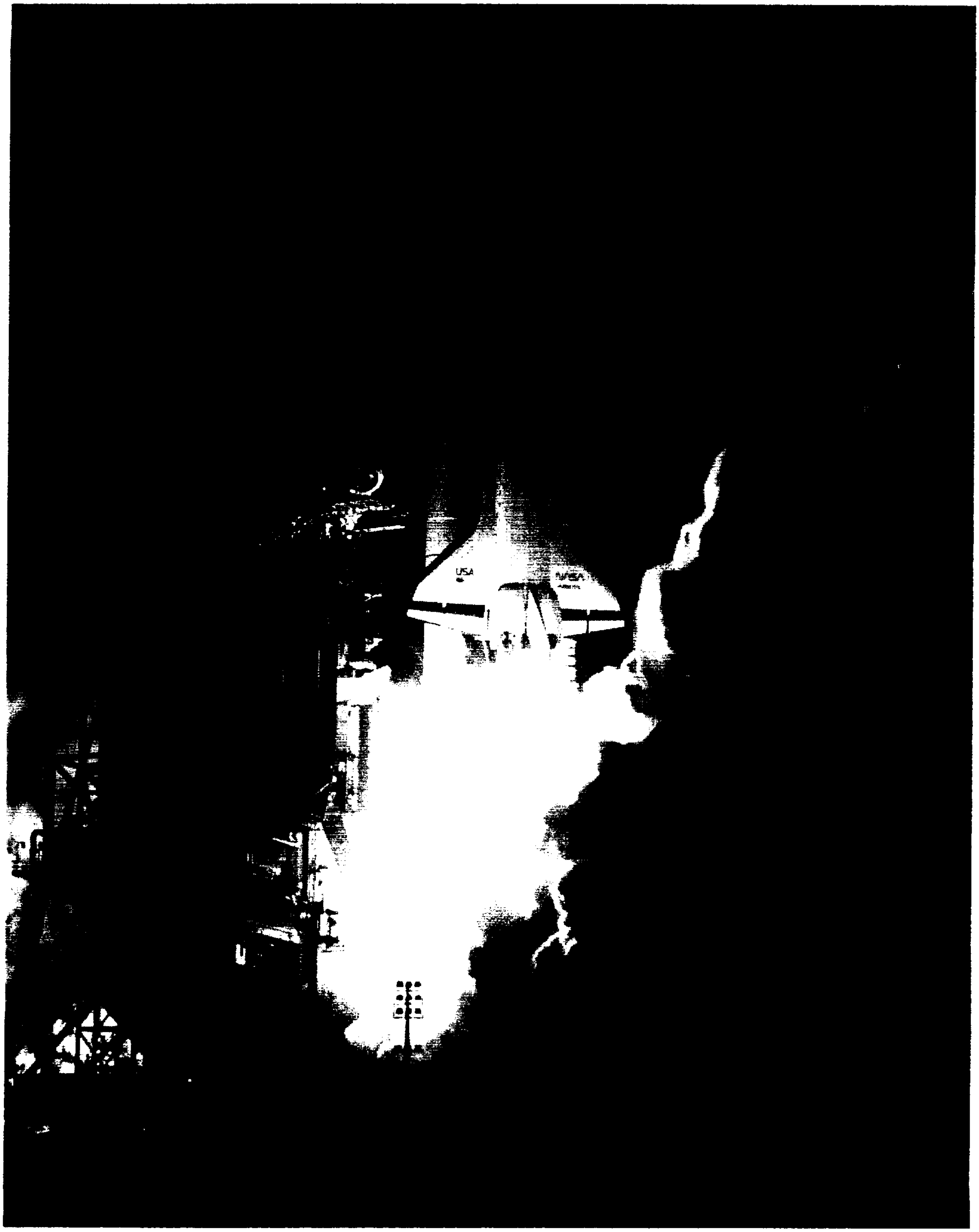


*Figure 51: STS-76 Launch.*

*Figure 52: STS-76 landing at Edwards Air Force Base early in the morning on March 31, 1996.*

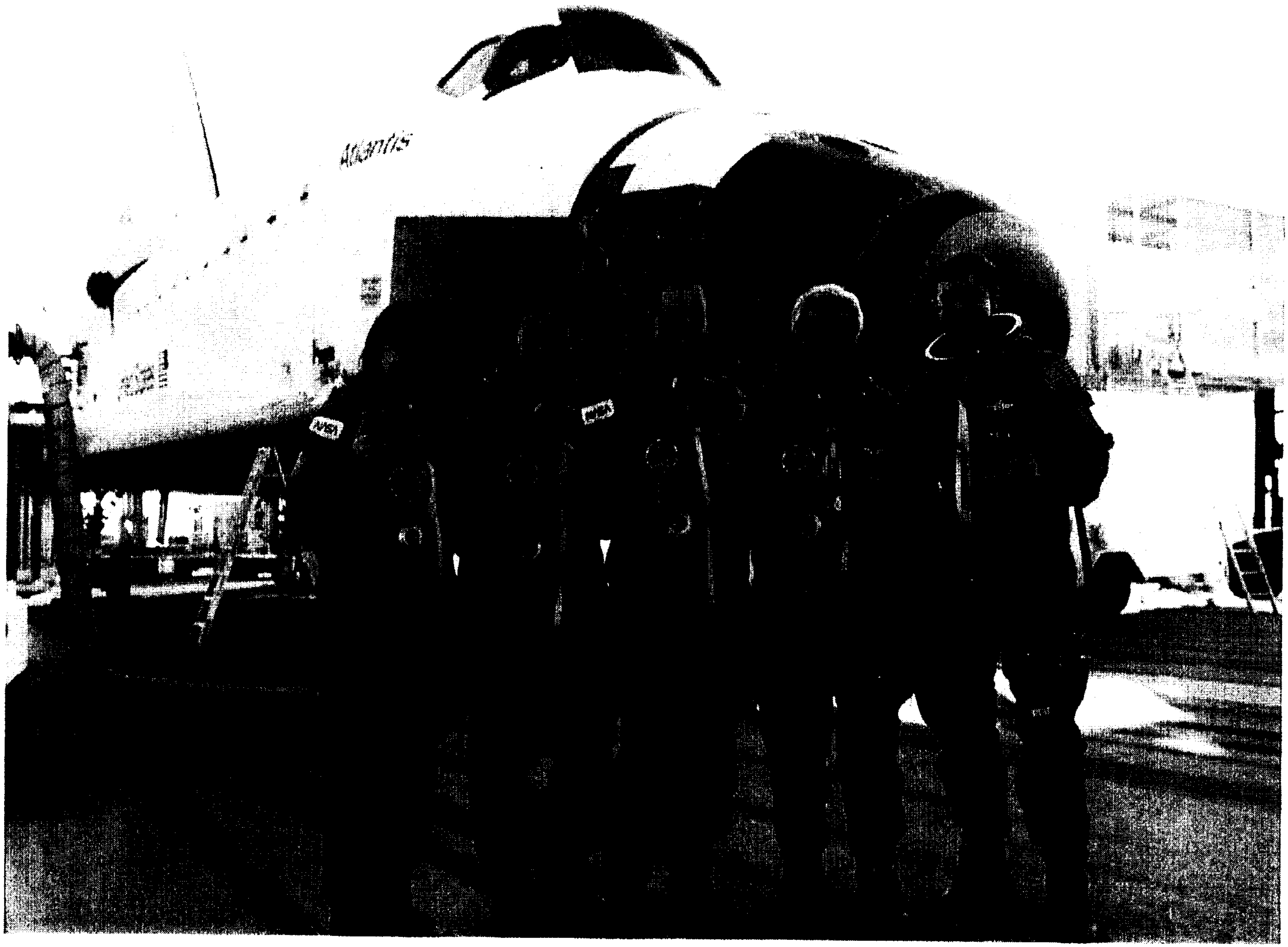



Figure 53: The STS-76 crew at Edwards Air Force Base after landing: Linda Godwin (KidSat Payload Officer); Richard Searfoss (Pilot); Kevin Chilton (Commander); Rich Clifford and Ronald Sega (Mission Specialists).

## 8.1 The First Mission: STS-76

The Space Shuttle Orbiter Atlantis took off from Kennedy Space Center Pad 39-B on March 21, 1996. This mission was the third of nine planned shuttle-Mir linkups and the sixteenth flight for Atlantis. The docking, crew transfers, and rendezvous prepared NASA for the assembly and operation of the International Space Station, which was set to begin in 1999. The flight ended on March 30, 1996, when Atlantis landed at Edwards Air Force Base (due to poor weather at Kennedy.) Members of the KidSat team met the shuttle at Edwards early in the morning on the day it landed.

On the sixth day of the mission, Linda Godwin and Rich Clifford performed a six-hour space walk while Atlantis was docked to Mir. They attached four experiments, known as the Mir Environmental Effects Payload (MEEP), onto the handrails of the Mir Docking Module. This Extra Vehicular Activity (EVA) was one in a series designed to test the equipment and procedures that may be used during the assembly of the International Space Station.

Another special feature of this flight was that it had the distinction of launching the first American woman to Mir, Shannon Lucid, to serve as a Mir station researcher. In addition to KidSat, a payload called the Shuttle Amateur Radio Experiment (SAREX) was also designed for young students; this experiment had already flown on a number of past flights. SAREX allowed students to talk with crew members via ham radio about mission activities, and life and work in space.

### *8.1.1 KidSat Operation*

The KidSat Flight System was set up by the crew 18 hours after launch. The latest version of the flight software was uploaded and KidSat was declared operational at MET (Mission Elapsed Time) 00/19:24. During the first photograph session, KidSat operated for 12 hours, 53 minutes, and 7 seconds, during which time 153 commands were sent to the camera and 149 images were received. KidSat was set up again after docking with Mir at MET 06/19:48 and operated until just before landing. The camera sent 63 commands and received 63 images before a general protection fault halted operations. The crew restarted the software, and a command file requesting 114 images was uploaded. By then, the $K_u$-band antenna had been stowed (at MET 07/05:10) so all the remaining images were received after landing. The final log file showed no anomalies and all 114 images were recovered. During the second portion of the mission, KidSat operated for 23 hours, 47 minutes, and 18 seconds. The total operating time for KidSat on STS-76 was 36 hours, 40 minutes, 25 seconds, and a total of 326 images were acquired. All the images were electronically transferred to the Data System at JPL in near real time or after landing from JSC. The lighting of the Earth in March and an early morning launch resulted in daylight coverage on the descending portions of the orbit.

Mission operations ran smoothly and efficiently at the Mission Control Gateway (MCG) and at the KidSat/ESC Payload Operations Control Center at JSC. MCG positions were staffed by undergraduate and high school students in three shifts during the flight. The pilot middle schools students, working from their SMOCs, actively participated during all KidSat observing periods by planning, requesting, receiving, and analyzing new images. They will be busy for years analyzing their large collection of images and exploring the Earth.

Figure 54: STS-76 coverage map.

Among the images from STS-76 were several excellent examples of sun glint on the ocean, coastlines, islands, deserts, mountain ranges, metropolitan areas, rivers, and clouds—lots of clouds. A dramatic stereo pair of images of a thunderstorm in Sudan was used to make a stereo anaglyph for three-dimensional viewing, using red-green glasses.

### *8.1.2 Participating Middle Schools*

Three schools participated in STS-76: Buist Academy from Charleston, South Carolina; Samuel Gompers Secondary School, San Diego, California; and Washington Accelerated Learning Center, Pasadena, California. These schools allowed at least 380 students to become actively involved in the KidSat mission. Buist Academy was selected based on their experience with Can Do (Nicholson 1994). Gompers Secondary School and Washington Accelerated Learning Center were selected due to their proximity to UCSD and JPL, respectively.

### *8.1.3 Results*

At the request of the middle school students, 326 photographs of the Earth were taken by the KidSat flight equipment. The Mission Operations team fully supported the mission. The Data System team released the images to the students and the world at unprecedented speeds and created a flyby using an image of Saudi Arabia. In addition, a video was created of the Aral Sea that combined KidSat images and shuttle video data. The Exploration team and the students in the middle schools focused their explorations during the mission on Kangaroo Island, the Rift Valley in Africa, and the Aral Sea.

Students had a clear understanding of the goals of the mission and their function in achieving these goals. They applied their skills in the operation of the SMOC, made decisions, carried out the mission with adult supervision, worked in teams, developed proficiency in using a wide range of technologies, and were excited to be part of something that was real and ongoing. Students had a strong sense of ownership and pride, learned to adapt to changes during the mission, were highly engaged during the project, and improved their communication skills.

Students were in charge: they communicated with the Gateway, plotted the orbital track based on the descending node, selected targets, confirmed the METs, cross-checked the weather, entered the selections into the SMOC Web pages, and retrieved their images. They applied the knowledge they gained to new explorations and were able to clearly express their understanding of the KidSat project.

*Figure 55 : The first KidSat image downloaded on STS-76 was of Kiev, acquired at MET 00/19:39:50.*

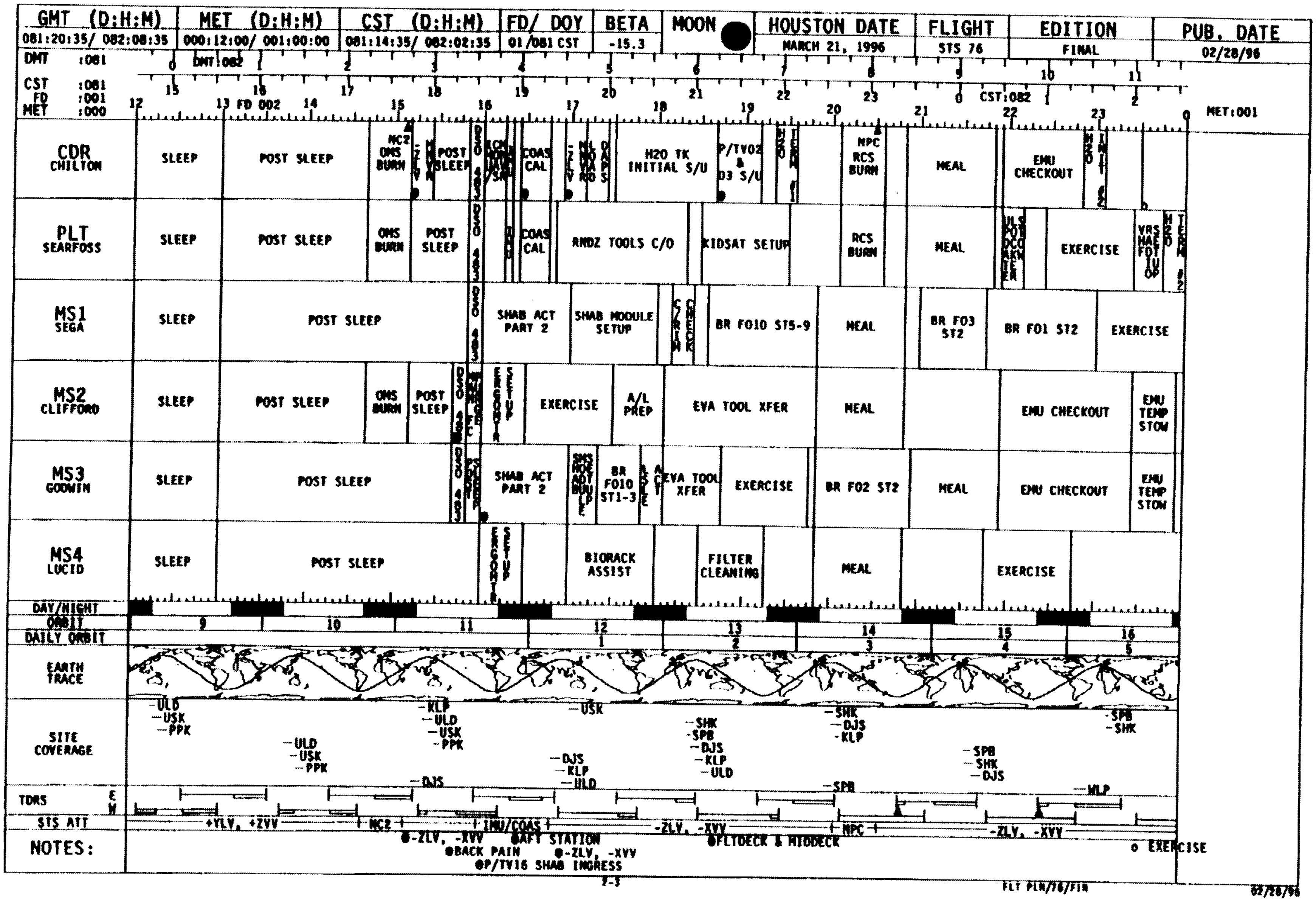



Figure 56: A page from the pre-launch flight plan for STS-76, showing the first KidSat setup.

*8.1.4 STS-76 Mission Information*

| | |
|---|---|
| **Crew** | |
| Kevin Chilton | Commander |
| Rick Searfoss | Pilot |
| Ron Sega | Mission specialist 1 |
| Rich Clifford | Mission specialist 2 |
| Linda Godwin | Mission specialist 3 |
| Shannon Lucid | Mission specialist 4 (left on Mir) |

| | |
|---|---|
| **Mission Summary** | |
| Pre-Launch press conference | March 12, 1996 |
| Launch date | March 22, 1996 |
| Launch time | 2:35 CST |
| Orbit inclination | 51.6° |
| Orbital altitude | 400 km |
| Mission duration | 9.22 days |
| Landing date and site | March 31, 1996, at Edwards Air Force Base |
| Landing time | 7:04 CST |
| Primary objectives | Supply mission to Mir<br>Deliver Lucid to Mir |

| | |
|---|---|
| **MET of Key Events During Mission** | |
| (days/hours:minutes:seconds) | |
| 00/00:00 | Launch |
| 00/01:45 | Ku antenna setup |
| 00/18:30 | KidSat setup |
| 00/19:24 | KidSat declared operational |
| 00/19:39:50 | First image |
| 01/12:45 | KidSat deactivation |
| 01/18:40 | Mir docking |
| 04/22:30 | Extra vehicular activity |
| 06/16:50 | Mir undocking |
| 06/20:35 | KidSat setup |
| 07/05:10 | Ku antenna stow |
| 07/20:00 | KidSat deactivation |
| 07/19:21:45 | Last image |
| 08/04:45 | Landing at Kennedy Space Center |

### *8.1.5 STS-76 Thumbnails*

**See Figure 57 (1 of 4)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | 07195015 | 07194035 | 07193932 | 07193745 | 07192343 | 07192334 | 07192321 |
| 2 | 07192208 | 07192145 | 07191949 | 07191919 | 07191915 | 07191729 | 07191448 |
| 3 | 07191333 | 07191328 | 07191126 | 07181402 | 07180922 | 07180738 | 07180453 |
| 4 | 07180139 | 07175741 | 07175621 | 07175452 | 07175223 | 07175058 | 07174755 |
| 5 | 07174718 | 07174242 | 07174203 | 07174115 | 07173935 | 07163724 | 07162817 |
| 6 | 07162800 | 07162658 | 07161645 | 07161620 | 07161535 | 07161501 | 07161448 |
| 7 | 07161234 | 07161214 | 07161136 | 07160914 | 07160738 | 07160624 | 07144154 |
| 8 | 07144130 | 07144114 | 07144059 | 07144031 | 07143916 | 07143822 | 07143800 |
| 9 | 07143654 | 07143618 | 07143329 | 07130437 | 07130425 | 07130243 | 07130124 |
| 10 | 07120851 | 07120738 | 07113953 | 07113245 | 07103501 | 07103349 | 07103224 |
| 11 | 07103214 | 07102259 | 07085721 | 07085701 | 07085544 | 07085511 | 07085457 |
| 12 | 07085434 | 07084641 | 07084305 | 07084137 | 07071629 | 07071050 | 07071047 |
| 13 | 07071006 | 07070758 | 07070649 | 07070533 | 07070457 | 07070140 | 07070136 |
| 14 | 07065847 | 07065756 | 07065746 | 07065639 | 07065610 | 07065535 | 07065520 |

**See Figure 57 (2 of 4)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | 07065451 | 07065439 | 07053859 | 07053856 | 07053451 | 07053430 | 07053218 |
| 2 | 07052737 | 07052717 | 07052657 | 07052434 | 07052401 | 07052324 | 07052147 |
| 3 | 07051847 | 07051838 | 07035106 | 07035058 | 07035027 | 07034954 | 07024522 |
| 4 | 07024318 | 07024305 | 07024218 | 07023242 | 07023204 | 07023141 | 07023117 |
| 5 | 07023108 | 07023058 | 07023042 | 07023027 | 07022944 | 07022920 | 07022840 |
| 6 | 07021600 | 07021524 | 07021513 | 07010927 | 07010904 | 07010638 | 07010119 |
| 7 | 07010103 | 07010039 | 07005829 | 07005821 | 07005754 | 07005111 | 07005102 |
| 8 | 07005041 | 07005034 | 06233257 | 06232930 | 06232721 | 06232532 | 06232512 |
| 9 | 06232507 | 06231806 | 06231643 | 06231336 | 06231323 | 06215127 | 06215123 |
| 10 | 06214838 | 06214832 | 06214457 | 06214453 | 06214254 | 06214237 | 06214233 |
| 11 | 06214217 | 06214057 | 06214053 | 06213852 | 06213848 | 06213752 | 06213748 |
| 12 | 06213718 | 06213713 | 01081335 | 01081318 | 01080843 | 01080828 | 01080812 |
| 13 | 01080736 | 01080555 | 01080438 | 01080413 | 01080351 | 01080335 | 01080323 |
| 14 | 01080259 | 01080043 | 01075607 | 01075452 | 01062030 | 01062000 | 01061930 |

**See Figure 57 (3 of 4)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | 01061900 | 01061839 | 01061806 | 01061750 | 01061730 | 01061700 | 01061600 |
| 2 | 01061530 | 01061500 | 01061420 | 01061400 | 01061340 | 01061320 | 01061300 |
| 3 | 01061240 | 01061220 | 01061200 | 01061141 | 01061122 | 01051705 | 01051649 |
| 4 | 01051632 | 01051615 | 01051600 | 01034419 | 01034312 | 01034122 | 01033947 |
| 5 | 01033833 | 01033803 | 01033546 | 01033538 | 01033500 | 01033253 | 01033226 |
| 6 | 01033152 | 01033046 | 01033006 | 01032726 | 01032652 | 01032644 | 01032627 |
| 7 | 01032508 | 01032406 | 01031530 | 01031515 | 01031500 | 01031445 | 01020855 |
| 8 | 01020358 | 01020339 | 01020139 | 01020124 | 01020109 | 01020054 | 01015123 |
| 9 | 01015113 | 01015012 | 01015006 | 01014942 | 01014912 | 01002923 | 01002911 |
| 10 | 01002520 | 01002440 | 01002353 | 01002324 | 01002150 | 01002122 | 01002052 |
| 11 | 01002037 | 01002022 | 01002005 | 01001840 | 01001742 | 01001550 | 01001530 |
| 12 | 00230130 | 00230101 | 00230034 | 00225940 | 00225600 | 00225544 | 00225235 |
| 13 | 00225134 | 00225122 | 00225020 | 00224940 | 00224923 | 00224904 | 00224754 |
| 14 | 00224731 | 00224603 | 00224549 | 00224442 | 00224127 | 00214849 | 00214704 |

**See Figure 57 (4 of 4)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | 00214627 | 00214558 | 00214347 | 00214237 | 00214148 | 00214133 | 00214118 |
| 2 | 00214102 | 00214048 | 00213654 | 00213520 | 00212726 | 00212713 | 00212654 |
| 3 | 00212548 | 00212429 | 00212404 | 00211835 | 00211157 | 00202000 | 00201945 |
| 4 | 00201930 | 00201436 | 00201006 | 00200940 | 00200154 | 00200130 | 00195732 |
| 5 | 00195616 | 00195244 | 00193950 | 00192601 | | | |

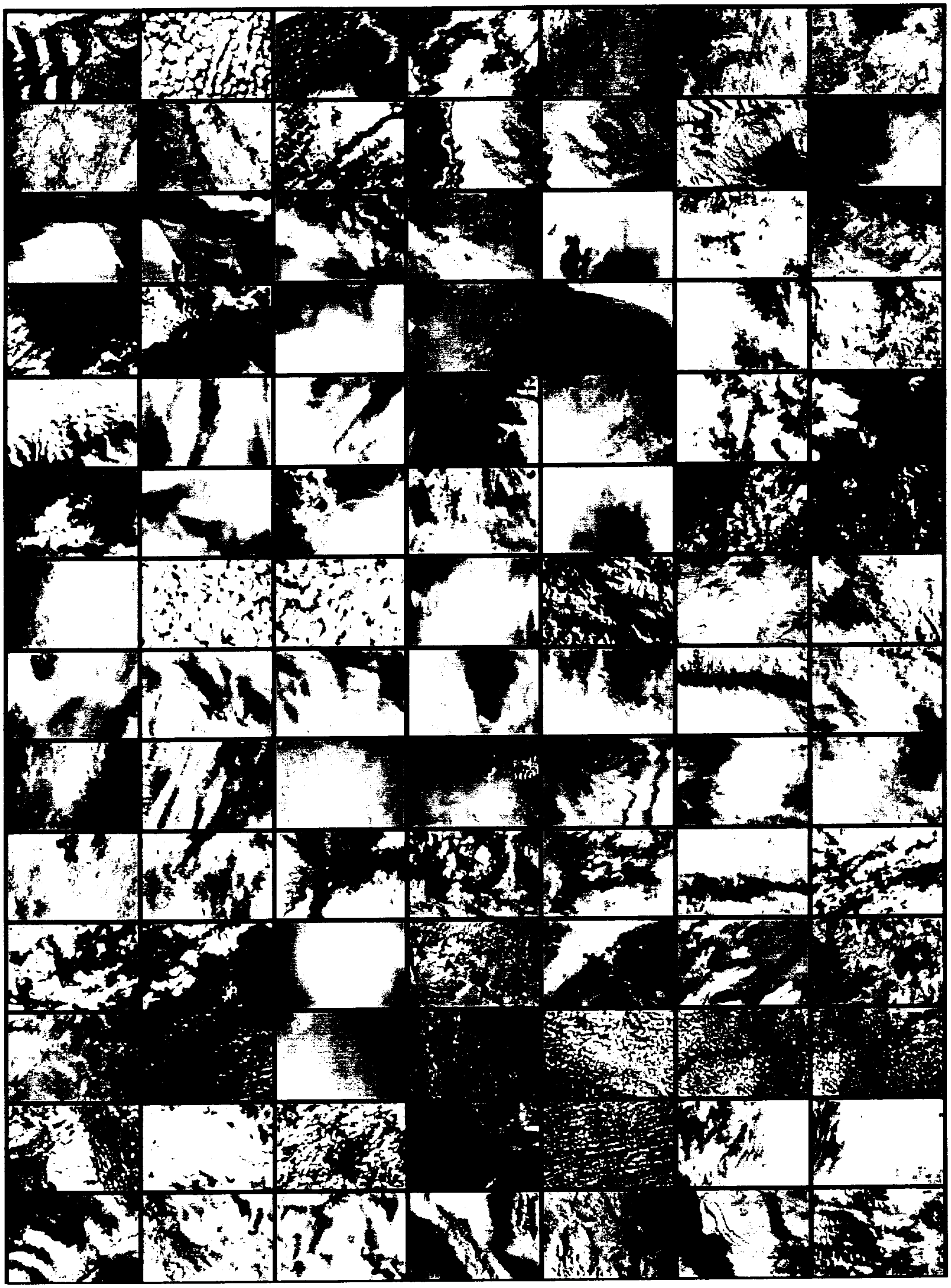


Figure 57: Thumbnail images of 326 photographs taken by STS-76 (1 of 4).

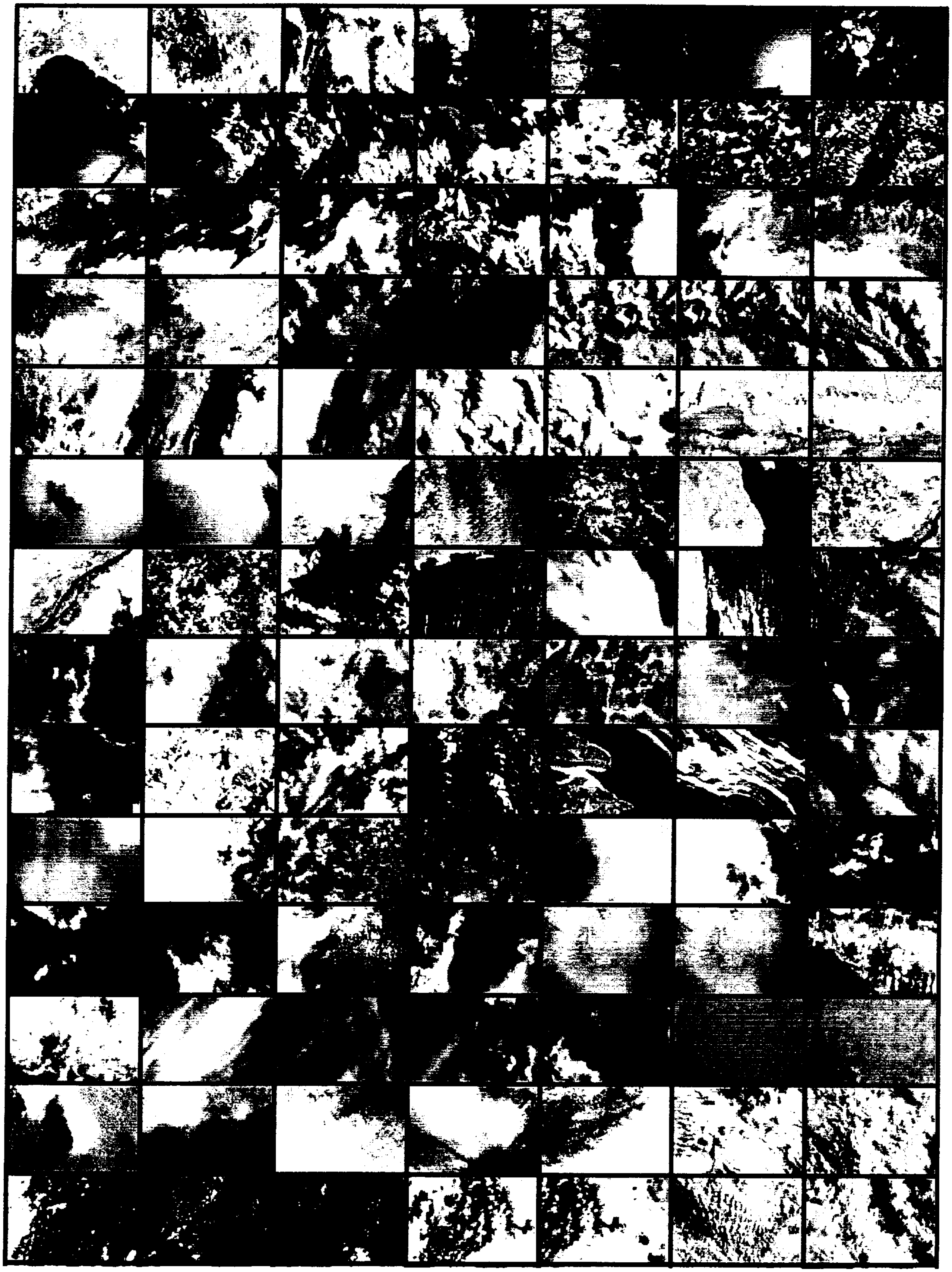


Figure 57: Thumbnail images of 326 photographs taken by STS-76 (2 of 4).

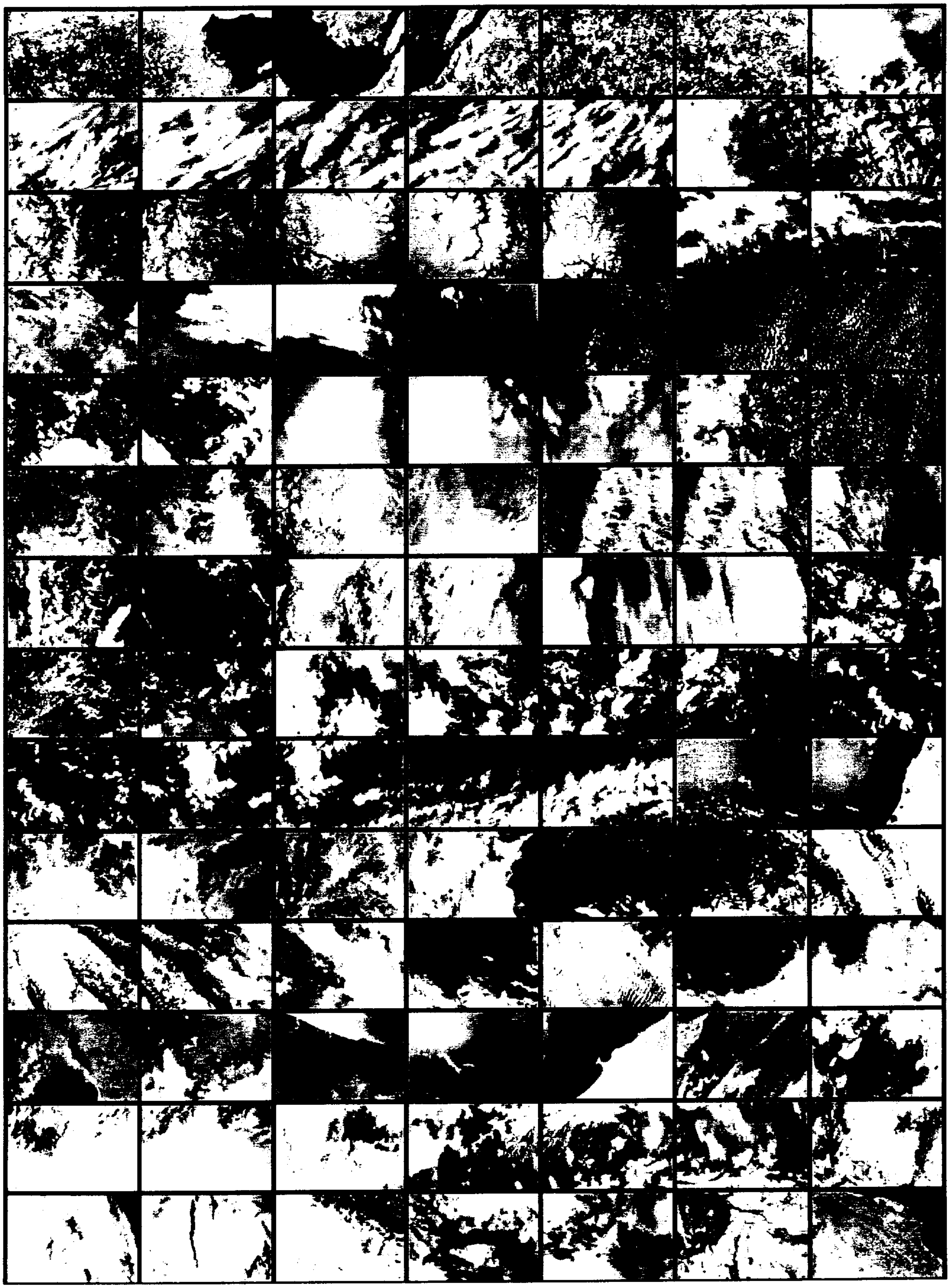


*Figure 57: Thumbnail images of 326 photographs taken by STS-76 (3 of 4).*

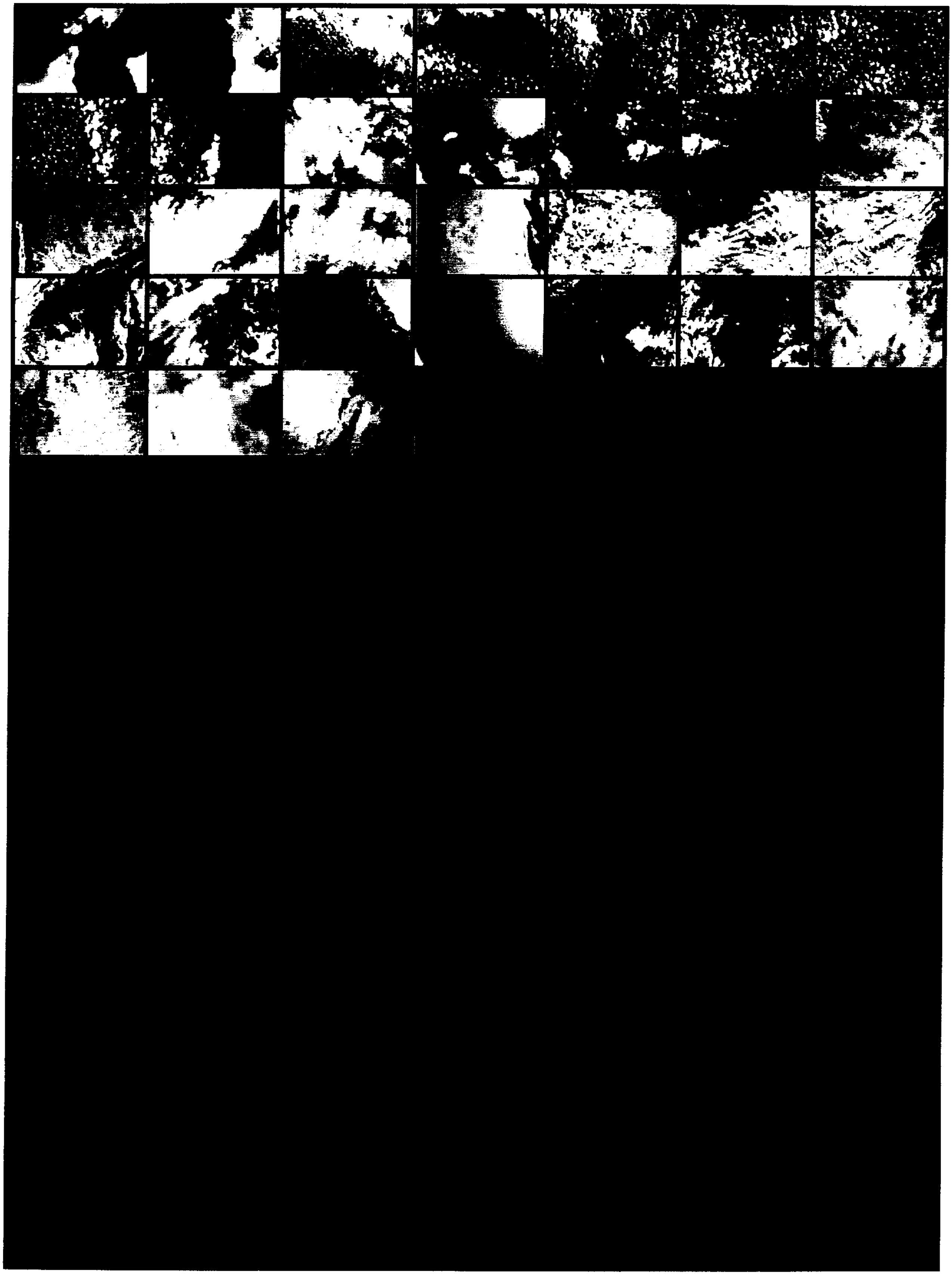


*Figure 57: Thumbnail images of 326 photographs taken by STS-76 (4 of 4).*

### *8.1.6 A Week in the Life of a Data System Student at the JSC Payload Operations Control Center*

*Casey Kirchner, Millard High School, KidSat Data System Team*

Overall, I think things went smoothly enough to call this experience a success. I think Mike Riddell (La Canada High School, KidSat Data System Team), Solil Patel (Creekside Institute, KidSat Data System Team), and Barbara Belek (Creekside Institute, KidSat Data System Team) were all prepared to do the job, but since Mr. Kassebaum (Millard High School) and I had not been trained on any of the SIMs, all we could do was read through the procedures before we got here. I was relieved to see that our software was just basic Windows, file manager, and FTP. I have plenty of experience with Windows, but recognizing the software is not the same thing as being trained on the operations software. We tried to find out earlier what software would be used so that we could run a SIM of our own, but had been given the name of some expensive commercial software that we thought sounded similar to the KCA software that Phyllis or Ron would use to actually downlink the images. Luckily, it was Mike's shift when the first images came down. We watched him the first time, then he let me do it the second time, and by then I was comfortable enough to do it myself. I was impressed that Mike offered to let me do it the second time. I felt like we were already working as a team, even though we had just met.

Phyllis had a downlink for me to send out the next morning, but other than that, my work in the POCC consisted mainly of copying and faxing the updated timelines, and keeping the log book up to date. This kept me busy, but not for the entire eight-hour shift. Sometimes, I would leave the POCC to do other things, and, often, I think those things were just as important to the future of KidSat as the work I did in the POCC. We were interviewed by three TV stations, a newspaper, and a magazine. We worked with the Earth Observations department to generate ideas for a curriculum. To get the word out, we briefed the crew of STS-75 about KidSat. By the way, they really seemed to perk up when we were introduced and started talking. They listened attentively and even asked questions. They seemed all for it!

After the Mir docking, I was thankful for the increased amount of work that came after the camera was set back up. I really felt that I was an integral part of the KidSat picture. Not being able to log on to JPL's computer because of its user limit was a good, healthy opportunity to do some problem solving, and it was actually fun. I don't think I've ever worked on a problem that impacted this many people. All of my work during this mission was a healthy, quiet, and steady source of pride. Paul Andres was patient and helpful. It was great working with everybody in Houston. Everybody was willing to help and easy to get along with.

Another thing I should mention is that we got Mandy Minino (a Millard High School freshman) an escort badge so she could be in the POCC for some of the interviews and become accustomed to the environment, should she be needed to do my job during the following mission. While she was there, I went through the procedure with her and showed her how to do things on the computer. On Friday, I had her FTP some files to JPL and call Paul for confirmation. I also had her fax some timelines. She did a good job.

One problem I saw was that we (the Data System Team), were not as connected with the SMOCs as I thought we would be, or as I think we needed to be. Neither Mr. Kassebaum nor I (and I suspect Mike or Barbara) ever talked by phone with the teachers from California. I talked to Kathy Rackley at Buist once, to find out why she was not getting the faxes. I had to call her office number and wait for her to call me back. When she did, she gave me the number of the phone in the SMOC! I didn't even know there was a phone in the SMOC, much less its number. This could be because I didn't read the notebook JoBea sent us thoroughly enough. The point is that I think there should have been more communication between the Data System and the SMOCs. Now that I think it over, I can't be sure that the two California schools ever got their timelines. Maybe they turned their fax machines off. Toward the end of the mission, we found out that the Mission Operations people in California had someone whose responsibility was to call the schools, but we were never in contact with that person. We knew from UCSD that the targeting was accurate, but, aside from two short e-mails that Mr. Kassebaum told me he received, I don't know if the schools were happy with the images. Maybe it was not really important that the Data System team was aware of the kids' level of satisfaction.

Another suggestion I have is to rewrite the procedures for file logging and transferring, and for faxing. We made a lot of revisions ourselves. We never looked at the ESC team's steps, so that really doesn't need to be in our procedures. I don't think they were really concerned with ours, either. Mike asked Ron to stop giving us the CCFs, since we didn't need them for anything. We only had bits and pieces of the paths to FTP the images to, and we didn't have the IP or username or password in our procedure. When the network crashed, it took KidSat a while to set the FTP back up again. I think it's important for us to have details like these in case of an emergency.

I would like to end my summary on a positive note. I feel very fortunate to have met Skip Reymann (Flight Team, JPL engineer). He had nothing but good to say about the students he met through his involvement with KidSat. He told one of the reporters that this mission was the most satisfying one he had ever worked on. I have a lot of respect for him and I place a lot of value on his opinion. I personally think it speaks very well of KidSat that he said that.

I have really enjoyed working with KidSat, and I want to thank everyone who helped the program. I really think this is special. I hope every kid has the opportunity to learn from space with KidSat. I know it will be hard since I'm going to college next year, but I hope to stay involved with KidSat in the future. KidSat has been good to me (and for me), and I think it can be so much more for the kids it was designed to teach.

### *8.1.7 A Day in the Life of the Gateway*

***Dan Barstow, Teacher Education Resource Center, KidSat CCDT***

I am now at the UCSD Gateway. The undergraduate students here are very focused on their work. They're getting ready for the second session with the KidSat camera. It's almost like the quiet focus of a golf tournament. In the Gateway room, the students are at their stations, each concentrating on his or her screen, getting the latest data from the shuttle, communicating status reports, asking questions of other stations—this is the real thing, now. It's especially impressive knowing that six months ago this room was empty, and that all of this was designed and built by these students—and it's working. In another room, students are communicating with the schools, receiving image requests, cross-checking the METs, locations and environmental data, and preparing the request files to be sent to the shuttle. And in a third room, there is an exact duplicate of the KidSat camera and Thinkpad, with the same image request files. When this camera clicks, the camera on the shuttle should be clicking.

Now the daylight part of the orbit is done. We wait anxiously for the downlink from the shuttle. We know the pre-Mir session worked, now let's hope this does. The file is received at JSC, then at UCSD and JPL. A seemingly endless format conversion takes place, and then the image appears. It looks like clouds, and there's not much land to confirm the location (to recalibrate the METs if necessary). Sally comes in. Can we at least figure out if this is the 180 mm lens? We can't tell for sure, but the cloud patterns do look larger, so we guess (until we can confirm with a land image) that it is the 180 mm.

As a weather fan, I actually like all these cloud images. There's a lot of learning that can be done with the different weather and cloud images from all over the world. I'm eager to start exploring them myself.

### *8.1.8 Messages Sent to the Crew During STS-76*

Several messages were sent from the KidSat Gateway to the crew during the STS-76 mission via the daily "Uplink," which is a text message of the revised plans for the upcoming day, changes to the flight plan, changes to procedures and comments about the events of the preceding day. Below are two of these messages:

- "KidSat Mission Operations has received a total of 182 images, and they're unbelievable. The schools are really enjoying them, and the targeting accuracy has been excellent. Justin Moresco, Mission Gateway Chief and undergraduate student at UCSD, says 'It's hard to believe this is really happening. We've worked so long and hard to finally come to this point. The whole project has been a fantastic experience, but these last few days have been incredible. Thanks!!!' Two images (Southeastern coast of Lake Superior and the Southern tip of India) have been included in message 31."

- "We're ecstatic! The three participating middle schools have each selected about 35–45 images. You'll be happy to know that we hit all of our target sites precisely. We'd especially like to thank you for the help in getting our last images down after the docking."

## 8.2 The Second Mission: STS-81

On January 12, 1997, the Space Shuttle Orbiter Atlantis shuttle took off from Kennedy Space Center Launch Pad 39-B. STS-81 was Atlantis' 18th flight and the 81st mission flown since the initiation of the Space Shuttle Program. This was the fifth of nine planned missions to Mir and continued the cooperative effort between the United States and Russia to further space exploration. STS-81 came to a close as Atlantis landed on January 22, 1997, at Kennedy Space Center. During STS-81, Atlantis flew at an altitude of approximately 400 km (240 miles) and at an inclination of 51.6°.

This ten-day flight held the distinction of transferring the largest number of items to and from Mir to date. Some of the items transferred included 1,400 pounds of water; 1,138 pounds of U.S. science equipment; 2,206 pounds of Russian logistics equipment; and 268 pounds of miscellaneous items. This mission also included several experiments in advanced technology, Earth sciences, fundamental biology, human life sciences, microgravity, and space sciences. Experiments to help plan and develop the International Space Station, commercial technology, and human and biological processes of Earth-based sciences were also performed. Astronauts replenished materials for experiments being performed on the Mir station and collected experiment samples and data for analysis back on Earth.

### *8.2.1 KidSat Operation*

Improvements were made to the KidSat Flight System for the STS-81 mission including the ability to track down and fix bugs in the camera interface driver; the addition of new features to support testing; the capacity for crew interfacing and the ability to enter a command onboard; and the introduction of a thumbnail image display for the most recent pictures taken by the camera.

Unlike the STS-76 mission, the images were transferred from the shuttle Thinkpad to an OCA computer at JSC. Then the images were automatically transferred to a Windows NT computer also located at JSC so that the images could be sent by FTP to JPL. During the first part of the mission, there was a KidSat student who would make sure that there were images to be transferred over from the Windows NT computer to JPL. For the second half of the mission, the data transfer from the Windows NT computer to JPL was done automatically.

### *8.2.2 Participating Middle Schools*

Fourteen additional schools joined the KidSat team for STS-81. Some of these schools were included through their collaboration with NASA Centers.

*Table 9: Middle Schools Participating in STS-81*

| School | City, State or Country |
|---|---|
| Bennett Middle School | Salisbury, Maryland |
| Buist Academy | Charleston, South Carolina |
| Canford School | Dorset, England |
| Canton Middle School | Baltimore, Maryland |
| Millard Central Middle School | Omaha, Nebraska |
| Collinwood Middle School | Cleveland, Ohio |
| Costano Middle School | Palo Alto, California |
| Crittendon Middle School | Newport News, Virginia |
| Gompers Secondary School | San Diego, California |
| Kearsney College | Kwa Zulu Natal, South Africa |
| Laing | Pleasant, South Carolina |
| Lewis Middle School | San Diego, California |
| Olive Pierce Middle School | Ramona, California |
| Ronald McNair Magnet School | Cocoa, Florida |
| Washington Accelerated Learning Center | Pasadena, California |
| Webster Magnet School | Webster, Texas |
| York County Middle School | Yorktown, Virginia |

### *8.2.3 Results*

Not only were 540 great photographs of Earth acquired during STS-81, but KidSat won some prestigious awards for hard work and effort! One of these awards was the FEDnet Webbie Award for the Most Innovative Web site. Another award KidSat was a finalist for the Computerworld Smithsonian Award in Education and Academia.

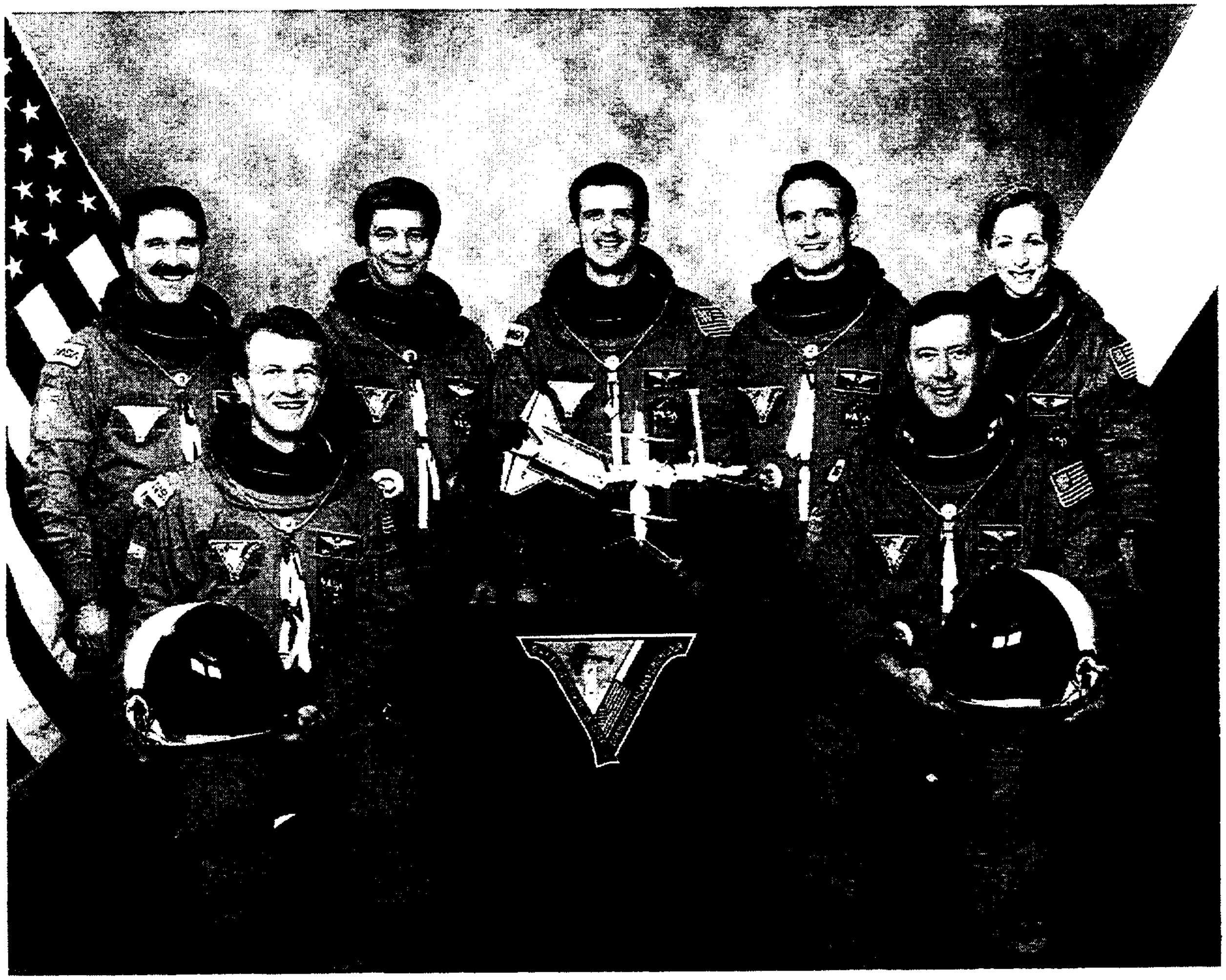


*Figure 58: The STS-81 crew: Top row, from left, Grunsfeld, Blaha, Wisoff, Linenger, Ivins (KidSat Payload Officer); bottom row, from left, Jett, Baker.*

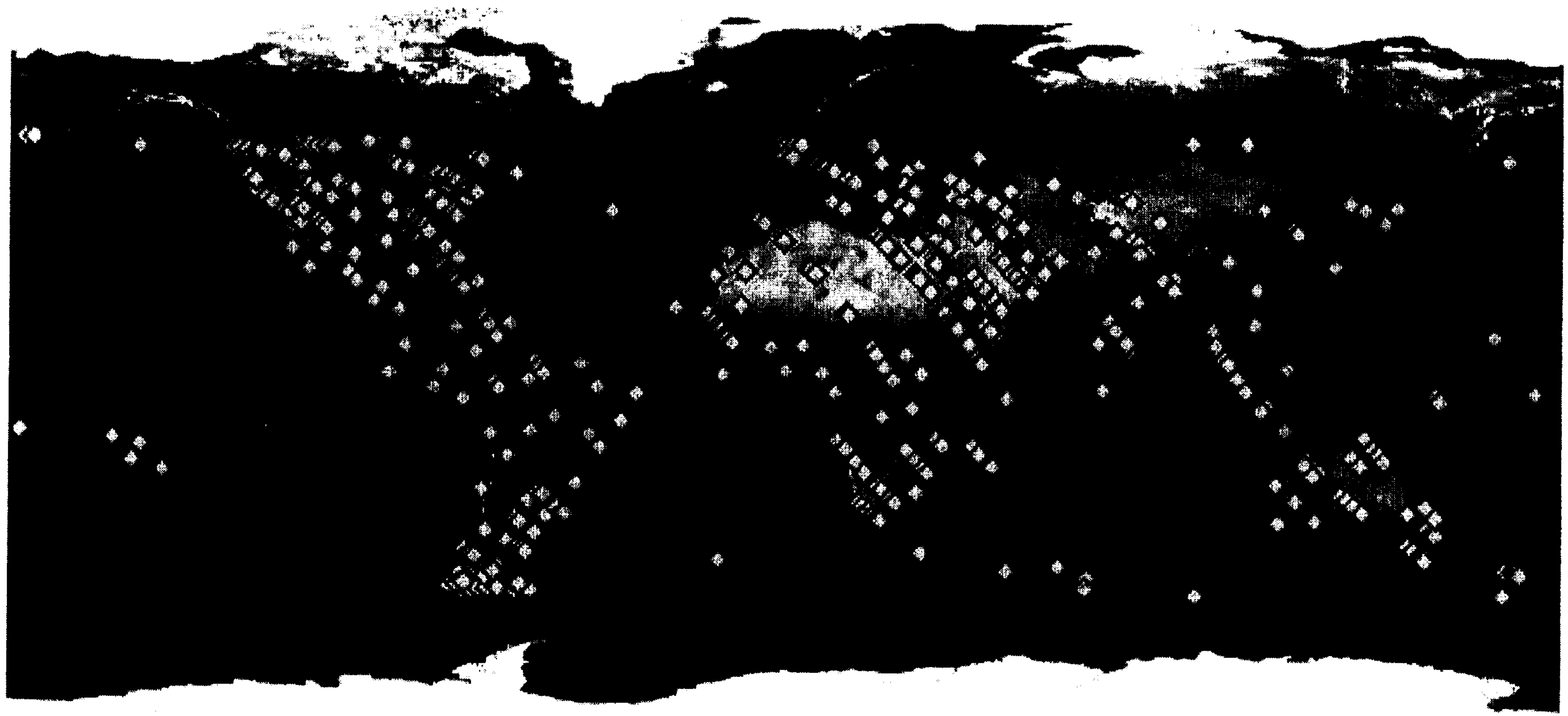


Figure 59: STS-81 coverage map.

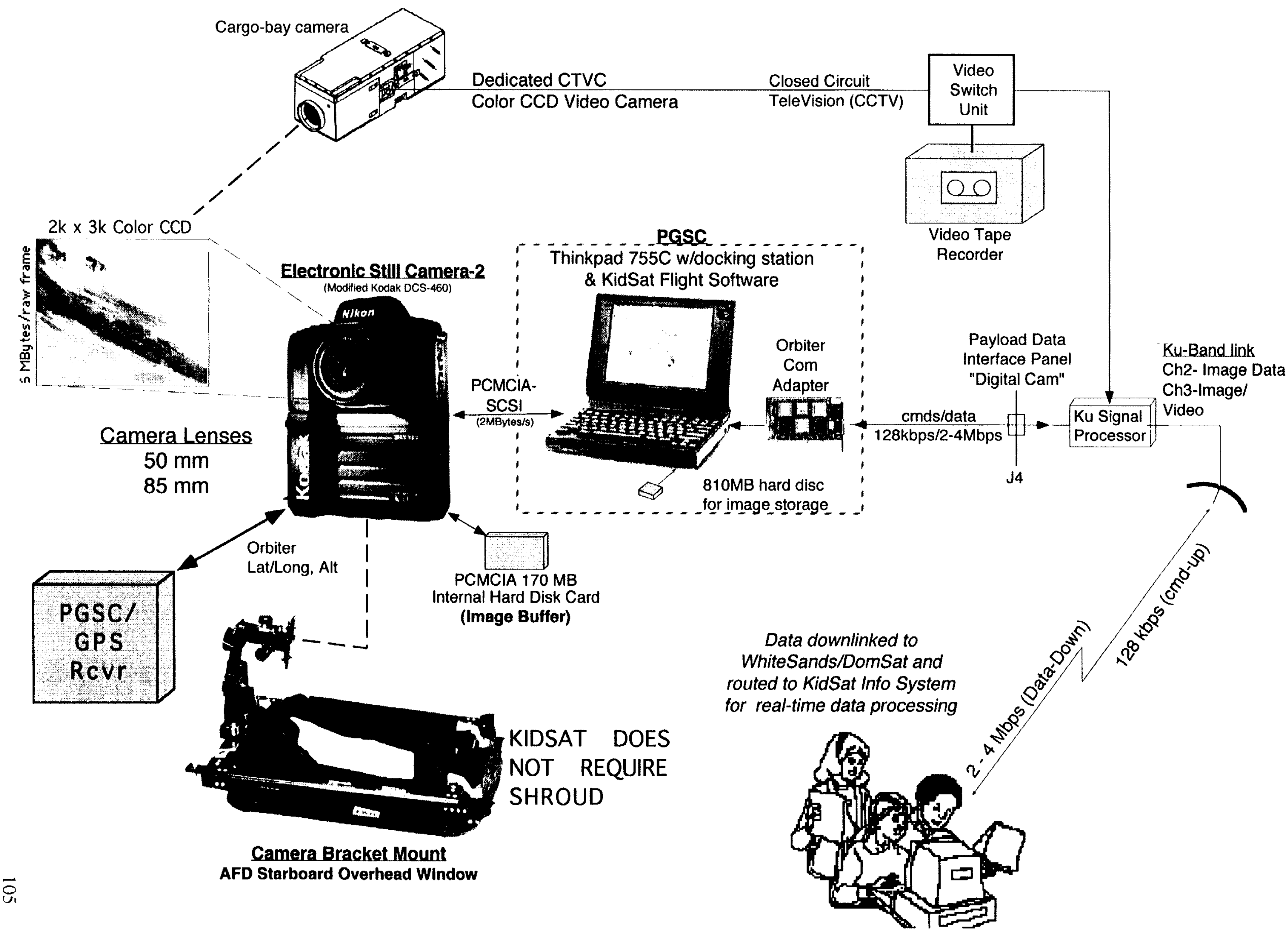



*Figure 60: STS-81 flight system configuration.*

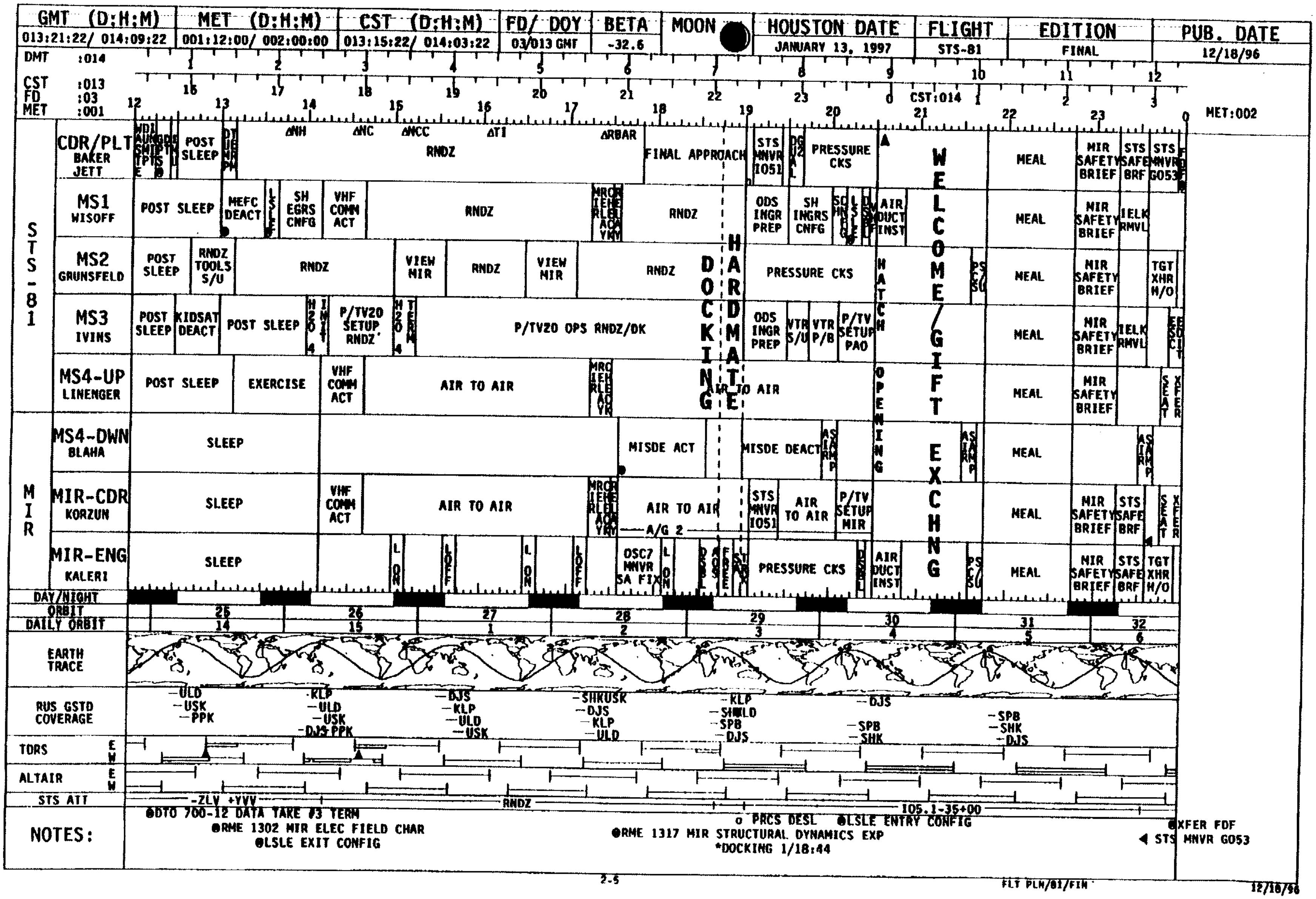



Figure 61: STS-81 flight plan, showing the KidSat stow preceding the Mir docking.

### *8.2.4 STS-81 Mission Information*

**Crew**

| | |
|---|---|
| Mike Baker | Commander |
| Brent Jett | Pilot |
| Jeff Wisoff | Mission specialist 1 |
| John Grunsfeld | Mission specialist 2 |
| Marsha Ivins | Mission specialist 3 |
| Jerry Linenger | Mission specialist 4 (left on Mir) |
| John Blaha | Mission specialist 4 (retrieved from Mir) |

**Mission Summary**

| | |
|---|---|
| Launch Date | January 12, 1997 |
| Launch Time | 03:27 CST |
| Orbit Inclination | 51.6° |
| Orbital Altitude | 400 km |
| Mission Duration | 10.21 days |
| Landing Date and Site | January 22, 1997, at Kennedy Space Center (KSC) |
| Landing Time | 06:47 CST |
| Primary Objectives | Supply mission to Mir<br>Deliver Linenger and retrieve Blaha from Mir |

**MET of Key Events During Mission**
(days/hours:minutes:seconds)

| | |
|---|---|
| 00/00:00 | Launch |
| 00/02:10 | Ku antenna setup |
| 00/18:50 | KidSat setup |
| 00/21:13:54 | First image |
| 02/12:55 | KidSat deactivation |
| 02/18:25 | Mir docking |
| 07/16:48 | Mir undocking |
| 07/18:32 | KidSat setup |
| 09/03:15 | Ku antenna stow |
| 09/20:00 | KidSat deactivation |
| 09/18:18:37 | Last image |
| 10/03:20 | Landing at KSC |

### 8.2.5 STS-81 Thumbnails

See Figure 62 (1 of 6)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | 09181837 | 09181745 | 09181735 | 09181340 | 09181207 | 09181110 | 09181007 |
| 2 | 09180948 | 09180846 | 09180445 | 09180427 | 09180346 | 09180145 | 09175954 |
| 3 | 09175616 | 09165501 | 09165449 | 09165439 | 09165429 | 09164933 | 09164837 |
| 4 | 09164456 | 09164429 | 09164357 | 09164310 | 09163207 | 09162948 | 09162912 |
| 5 | 09162651 | 09162608 | 09151438 | 09151421 | 09150924 | 09150845 | 09150818 |
| 6 | 09145824 | 09145818 | 09145603 | 09145537 | 09145524 | 09145332 | 09140526 |
| 7 | 09140500 | 09140356 | 09140343 | 09140320 | 09134000 | 09133625 | 09133206 |
| 8 | 09132300 | 09132250 | 09132234 | 09132149 | 09132100 | 09122957 | 09122905 |
| 9 | 09122836 | 09122816 | 09122757 | 09122735 | 09121155 | 09120953 | 09120942 |
| 10 | 09120932 | 09105444 | 09105429 | 09105410 | 09105254 | 09105220 | 09105210 |
| 11 | 09105158 | 09091713 | 09091613 | 09091555 | 09091533 | 09074206 | 09074108 |
| 12 | 09074045 | 09073811 | 09073800 | 09072916 | 09072914 | 09072123 | 09072053 |
| 13 | 09072039 | 09071952 | 09071938 | 09060604 | 09060157 | 09055838 | 09055807 |
| 14 | 09055559 | 09055408 | 09054954 | 09054737 | 09054726 | 09054712 | 09054702 |

See Figure 62 (2 of 6)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | 09054516 | 09054345 | 09054249 | 09054230 | 09054220 | 09054205 | 09042917 |
| 2 | 09042642 | 09042614 | 09042540 | 09042456 | 09041337 | 09041318 | 09041236 |
| 3 | 09041225 | 09041155 | 09041055 | 09035345 | 09013907 | 09013215 | 09013201 |
| 4 | 09013116 | 09013052 | 09012952 | 09012900 | 09012801 | 09012719 | 09012704 |
| 5 | 09012020 | 09012005 | 09011708 | 09011448 | 09002049 | 08235553 | 08235525 |
| 6 | 08235513 | 08235301 | 08235057 | 08234957 | 08234859 | 08234838 | 08234825 |
| 7 | 08234610 | 08234556 | 08234304 | 08234235 | 08234021 | 08233857 | 08233829 |
| 8 | 08233819 | 08224806 | 08222036 | 08221802 | 08221752 | 08221731 | 08221632 |
| 9 | 08221521 | 08221511 | 08221501 | 08221446 | 08221411 | 08221240 | 08221140 |
| 10 | 08221130 | 08221118 | 08220959 | 08220859 | 08220850 | 08220828 | 08220805 |
| 11 | 08220755 | 08220745 | 08220550 | 08220505 | 08211338 | 08211221 | 08204818 |
| 12 | 08204059 | 08204049 | 08204039 | 08204015 | 08203943 | 08203920 | 08203836 |
| 13 | 08203814 | 08203614 | 08203224 | 08203212 | 08203145 | 08193610 | 08192641 |
| 14 | 08192631 | 08192510 | 08192454 | 08192338 | 08192328 | 08190949 | 08190939 |

See Figure 62 (3 of 6)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | 08190554 | 08190020 | 08180047 | 08180025 | 08175616 | 08175607 | 08175543 |
| 2 | 08175421 | 08175024 | 08174942 | 08174300 | 08173943 | 08173934 | 08173135 |
| 3 | 08172945 | 08071259 | 08071249 | 08071221 | 08071115 | 08071059 | 08070804 |
| 4 | 08070752 | 08070742 | 08070627 | 08070345 | 08070137 | 08065712 | 08065659 |
| 5 | 08065532 | 08065257 | 08065046 | 08065028 | 08065005 | 08064907 | 08064842 |
| 6 | 08064617 | 08064554 | 08053605 | 08053505 | 08053028 | 08053001 | 08052927 |
| 7 | 08052641 | 08052333 | 08052144 | 08052046 | 08052036 | 08051926 | 08051900 |
| 8 | 08051843 | 08051831 | 08051815 | 08051755 | 08051632 | 08051618 | 08042405 |
| 9 | 08034338 | 08034328 | 08034316 | 08034303 | 08034230 | 08034218 | 08034154 |
| 10 | 08034130 | 08024038 | 07213930 | 07213909 | 07213859 | 07213841 | 07213834 |
| 11 | 07213825 | 07213759 | 07213641 | 07213607 | 07213558 | 07213226 | 07213218 |
| 12 | 07213201 | 07202853 | 07201451 | 07201344 | 07200822 | 07200750 | 07200419 |
| 13 | 07200324 | 07200235 | 07200139 | 02130229 | 02130156 | 02112843 | 02112827 |
| 14 | 02112817 | 02112737 | 02112621 | 02112611 | 02105214 | 02105152 | 02095340 |

**See Figure 62 (4 of 6)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | 02095334 | 02095224 | 02094329 | 02094020 | 02093702 | 02093651 | 02093531 |
| 2 | 02093442 | 02093246 | 02093041 | 02093039 | 02092955 | 02092935 | 02092847 |
| 3 | 02092826 | 02092743 | 02092730 | 02092206 | 02082705 | 02081445 | 02081430 |
| 4 | 02081151 | 02080707 | 02080503 | 02080447 | 02080425 | 02080409 | 02080359 |
| 5 | 02080345 | 02080333 | 02080315 | 02080300 | 02080242 | 02080239 | 02080229 |
| 6 | 02080225 | 02080215 | 02080200 | 02080145 | 02080130 | 02080115 | 02080100 |
| 7 | 02080057 | 02080045 | 02080030 | 02075913 | 02075647 | 02075630 | 02075552 |
| 8 | 02075454 | 02075404 | 02075325 | 02075310 | 02075255 | 02075242 | 02075204 |
| 9 | 02075149 | 02075127 | 02075106 | 02075051 | 02064154 | 02062635 | 02062624 |
| 10 | 02062611 | 02062559 | 02062530 | 02062514 | 02062459 | 02062449 | 02062430 |
| 11 | 02062416 | 02062404 | 02062319 | 02062250 | 02062237 | 02062222 | 02062000 |
| 12 | 02061940 | 02061920 | 02061901 | 02061845 | 02061830 | 02050926 | 02050426 |
| 13 | 02045243 | 02045105 | 02045058 | 02045043 | 02044751 | 02044627 | 02034740 |
| 14 | 02033947 | 02033823 | 02033615 | 02033602 | 02033032 | 02032902 | 02021427 |

**See Figure 62 (5 of 6)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | 02021326 | 02021246 | 02020717 | 02020542 | 02020405 | 02020106 | 02020026 |
| 2 | 02003304 | 02003238 | 02003054 | 02002914 | 02002751 | 02002623 | 02002611 |
| 3 | 02002407 | 02001747 | 01232854 | 01230324 | 01225809 | 01225652 | 01225445 |
| 4 | 01225430 | 01225213 | 01225142 | 01224918 | 01224803 | 01165419 | 01165404 |
| 5 | 01165349 | 01164629 | 01164626 | 01164436 | 01160006 | 01154300 | 01154109 |
| 6 | 01051801 | 01051746 | 01051730 | 01051715 | 01051649 | 01051630 | 01050415 |
| 7 | 01050353 | 01050314 | 01050258 | 01050235 | 01050200 | 01045400 | 01044316 |
| 8 | 01035823 | 01035401 | 01035242 | 01034408 | 01034341 | 01034308 | 01034215 |
| 9 | 01034206 | 01033951 | 01003151 | 01003147 | 01003120 | 01003108 | 01003024 |
| 10 | 01002957 | 01002920 | 01002708 | 01002618 | 01002601 | 01002552 | 01002535 |
| 11 | 01002239 | 01002114 | 01002047 | 01002024 | 01002012 | 01001959 | 01001941 |
| 12 | 01001930 | 01001920 | 01001820 | 01001810 | 01001754 | 00231821 | 00231817 |
| 13 | 00230455 | 00230437 | 00230359 | 00230354 | 00230254 | 00230244 | 00225836 |
| 14 | 00225824 | 00225534 | 00225435 | 00225427 | 00225412 | 00225359 | 00225351 |

**See Figure 62 (6 of 6)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | 00225212 | 00225104 | 00225054 | 00224934 | 00224925 | 00224448 | 00224428 |
| 2 | 00224415 | 00224402 | 00224356 | 00215128 | 00215120 | 00215055 | 00215029 |
| 3 | 00214728 | 00214657 | 00214624 | 00214558 | 00214407 | 00214345 | 00214300 |
| 4 | 00214058 | 00213904 | 00213330 | 00213325 | 00213309 | 00212943 | 00212933 |
| 5 | 00212736 | 00212656 | 00212631 | 00212249 | 00212126 | 00211800 | 00211354 |

*Figure 62: Thumbnail images of 540 photographs taken by STS-81 (1 of 6).*

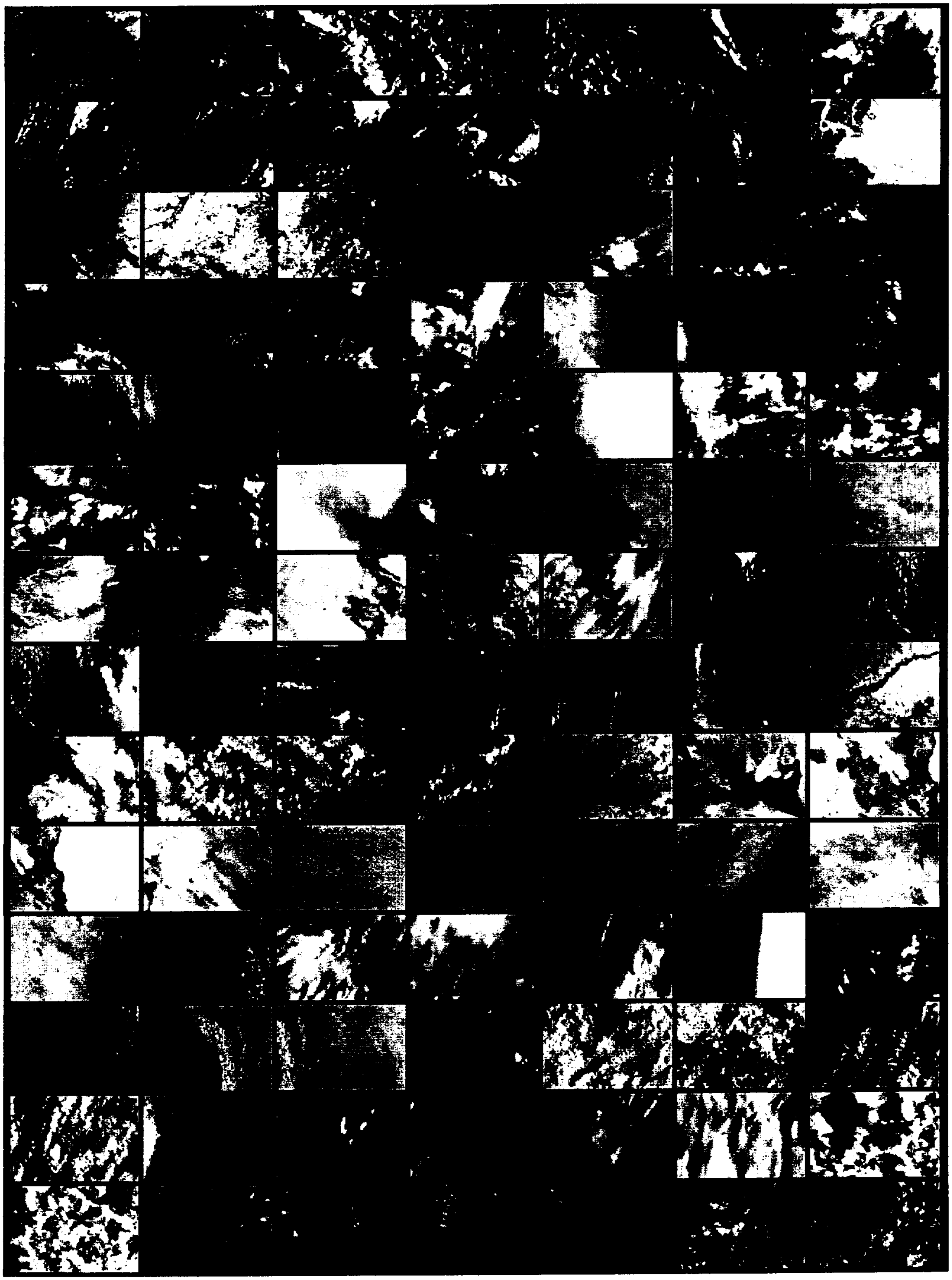


Figure 62: Thumbnail images of 540 photographs taken by STS-81 (2 of 6).

Figure 62: Thumbnail images of 540 photographs taken by STS-81 (3 of 6).

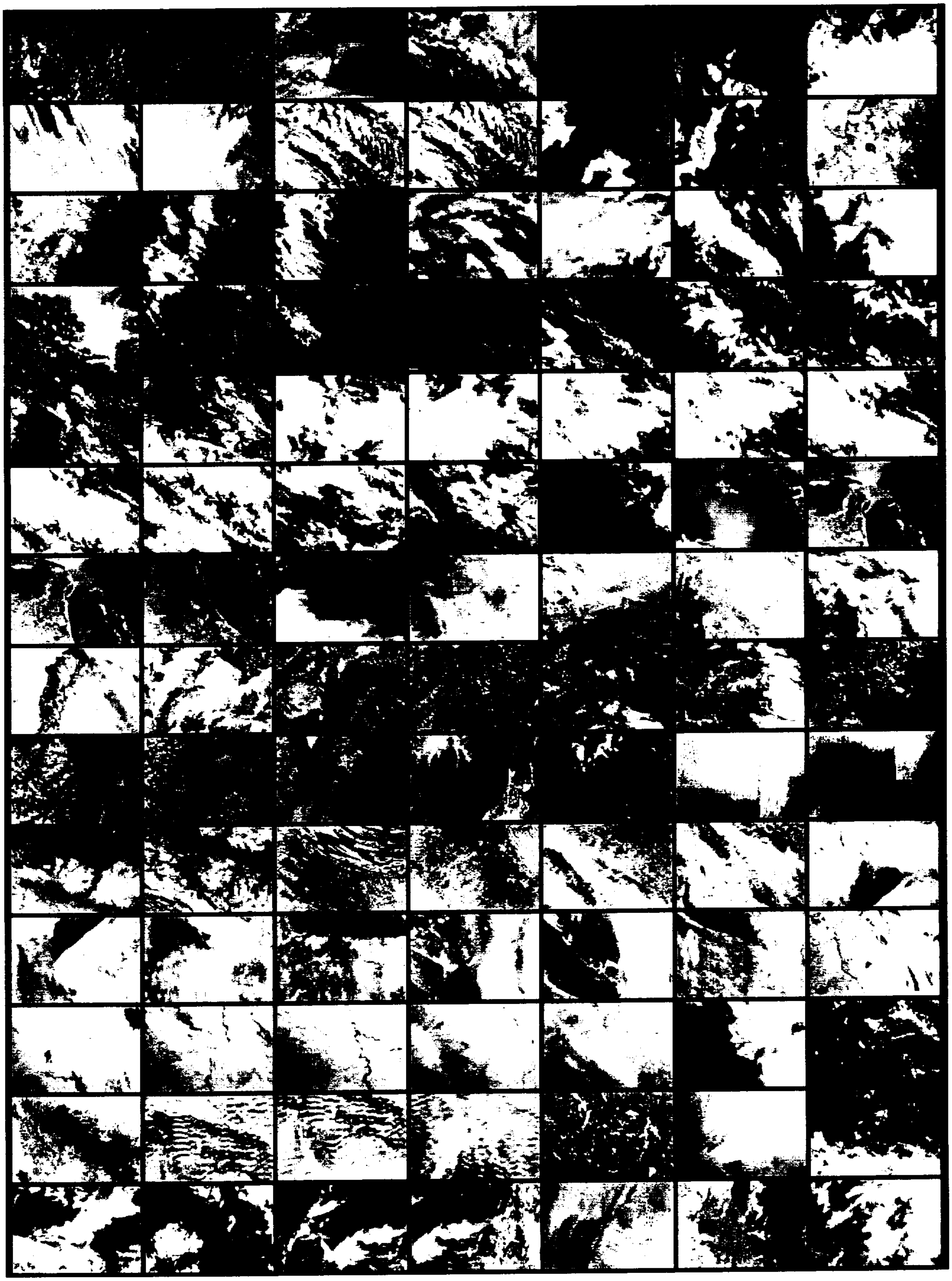


Figure 62: Thumbnail images of 540 photographs taken by STS-81 (4 of 6).

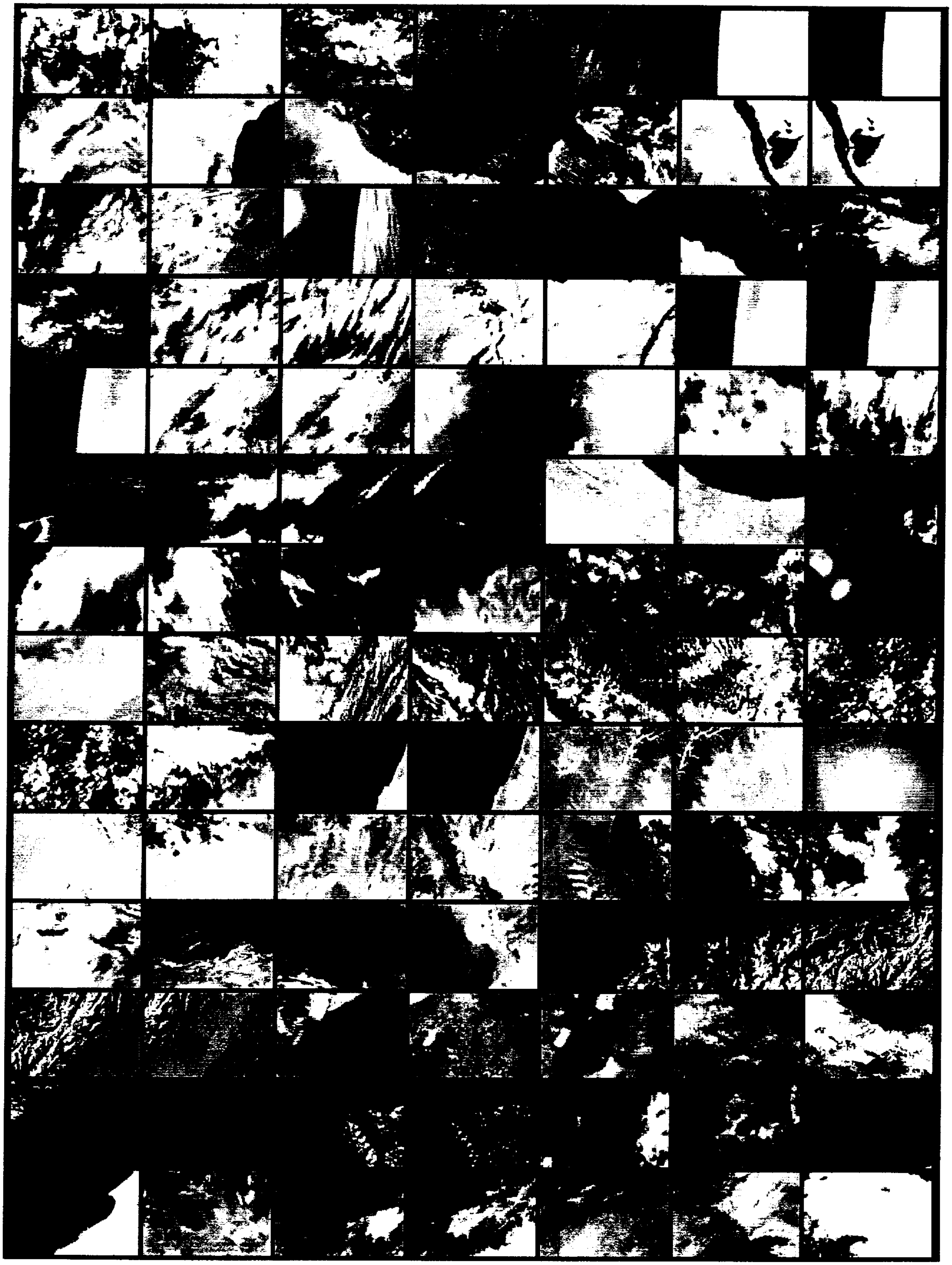


*Figure 62: Thumbnail images of 540 photographs taken by STS-81 (5 of 6).*

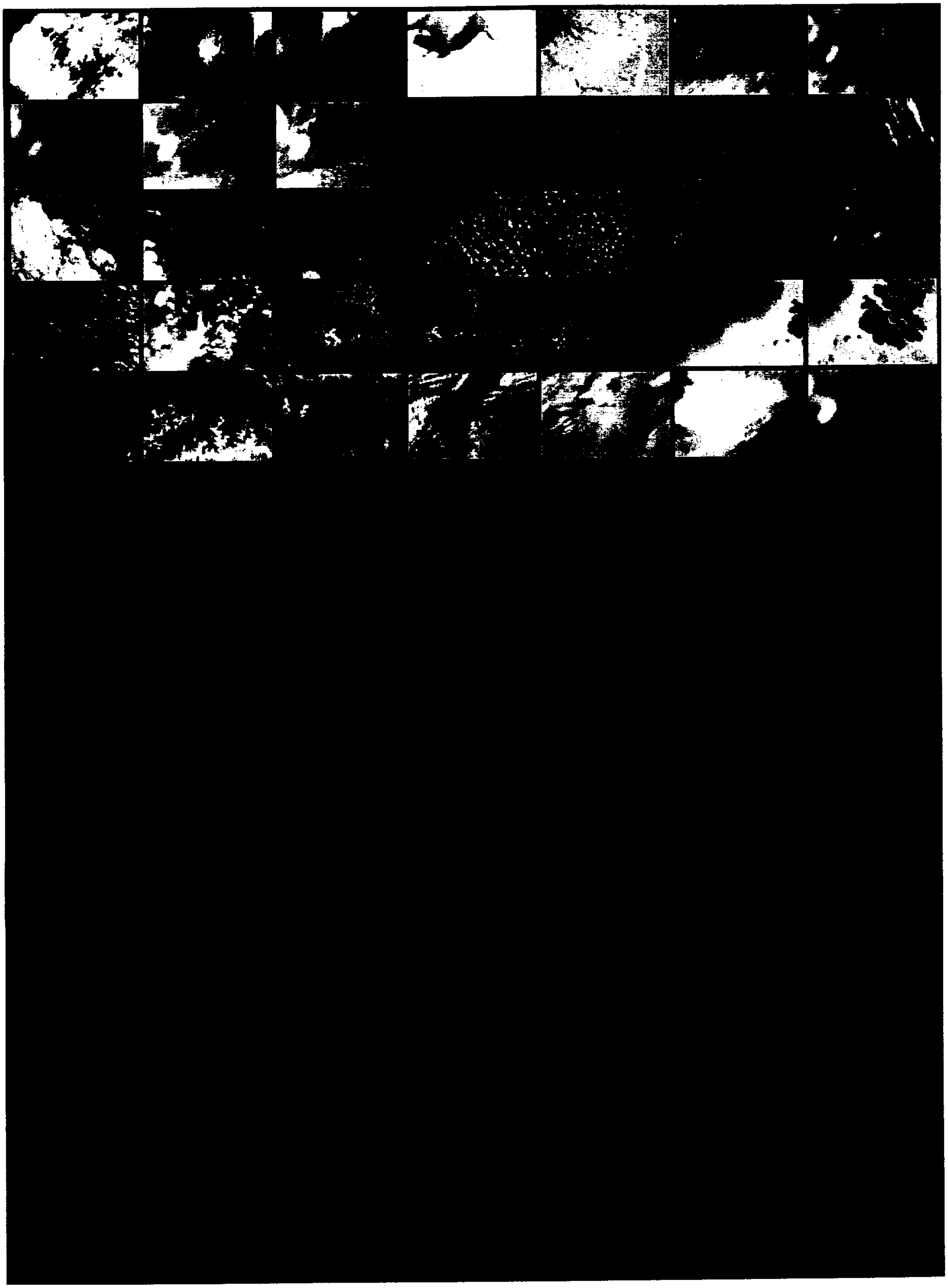


Figure 62: Thumbnail images of 540 photographs taken by STS-81 (6 of 6).

### *8.2.6 A Day in the Life of an Exploration Team Member*

***Conray Tseng, La Cañada High School***

Finally, after all this time of preparing for the mission, STS-81 is finally here! However, it's not all fun and games. Sure, I get to miss some school because I need to make explorations from the latest images, but there's a lot of work, too. No one truly realizes all the sweat and grit that go into making a great exploration. First, I have to find a great image. I'm not only referring to an image that stands out with bright colors and interesting terrain, such as mountains and rivers. When I talk about "a great image," I also mean an image that has historical, geographic or cultural significance. What is the use of having a great picture of some location with no information to write about?

Once I finally have a good image, I research the image location. Usually, I try finding some interesting and unique feature about the image. I might find this feature by looking up the picture's geography, history, or any other aspect. Finding this information is not that simple, however. I must use a wide variety of resources to make sure that my information is correct. After all, the explorations I make are going on the Internet for the public to read and enjoy. So, for this reason, I use the Internet, encyclopedias, the people I work with, educational books, and magazines to research an image. More often than not, I strike gold by finding that elusive "interesting feature."

Once I have found an interesting feature, I analyze the image. I look at the image's geographical features, such as the terrain or the types of clouds. Sometimes I get really lucky by spotting a natural disaster, such as a fire! It's funny how something as mundane as land color can tell so much about an image. For example, reddish land is usually deserts, while green land is grass and forest. The unique ecosystem in that particular environment can be inferred from the type of land seen in the picture.

With all these data stored in my brain, I finally start writing the exploration. Using HTML format, I include the information I found from my research in a fun, but educational way. Then, when my masterpiece is complete, I wipe the sweat from my brow and relax for about ten minutes. After I settle into a state of tranquillity—wouldn't you know—another stack of images has been downloaded! Oh well, that's life. So, off I go to start the entire process again and write another exploration.

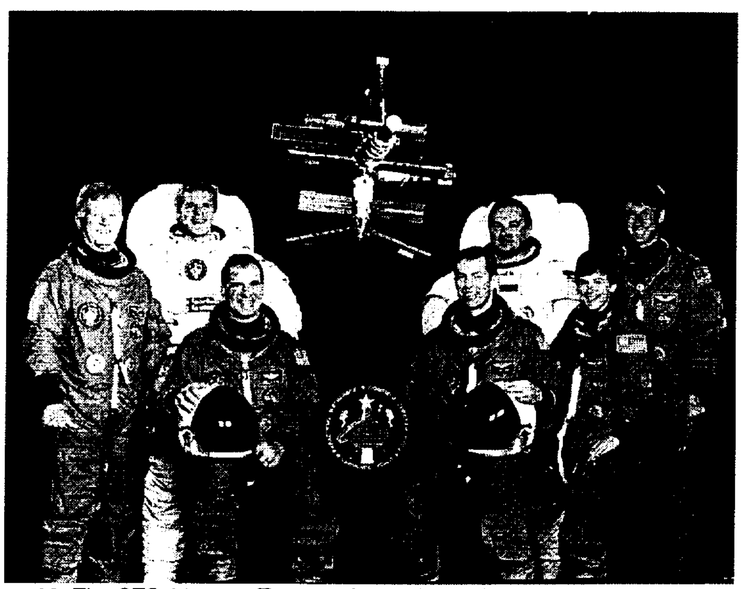


*Figure 63: The STS-86 crew: Top row, from left, Chrétien, Titov, Parazynski, Foale; bottom row, from left, Bloomfield (KidSat Payload Officer), Wetherbee, Lawrence.*

## 8.3 The Third Mission: STS-86

The STS-86 flight began with the launch of Space Shuttle Orbiter Atlantis on September 28, 1996, from Kennedy Space Center Pad 39-A. Originally, the launch was scheduled for September 18, 1997, but was slipped to late September so that Columbia could refly the STS-83 Microgravity Science Laboratory mission that was cut short due to a fuel cell problem. STS-86 was the 87th shuttle mission for the NASA space program and the 20th flight of Atlantis.

This mission was the seventh Mir docking and involved carrying a SpaceHab double module. Additional highlights of the nine-day mission included five days of docked operations between Atlantis and Mir and the exchange of crew members Foale and Lawrence to continue a permanent American presence on the Russian complex. A space walk or EVA by Vladimir Titov and Scott Parazynski was scheduled to retrieve the four Mir Environmental Effects Payloads which were attached to Mir's docking module by Linda Godwin and Rich Clifford during STS-76. Atlantis carried the SpaceHab double module to support the transfer of logistics and supplies for Mir, and the return of the experiment hardware and specimens to Earth.

### *8.3.1 KidSat Operation*

The configuration of the KidSat systems was much the same as for the two previous flights with some upgrades to the Gateway, which was moved to a new location at UCSD, and to the Flight and Data Systems to make the mission run more smoothly and improve the efficiency of the data transfers. The Data System activities at JSC were all done remotely via FTP, totally eliminating the need for Data System personnel at JSC during the mission.

### *8.3.2 Participating Middle Schools*

Fifty-two middle schools, and more than 6,000 students, were involved in STS-86, including a growing number of schools associated with NASA centers.

### *8.3.3 Results*

During the STS-86 mission flight, 656 images were acquired and more than 6,000 students in 52 schools joined in the adventure. The students focused on smoke palls from fires in Indonesia and Brazil. This mission concluded the KidSat pilot project missions.

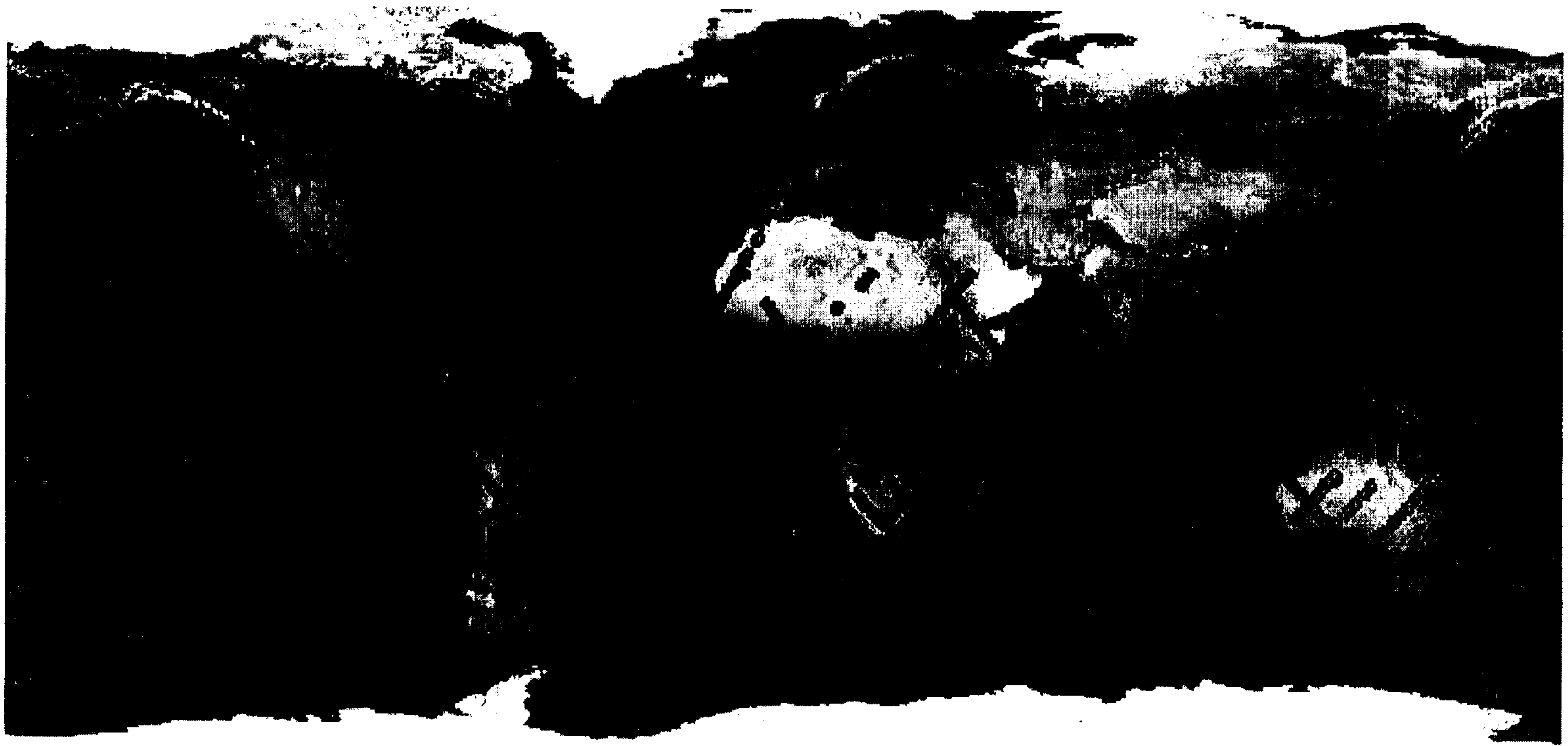


Figure 64: STS-86 coverage map.

*Table 10: Middle Schools Participating in STS-86*

| School | City, State or Country |
|---|---|
| Apex Middle School | Apex, North Carolina |
| Arbor Park Middle School | Blair, Nebraska |
| Bell Junior High School | San Diego, California |
| Bennett Middle School | Salisbury, Maryland |
| Buist Academy | Charleston, South Carolina |
| California Trail Junior High School | Olathe, Kansas |
| Canford School | Dorset, England |
| Canton Middle School | Baltimore, Maryland |
| Carroll County Middle School | Carrollton, Kentucky |
| Challenger Middle School | San Diego, California |
| Collinwood Middle School | Cleveland, Ohio |
| Costano Middle School | Palo Alto, California |
| Crittendon Middle School | Yorktown, Virginia |
| Cutten Middle School | Arcata, California |
| Davis Drive Middle School | Apex, North Carolina |
| Drayton Hall Middle School | Charleston, South Carolina |
| Foley Middle School | Berea, Kentucky |
| Fort Calhoun Middle School | Blair, Nebraska |
| Fortuna Elementary School | Fortuna, California |
| Gompers Secondary School | San Diego, California |
| Grishman Middle School | Austin, Texas |
| Highway 1 | Washington, D.C. |
| Jacoby Creek Middle School | Arcata, California |
| James Island Middle School | James Island, South Carolina |
| Kearsney College | Kwa Zulu Natal, South Africa |
| La Cañada Elementary School | La Cañada, California |
| La Cañada High School | La Cañada, California |
| Laing Middle School | Mount Pleasant, South Carolina |
| Lewis Middle School | San Diego, California |
| Millard Central Middle School | Omaha, Nebraska |
| Millard Technology | Omaha, Nebraska |
| Nathan Hale Middle School | Omaha, Nebraska |
| Olive Pierce Middle School | Ramona, California |
| Outlook Elementary School | Outlook, Washington |
| Pacific Union School | Arcata, California |
| Patrick Henry Middle School | Sioux Falls, South Dakota |
| Pine Hall Elementary School | Pine Hall, North Carolina |
| Putnam City Schools | Oklahoma City, Oklahoma |
| Ronald McNair Magnet School | Cocoa, Florida |
| Russell Middle School | Omaha, Nebraska |
| School of the Arts | Charleston, South Carolina |
| Seabrook Intermediate School | Seabrook, Texas |
| Shiprock Intermediate School | Kirtland, New Mexico |
| Silk Hope Middle School | Siler City, North Carolina |
| Skinner Magnet Center | Omaha, Nebraska |
| Space Coast Middle School | Cocoa, Florida |
| Stone Middle School | Wiggins, Mississippi |
| Valley Junior High School | Carlsbad, California |
| Warwood Middle School | Wheeling, West Virginia |
| Webster Magnet School | Webster, Texas |
| West Middle School | Colorado Springs, Colorado |
| York County Middle School | Yorktown, Virginia |

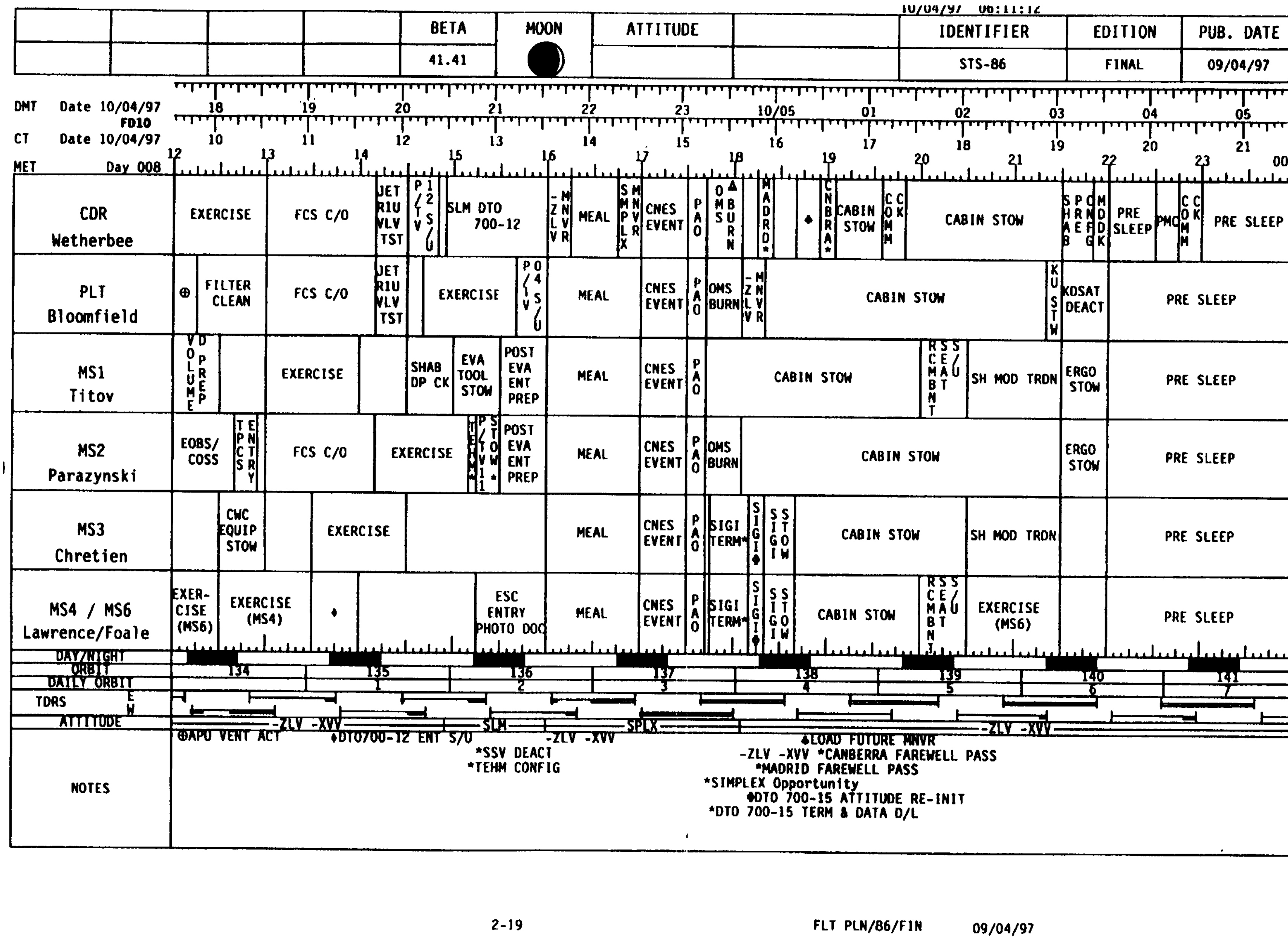



Figure 65: A page from the STS-86 flight plan, showing the last KidSat stow.

### *8.3.4 STS-86 Mission Information*

**Crew**

| | |
|---|---|
| James Wetherbee | Commander |
| Mike Bloomfield | Pilot |
| Vladimir Titov | Mission specialist 1 |
| Scott Parazynski | Mission specialist 2 |
| Jean-Loup Chrétien | Mission specialist 3 |
| Wendy Lawrence | Mission specialist 4 |
| David Wolf | Mission specialist 5 (left on Mir) |
| Michael Foale | Mission specialist 5 (retrieved from Mir) |

**Mission Summary**

| | |
|---|---|
| Launch Date | September 25, 1997 |
| Launch Time | 21:35 CST |
| Orbit Inclination | 51.6° |
| Orbital Altitude | 400 km |
| Mission Duration | 10.8 days |
| Landing Date and Site | October 6, 1997, at KSC |
| Landing Time | 17:58 CST |
| Primary Objectives | Supply mission to Mir<br>Deliver Wolf and retrieve Foale from Mir |

**MET of Key Events During Mission**
(days/hours:minutes:seconds)

| | |
|---|---|
| 00/00:00 | Launch |
| 00/02:30 | Ku antenna setup |
| 00/07:00 | KidSat setup |
| 00/08:06:12 | First image |
| 01/12:00 | KidSat deactivation |
| 01/17:20 | Mir docking |
| 05/16:07 | EVA |
| 07/13:07 | Mir undocking |
| 07/19:12 | KidSat setup |
| 08/21:17 | Ku antenna stow |
| 08/21:30 | KidSat deactivation |
| 08/11:55:22 | Last image |
| 09/20:24 | Landing at KSC |

### *8.3.5 STS-86 Thumbnails*

**See Figure 66 (1 of 7)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | 08211354 | 08211311 | 08211256 | 08211240 | 08211225 | 08211211 | 08211156 |
| 2 | 08211137 | 08211126 | 08205949 | 08204545 | 08204334 | 08194119 | 08194110 |
| 3 | 08194034 | 08194023 | 08194010 | 08193956 | 08193945 | 08193918 | 08193756 |
| 4 | 08193727 | 08193718 | 08193705 | 08193649 | 08193358 | 08193346 | 08193335 |
| 5 | 08193324 | 08190747 | 08190355 | 08190345 | 08190331 | 08190247 | 08185849 |
| 6 | 08185840 | 08185827 | 08185818 | 08185803 | 08185751 | 08185731 | 08185712 |
| 7 | 08181017 | 08180553 | 08180506 | 08180448 | 08180422 | 08180353 | 08180330 |
| 8 | 08180316 | 08180242 | 08180218 | 08180140 | 08180059 | 08180036 | 08175953 |
| 9 | 08175906 | 08175844 | 08175828 | 08175818 | 08175803 | 08175749 | 08173350 |
| 10 | 08173233 | 08173218 | 08173208 | 08173156 | 08173145 | 08172713 | 08172704 |
| 11 | 08172645 | 08172546 | 08172525 | 08162952 | 08162940 | 08162931 | 08162912 |
| 12 | 08162822 | 08162810 | 08162619 | 08162606 | 08162543 | 08162533 | 08162523 |
| 13 | 08162502 | 08162421 | 08162412 | 08162343 | 08162321 | 08162234 | 08162219 |
| 14 | 08162147 | 08162129 | 08162112 | 08162054 | 08162007 | 08161949 | 08161939 |

**See Figure 66 (2 of 7)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | 08161929 | 08161919 | 08161906 | 08150622 | 08150610 | 08150528 | 08150510 |
| 2 | 08150455 | 08150419 | 08150346 | 08150326 | 08150250 | 08150231 | 08150200 |
| 3 | 08150143 | 08150133 | 08150101 | 08144450 | 08144342 | 08144303 | 08144252 |
| 4 | 08144200 | 08144136 | 08144116 | 08144055 | 08144045 | 08144029 | 08142141 |
| 5 | 08133404 | 08133352 | 08133335 | 08133316 | 08133307 | 08133120 | 08133110 |
| 6 | 08132941 | 08132920 | 08132910 | 08132900 | 08132831 | 08132812 | 08132801 |
| 7 | 08130537 | 08130447 | 08130437 | 08124905 | 08120213 | 08120154 | 08120140 |
| 8 | 08120119 | 08120110 | 08120059 | 08120049 | 08120039 | 08120030 | 08120020 |
| 9 | 08120010 | 08115932 | 08115838 | 08115820 | 08115745 | 08115718 | 08115706 |
| 10 | 08115654 | 08115616 | 08115548 | 08115531 | 08115515 | 08115441 | 08115430 |
| 11 | 08115419 | 08115326 | 08115308 | 08115242 | 08115206 | 08115123 | 08115107 |
| 12 | 08115048 | 08115027 | 08114941 | 08114923 | 08114908 | 08114859 | 08114846 |
| 13 | 08114835 | 08114826 | 08113150 | 08113135 | 08113124 | 08113110 | 08113008 |
| 14 | 08112958 | 08112948 | 08112908 | 08112859 | 08112848 | 08103049 | 08103039 |

**See Figure 66 (3 of 7)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | 08101919 | 08101909 | 08101854 | 08101810 | 08101745 | 08101715 | 08101649 |
| 2 | 08101631 | 08101621 | 08101513 | 08101423 | 08101407 | 08101344 | 08101321 |
| 3 | 08101258 | 08101247 | 08101228 | 08101218 | 08101116 | 08101106 | 08101057 |
| 4 | 08095419 | 08095339 | 08095321 | 08095300 | 08095251 | 08095241 | 08095232 |
| 5 | 08085836 | 08085808 | 08085754 | 08085744 | 08085723 | 08085713 | 08085458 |
| 6 | 08085430 | 08085420 | 08085409 | 08085400 | 08085350 | 08085339 | 08085330 |
| 7 | 08084359 | 08081827 | 08081813 | 08081758 | 08081748 | 08081739 | 08081728 |
| 8 | 08081617 | 08081541 | 08072650 | 08072641 | 08072631 | 08072611 | 08072601 |
| 9 | 08072550 | 08072541 | 08072531 | 08072507 | 08072357 | 08072311 | 08072301 |
| 10 | 08072242 | 08072135 | 08072124 | 08072103 | 08072048 | 08072025 | 08072015 |
| 11 | 08071946 | 08070143 | 08064304 | 08064249 | 08064239 | 08064223 | 08064212 |
| 12 | 08064203 | 08064152 | 08064142 | 08064131 | 08055041 | 08055029 | 08055010 |
| 13 | 08055000 | 08054949 | 08054939 | 08054722 | 08054642 | 08054623 | 08054559 |
| 14 | 08054446 | 08054435 | 08051549 | 08044513 | 08041437 | 08041420 | 08041406 |

**See Figure 66 (4 of 7)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | 08041341 | 08041139 | 08041035 | 08040856 | 08040826 | 08040808 | 08040728 |
| 2 | 08040716 | 08040657 | 08040614 | 08040553 | 08040531 | 08040506 | 08040450 |
| 3 | 08040425 | 08034050 | 08031304 | 08024103 | 08024054 | 08024038 | 08023718 |
| 4 | 08023709 | 08023654 | 08023638 | 08023617 | 08023556 | 08023534 | 08023520 |
| 5 | 08023446 | 08023433 | 08023409 | 08023355 | 08023340 | 08023325 | 08023255 |
| 6 | 08023243 | 08023227 | 08023156 | 08023150 | 08021509 | 08020921 | 08020915 |
| 7 | 08020857 | 08020820 | 08020802 | 08020743 | 08020734 | 08020720 | 08020703 |
| 8 | 08020641 | 08020618 | 08020603 | 08020543 | 08020506 | 08011830 | 08011823 |
| 9 | 08011737 | 08011008 | 08011002 | 08005842 | 08005709 | 08005648 | 08005633 |
| 10 | 08005614 | 08005535 | 08003504 | 07232702 | 07232629 | 07232617 | 07232604 |
| 11 | 07230658 | 07220153 | 07220146 | 07220104 | 07215050 | 07215002 | 07214746 |
| 12 | 07212627 | 01115604 | 01115553 | 01115536 | 01115515 | 01115455 | 01115438 |
| 13 | 01115423 | 01115406 | 01115346 | 01115335 | 01115201 | 01115154 | 01102035 |
| 14 | 01102023 | 01102000 | 01101947 | 01101934 | 01101915 | 01101858 | 01101837 |

**See Figure 66 (5 of 7)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | 01101820 | 01101758 | 01101735 | 01101720 | 01101705 | 01101650 | 01101622 |
| 2 | 01101609 | 01101536 | 01101523 | 01101359 | 01101345 | 01101330 | 01101315 |
| 3 | 01101300 | 01101241 | 01101226 | 01101212 | 01100414 | 01100332 | 01100322 |
| 4 | 01100300 | 01100245 | 01100232 | 01100157 | 01100143 | 01100128 | 01100113 |
| 5 | 01100039 | 01100021 | 01100002 | 01095952 | 01095939 | 01095919 | 01095858 |
| 6 | 01095838 | 01095821 | 01084445 | 01084433 | 01084327 | 01084305 | 01084250 |
| 7 | 01084229 | 01084210 | 01084151 | 01084131 | 01084111 | 01084057 | 01084023 |
| 8 | 01083958 | 01083942 | 01083930 | 01083914 | 01083900 | 01083834 | 01083811 |
| 9 | 01083759 | 01083743 | 01083727 | 01083700 | 01083640 | 01083619 | 01083559 |
| 10 | 01083540 | 01083520 | 01083458 | 01083438 | 01083424 | 01083312 | 01083255 |
| 11 | 01083059 | 01083029 | 01083018 | 01082959 | 01082935 | 01082928 | 01082856 |
| 12 | 01082849 | 01082651 | 01082633 | 01082618 | 01073245 | 01073236 | 01072732 |
| 13 | 01070705 | 01070656 | 01061221 | 01061147 | 01061106 | 01061055 | 01061032 |
| 14 | 01061013 | 01060931 | 01060915 | 01060854 | 01060847 | 01060822 | 01043615 |

**See Figure 66 (6 of 7)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | 01043452 | 01042118 | 01042110 | 01041359 | 01041152 | 01041140 | 01041105 |
| 2 | 01041042 | 01041025 | 01041005 | 01040956 | 01040924 | 01040915 | 01040601 |
| 3 | 01040441 | 01040432 | 01040418 | 01040359 | 01040144 | 01040038 | 01035955 |
| 4 | 01035939 | 01035800 | 01035739 | 01035725 | 01035646 | 01035638 | 01035429 |
| 5 | 01031000 | 01012642 | 01005630 | 01005620 | 01005604 | 01005535 | 01005508 |
| 6 | 01005502 | 01005430 | 01005410 | 01005347 | 01005329 | 01005314 | 01005308 |
| 7 | 01005225 | 01005210 | 01005154 | 00232707 | 00232459 | 00232451 | 00232332 |
| 8 | 00221526 | 00221520 | 00221117 | 00221107 | 00220621 | 00220557 | 00220547 |
| 9 | 00220435 | 00220402 | 00220341 | 00220332 | 00220301 | 00220247 | 00220237 |
| 10 | 00220223 | 00220205 | 00220141 | 00215750 | 00215737 | 00215725 | 00215714 |
| 11 | 00215701 | 00215637 | 00215624 | 00215618 | 00215553 | 00215537 | 00215530 |
| 12 | 00215506 | 00215424 | 00215417 | 00215402 | 00215343 | 00215147 | 00215140 |
| 13 | 00213029 | 00175123 | 00172709 | 00172529 | 00161425 | 00161408 | 00161352 |
| 14 | 00161327 | 00161314 | 00161308 | 00155747 | 00155408 | 00141018 | 00132309 |

**See Figure 66 (7 of 7)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | 00132254 | 00132225 | 00132108 | 00131902 | 00131835 | 00130533 | 00130517 |
| 2 | 00130352 | 00130300 | 00130233 | 00130210 | 00130133 | 00130110 | 00130050 |
| 3 | 00125808 | 00112833 | 00112618 | 00112554 | 00112453 | 00110615 | 00102004 |
| 4 | 00095314 | 00095259 | 00095241 | 00095136 | 00094958 | 00094839 | 00094825 |
| 5 | 00094809 | 00094751 | 00094715 | 00094626 | 00094548 | 00094507 | 00094445 |
| 6 | 00094416 | 00094401 | 00094346 | 00094332 | 00094249 | 00094211 | 00094136 |
| 7 | 00094056 | 00094042 | 00093902 | 00093740 | 00093720 | 00093656 | 00093535 |
| 8 | 00093506 | 00093415 | 00084923 | 00081736 | 00081722 | 00081702 | 00081624 |
| 9 | 00081556 | 00081519 | 00081321 | 00081259 | 00081247 | 00081150 | 00081115 |
| 10 | 00081103 | 00080833 | 00080735 | 00080721 | 00080703 | 00080612 | 00080313 |

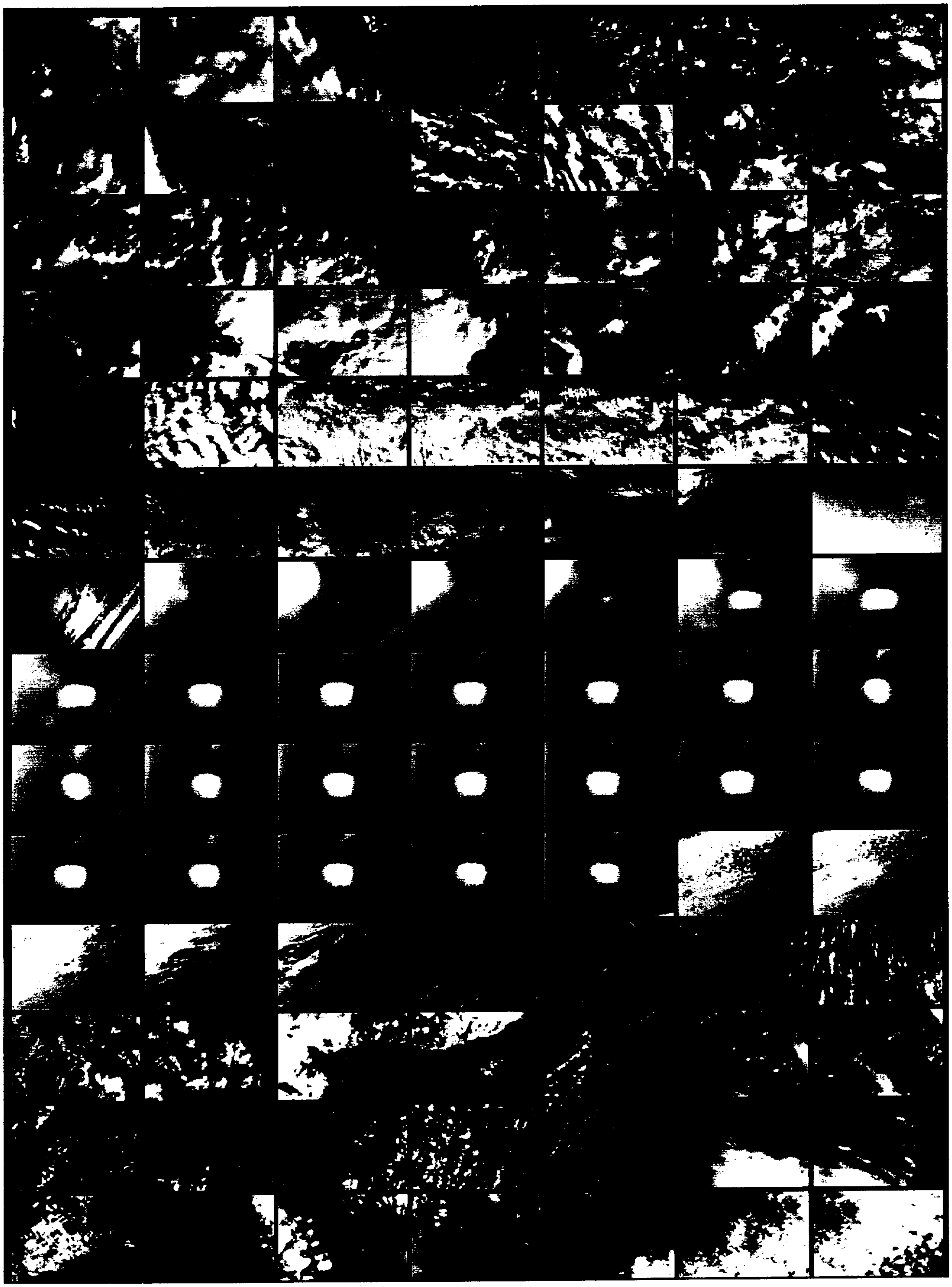


Figure 66: Thumbnail images of 656 photographs taken by STS-86 (1 of 7).

Figure 66: Thumbnail images of 656 photographs taken by STS-86 (2 of 7).

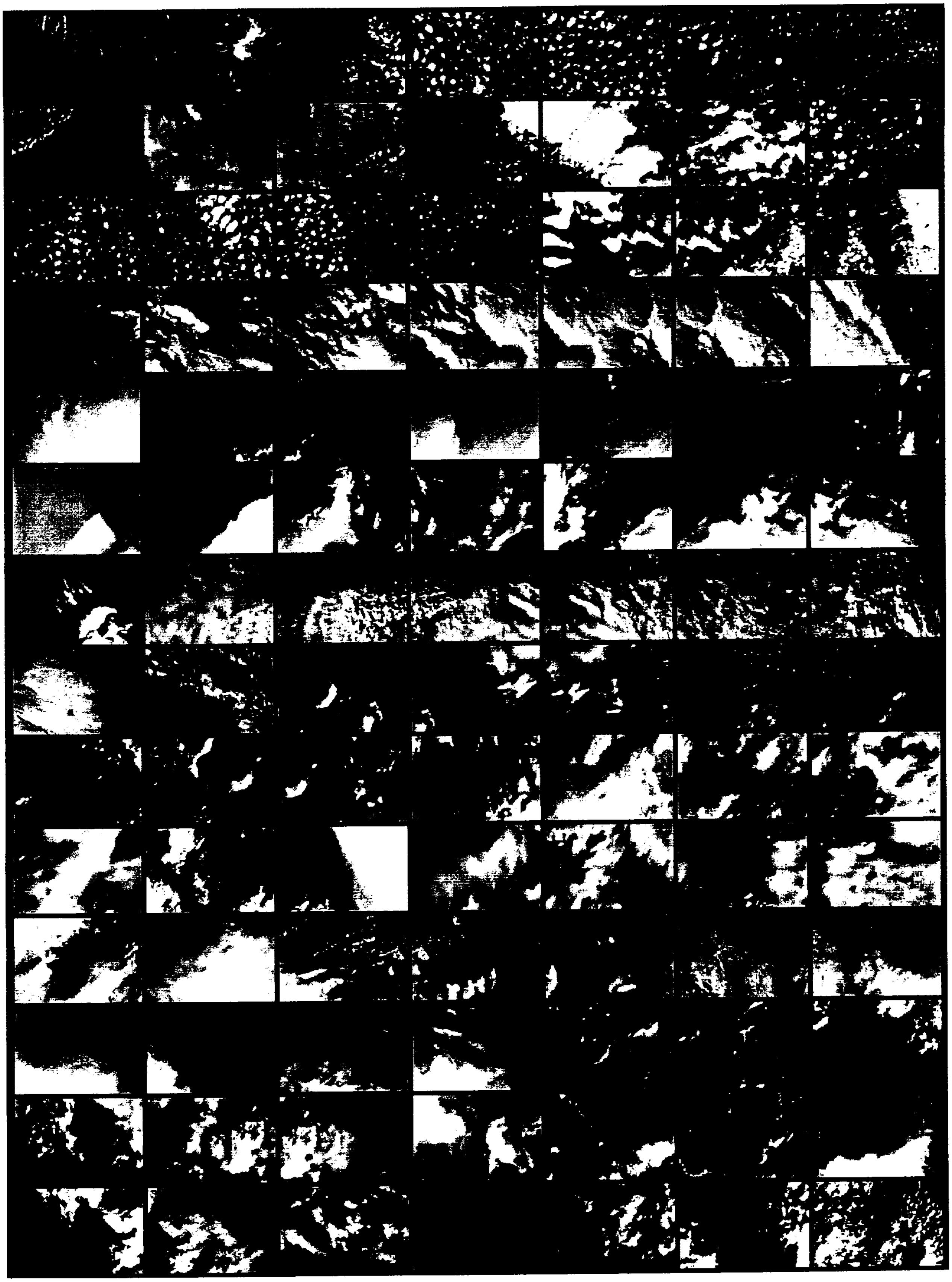


Figure 66: Thumbnail images of 656 photographs taken by STS-86 (3 of 7).

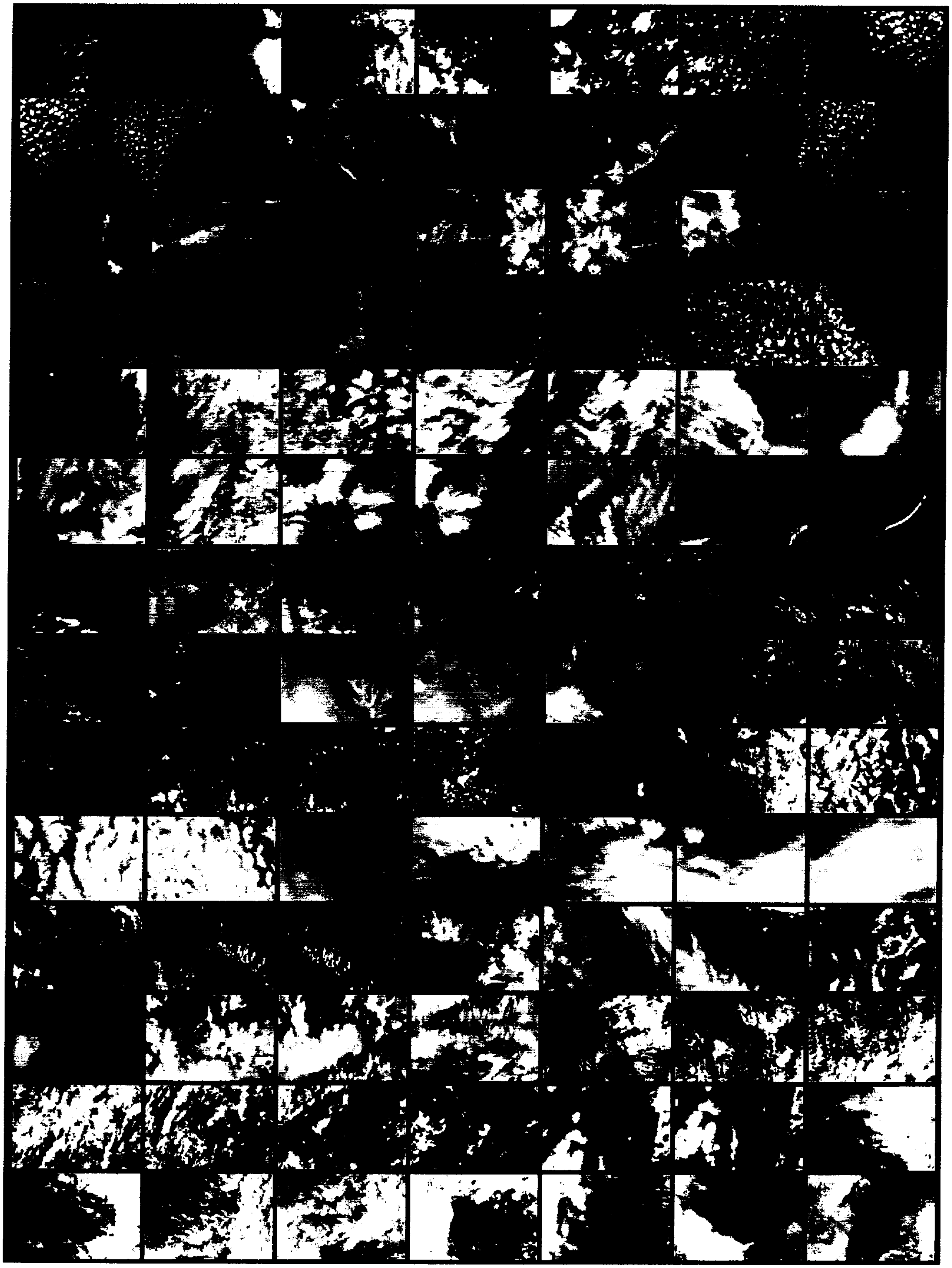


*Figure 66: Thumbnail images of 656 photographs taken by STS-86 (4 of 7).*

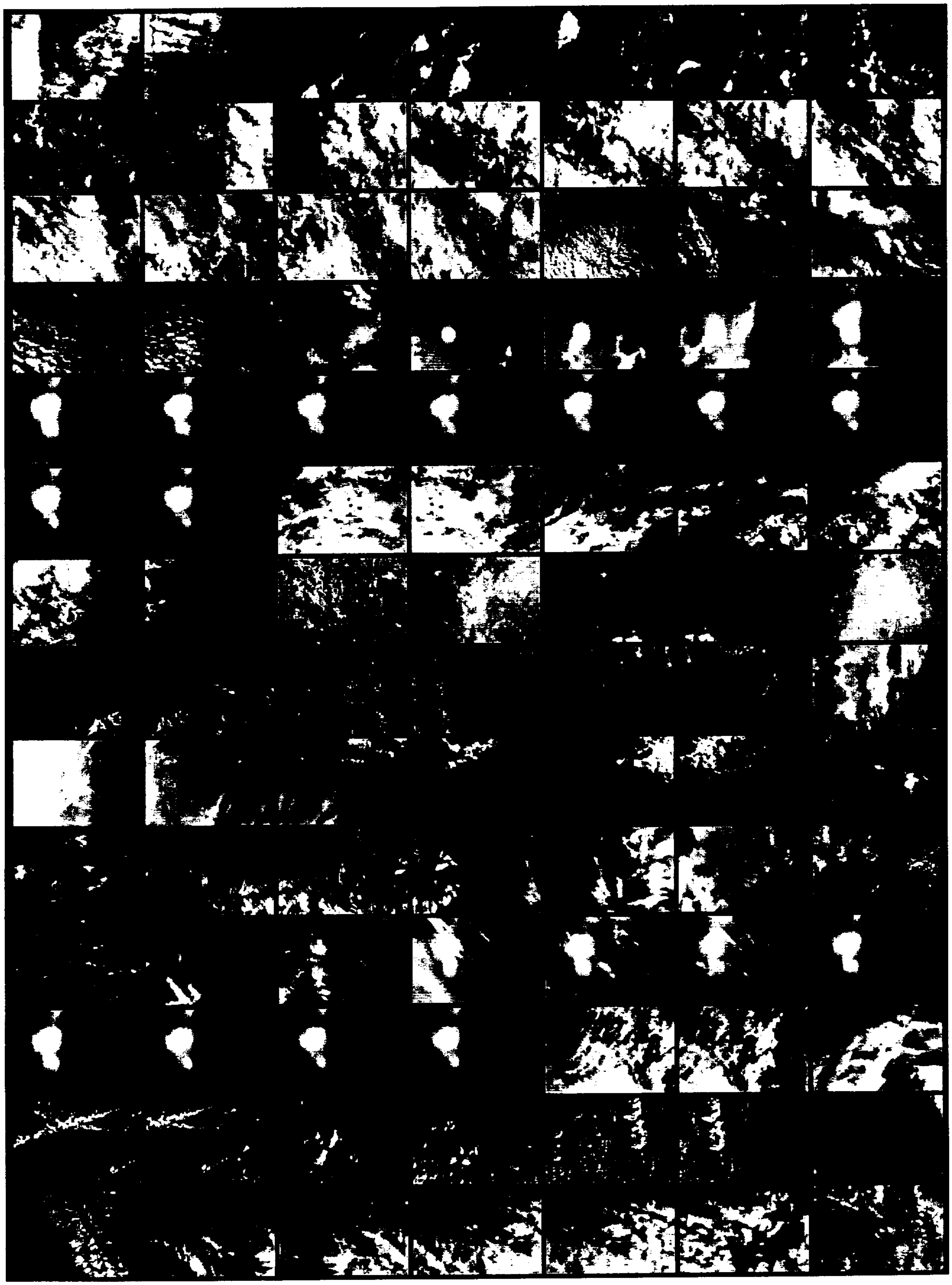


Figure 66: Thumbnail images of 656 photographs taken by STS-86 (5 of 7).

Figure 66: Thumbnail images of 656 photographs taken by STS-86 (6 of 7).

Figure 66: Thumbnail images of 656 photographs taken by STS-86 (7 of 7).

### *8.3.6 Highlights on STS-86 from the SMOCs*

***Rie Cowan, Johns Hopkins University IAAY, KidSat Education Team***

The Redwood SMOC in California included five middle schools. A week long summer institute for 50 students was held in August 1997 to prepare for the flight, which occurred at the start of the school year. The SMOC was in full operation continuously during the time the camera was in operation. Following the mission, the Redwood SMOC held a science symposium for 160 students, and the KidSat images are currently being used for science fairs and history day projects.

Russell Middle School in Nebraska partnered with Offutt Air Force Base to provide global weather information for STS-86. They created a KidSat Hall of Information for school tours, and produced business cards, brochures, and a video using the school technology center. The Russell SMOC operated continuously during the times the KidSat camera was in operation.

Davis Drive Middle School in North Carolina involved an entire eighth grade in KidSat. They conducted a successful mission using modems and eight telephone lines routed in the media center. Images are being used for History Day and Science Fair projects.

Pine Hall Elementary in North Carolina obtained T-1 lines and Internet services donated by Sprint. They held a press conference attended by three local TV stations, two local radio stations, and state and local newspapers. Six students were flown to the launch at KSC and were able to interview astronauts for a school television program.

James Island Middle School in South Carolina involved an entire sixth grade and used images to guide a sixth grade thematic unit on rain forests.

The School of the Arts in South Carolina partnered with Buist Academy for image selection, and worked with hard-copy images to produce their student research projects. Their results were presented to parents at Family Science Night.

## 8.4 Detailed Coverage Maps from all Missions

The maps on the following pages show the locations of all KidSat images from different regions of the world.

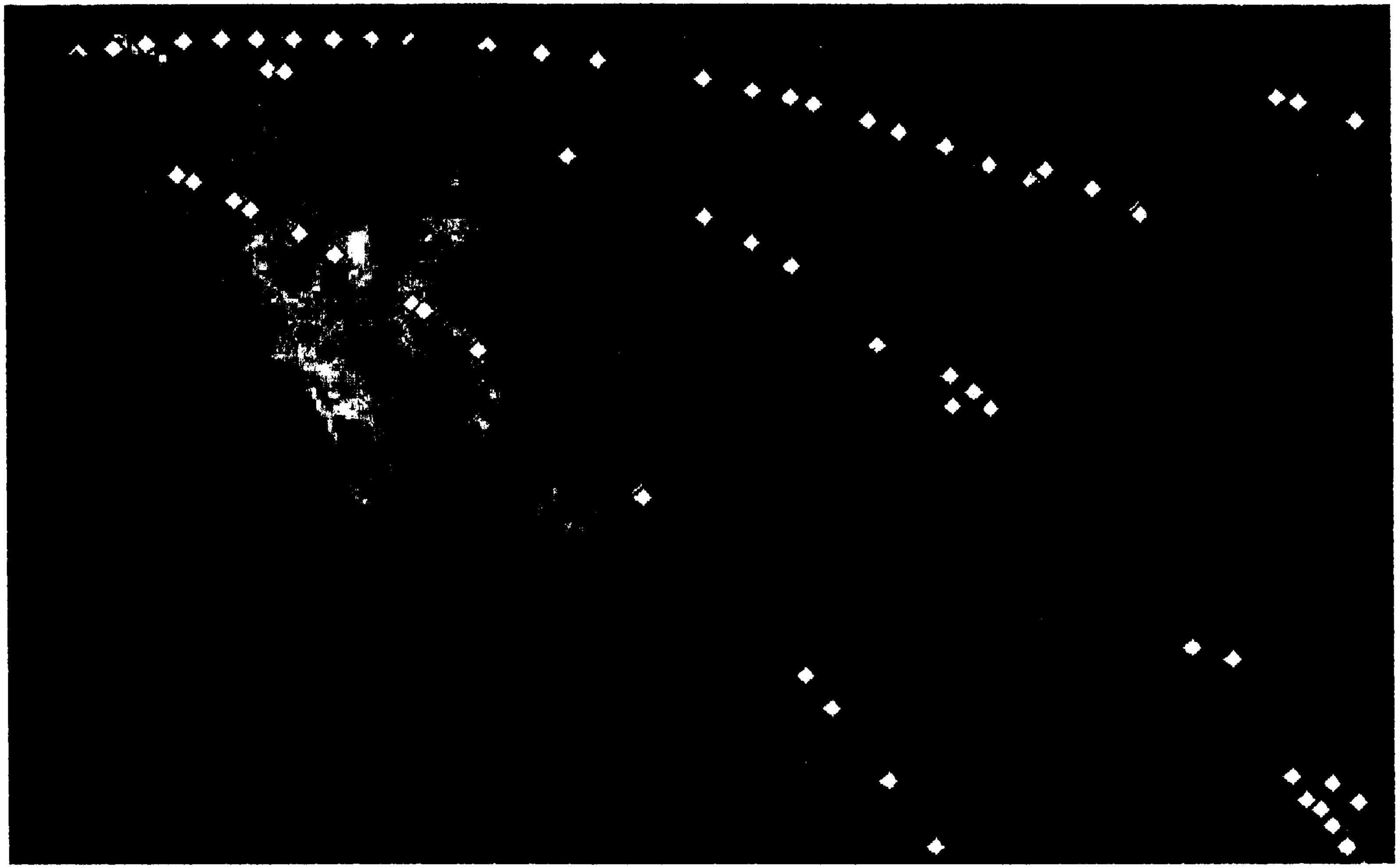


*Figure 67: Detailed coverage maps for STS-76, -81 and -86. Yellow dots are for STS-76, green dots are for STS-81, and red dots are for STS-86. Figures include North America, South America, Europe, Asia, Africa, and Australia (1 of 6).*

Figure 67: Detailed coverage maps for STS-76, -81 and -86. Yellow dots are for STS-76, green dots are for STS-81, and red dots are for STS-86. Figures include North America, South America, Europe, Asia, Africa, and Australia (2 of 6).

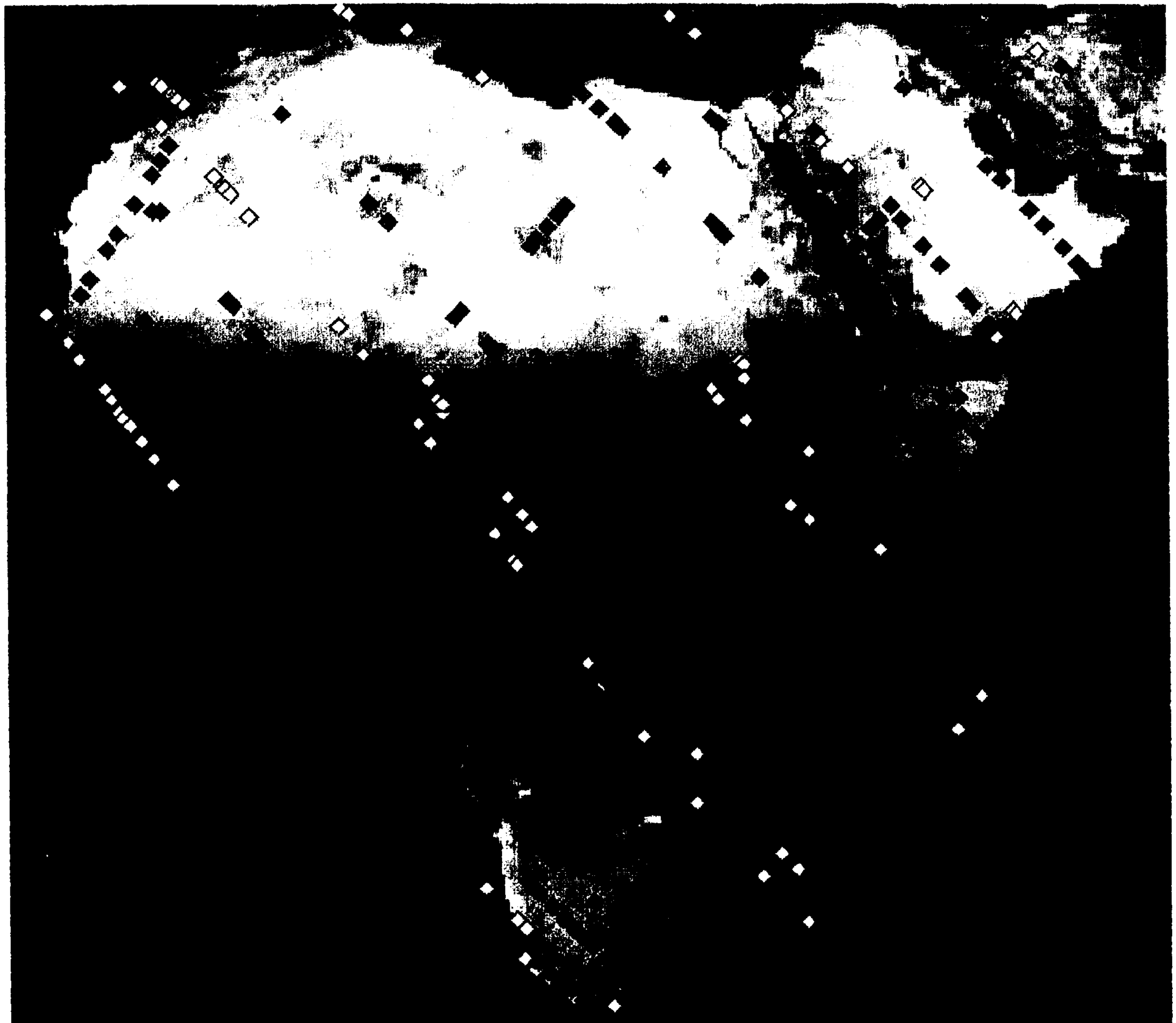


Figure 67: Detailed coverage maps for STS-76, -81 and -86. Yellow dots are for STS-76, green dots are for STS-81, and red dots are for STS-86. Figures include North America, South America, Europe, Asia, Africa, and Australia (3 of 6).

*Figure 67: Detailed coverage maps for STS-76, -81 and -86. Yellow dots are for STS-76, green dots are for STS-81, and red dots are for STS-86. Figures include North America, South America, Europe, Asia, Africa, and Australia (4 of 6).*

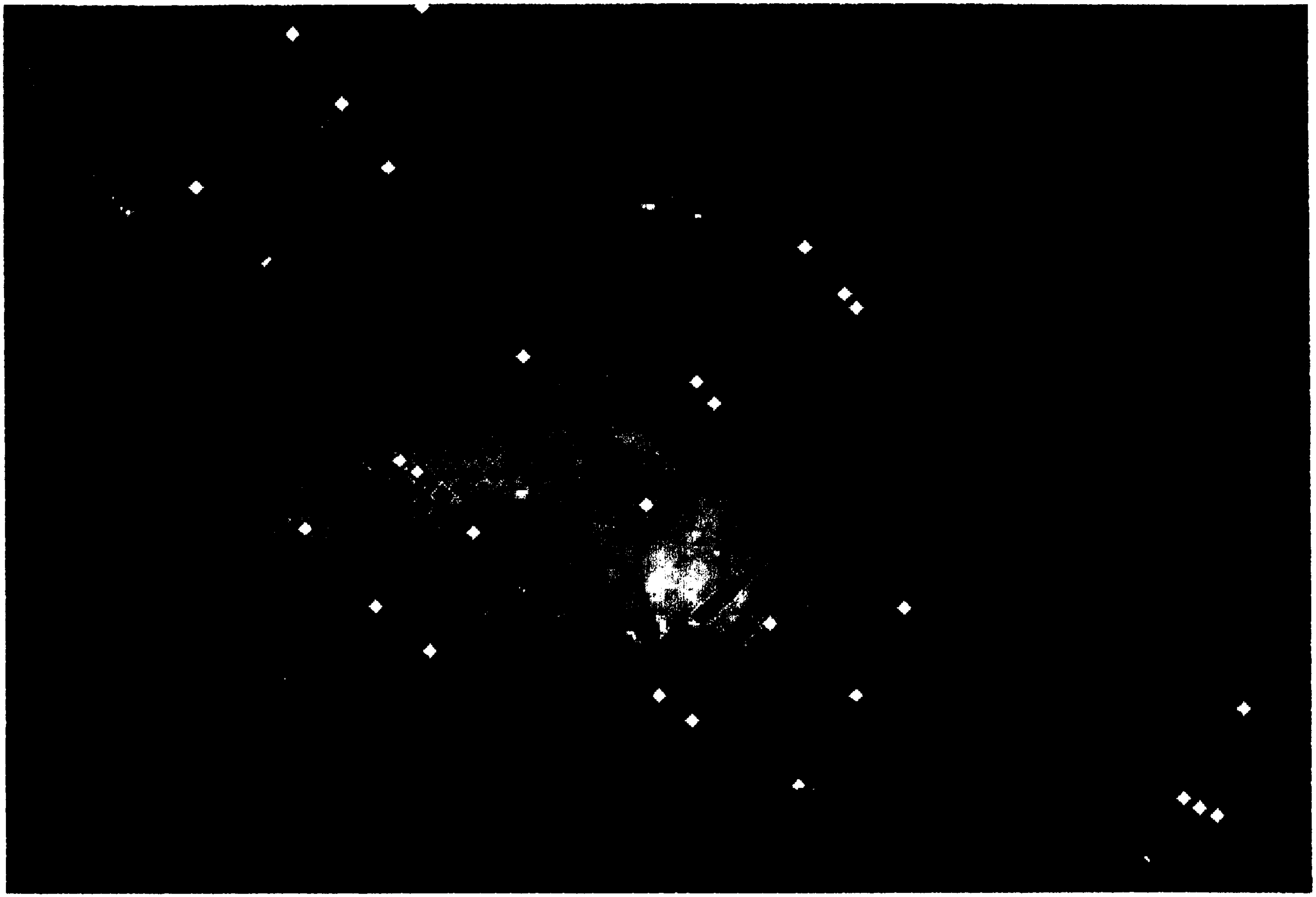


Figure 67: Detailed coverage maps for STS-76, -81 and -86. Yellow dots are for STS-76, green dots are for STS-81, and red dots are for STS-86. Figures include North America, South America, Europe, Asia, Africa, and Australia (5 of 6).

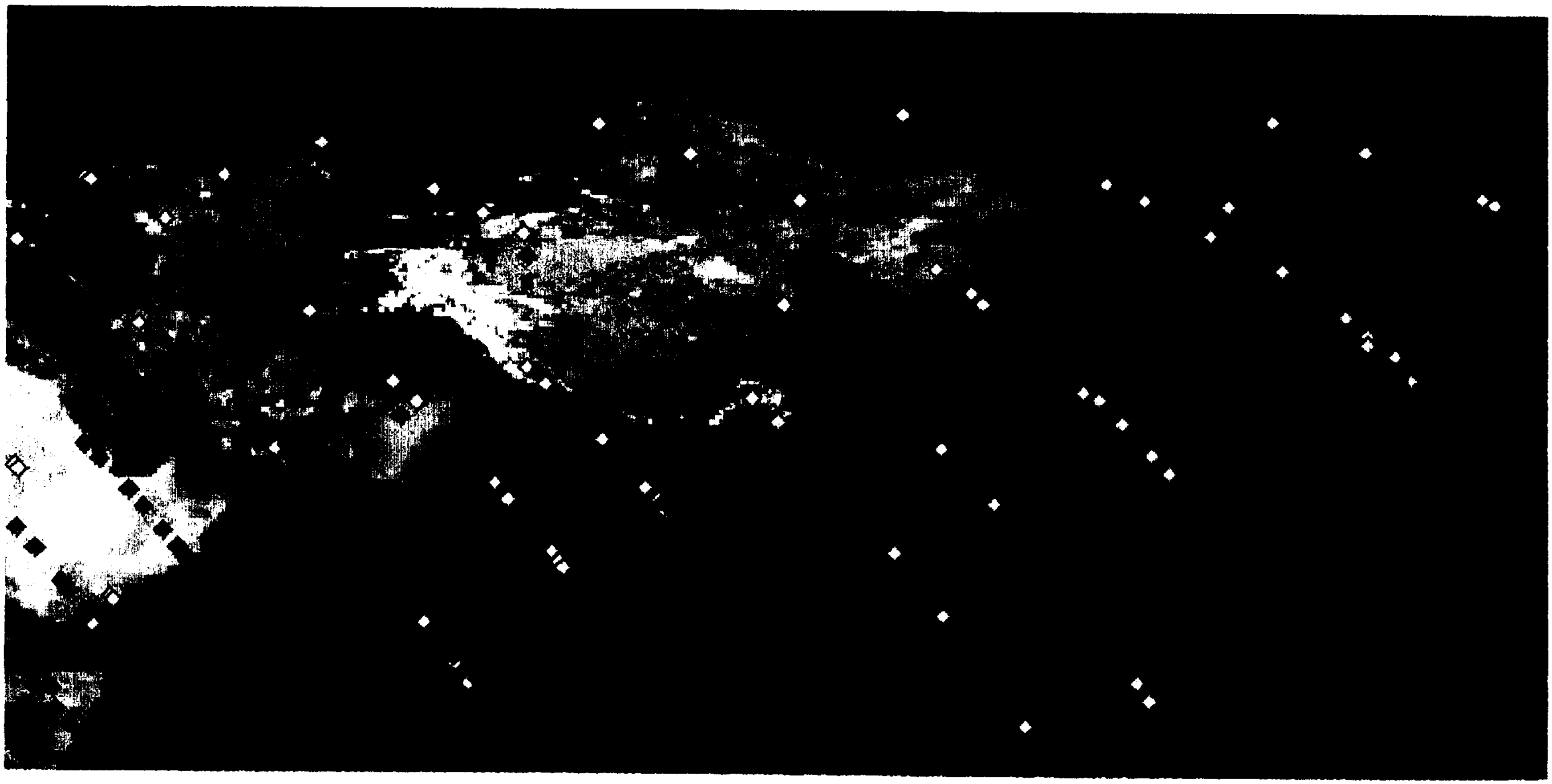


Figure 67: Detailed coverage maps for STS-76, -81 and -86. Yellow dots are for STS-76, green dots are for STS-81, and red dots are for STS-86. Figures include North America, South America, Europe, Asia, Africa, and Australia (6 of 6).

# IX. Presenting KidSat Results

## 9.1 Presenting Results of the First Mission at IGARSS '96

The 1996 International Geoscience and Remote Sensing Symposium, IGARSS '96, was held in Lincoln, Nebraska. Its theme, Remote Sensing for a Sustainable Future, emphasized the role of remote sensing to help conserve resources for coming generations. Plenary and special sessions focused on advances made in both theoretical and experimental aspects of terrestrial and atmospheric remote sensing. A special session on KidSat was included and students and teachers involved in the first KidSat mission made presentations. The agenda for that session follows:

*Table 11: Papers Presented at the Special Session on KidSat at IGARSS '96*

| | | |
|---|---|---|
| Roger Kassebaum and JoBea Way, Co-Chairs | | |
| "Youth Enhancing Space" | Moon Young Choi (HS)<br>Go Nagatani (HS) | JoBea Way*<br>Elizabeth Jones Stork** |
| "The Education Element" | John McGuire (T)<br>Bruce Fisher (T)<br>Roger Kassebaum (T)<br>Dan Barstow*** | Kathy Rackley (T)<br>Paul Bixler (T)<br>Mark Jones**<br>Jackie Hunt (T) |
| "The Space Element" | Josh Lane (HS)<br>Steve Davis (HS) | Austin Leach (HS)<br>John Baker* |
| "Mission Operations in the Classroom" | Kathy Rackley (T)<br>Hillary Haugen (US) | Paul Bixler (T) |
| "The Data System" | Casey Kirchner (HS)<br>Roger Kassebaum (T)<br>Paul Andres* | Mandy Minino (HS)<br>Jeff Lawson (HS) |
| "Exploration Results from Charleston" | Jennifer Fox (MS)<br>Rie Cowan ** | Kathy Rackley (T) |
| "Exploration Results from San Diego" | Amanda Austin (MS)<br>Paul Bixler (T) | Rick Anderson (T)<br>Ronnie Ebel (MS) |
| "Exploration Results from Pasadena" | Cynthia Brammer (T)<br>Daisy Ventura (MS) | Mark Jones**<br>Emma Juarez (MS) |

T = teacher. MS = middle school student. HS = high school student. US = university student.
* = JPL or NASA scientist. ** = Johns Hopkins University. *** = TERC

Presenters are underlined.

*Figure 68: Daisy Ventura and Emma Juarez, fifth grade students from WALC, present their results on the Aral Sea at IGARSS '96.*

*Figure 69: The audience views the student products in three dimensions at IGARSS '96.*

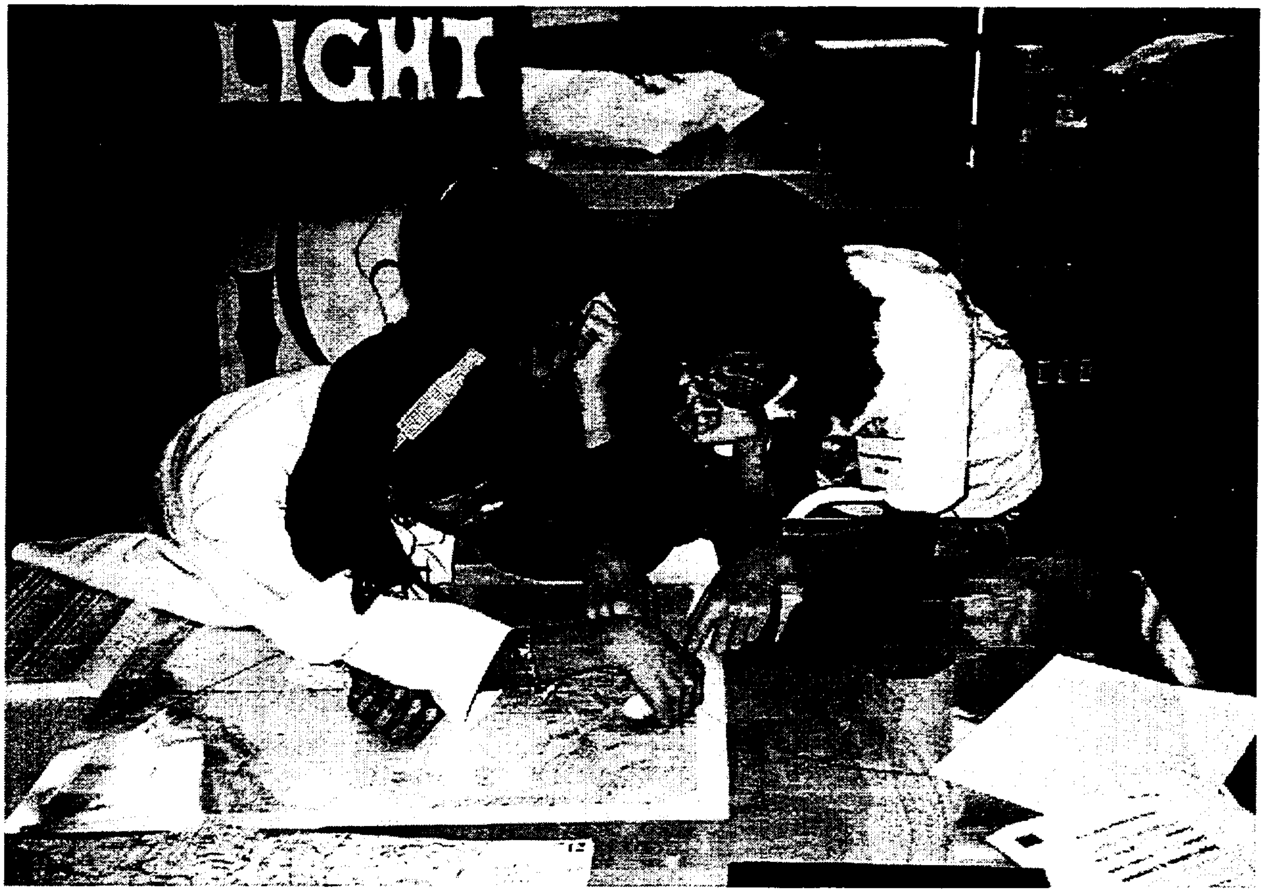



*Figure 70: Students from the middle schools use slider maps during the STS-86 mission.*

## 9.2 Publishing the Results of the Pilot Project in a Scientific Journal

Students continued to explore images and report their results well beyond the actual KidSat missions. A variety of science workshops were held. A special section will be included in the June 1999 issue of *Transactions on Geoscience and Remote Sensing*, a scientific journal in which remote sensing science and technology results are presented. The papers in this section went through an official review process, as do all papers for this journal. Below is the list of titles and authors for this special section. JoBea Way and John McGuire, a middle school teacher from Eureka, California and a member of the CCDT, are the guest editors for this special section.

*Table 12: Papers Published in Transactions on Geoscience and Remote Sensing*

| Special Section of *Transactions on Geoscience and Remote Sensing* John McGuire and JoBea Way, guest editors |
|---|
| "The KidSat Project"<br>J. B. Way*, J. Baker*, P. Andres*, J. McGuire (T), M. Galindo (MS), J. Fox (MS), and E. J. Stork** |
| "The KidSat Project Flight System"<br>J. Baker*, J. Woodring (US), J. Lane (MS), A. Leach (MS), and R. Spohr*** |
| "The KidSat Student Mission Operations Center—SMOC"<br>K. Rackley (T) |
| "Making Sense of Space-based Earth Image Data: The KidSat Data System"<br>P. Andres*, L. Amy*, D. Steinwand (US), J. Lawson (US), and R. Moffitt (HS) |
| "The Integration of Science Explorations Through the Use of Earth Images in Middle School Curriculum"<br>E.J. Stork**, S. O. Sakamoto**, and R. Cowan ** |
| "Changes in Manaus in our Lifetime as Viewed by KidSat"<br>M. Barr (MS), D. Graham (MS), and J. McGuire (T) |
| "KidSat Views 1997 Indonesia Fires"<br>C. Tseng (MS), N. Hung (MS), S. Jue (MS) |
| "Rediscovering the Meaning of the World: Using Space Shuttle Images to Inspire Poetry"<br>B. Green (T) |
| "The Use of KidSat Images in the Further Pursuit of the Frankincense Roads to Ubar"<br>J. Fisher (MS) and B. Fisher (T) |
| T = teacher. MS = middle school student. HS = high school student. US = university student.<br>* = JPL or NASA scientist. ** = Johns Hopkins University. *** = Johnson Space Center. |

## 9.3 KidSat in the News

The KidSat public relations team included representatives from NASA Headquarters, JPL, JHU, UCSD, JSC, and the middle school districts. The goal of press-related activities was to release information that the middle school districts could use to encourage community interest in KidSat. For each mission, an information sheet was distributed before launch and a press release (including an image) was issued at the end of the mission. The captions and the image were selected by students on the KidSat team at JPL. The image was released by NASA Headquarters and JPL in parallel.

Pre-launch press releases included:

- "Students Prepare New KidSat Payload to Fly on Space Shuttle," JPL, 11 October 1995.
- "Students to Present KidSat Preflight Briefing at JPL," JPL Note to Editors and News Directors, 5 March 1996.
- "Educators to Use Space Technology in Daily Lessons," Johns Hopkins University, 12 March 1996.
- "KidSat Brings Space shuttle Experience to Classrooms," JPL and NASA Headquarters, 12 March 1996.
- "Students Prepare Third Flight Payload Aboard Space Shuttle," JPL, 23 September 1997.

KidSat participated in the pre-launch press conference for the first mission and was included in the Mission Update on NTV. A mirror Web site on the JPL home page was established for public access so that high usage during the mission would not slow down Web access in the classrooms. Additional images and student explorations were made available to the public through the Web page.

Below are some of the articles written about KidSat.

- "Permanent Research Payload Proposed to Benefit Students; KidSat Ideal to Promote Science, Math, History to Middle School Youth," *Space News*, 17 October 1994.
- "JPL's KidSat Education Program Brings Space Exploration to the Classroom," *JPL Universe*, 18 November 1994.
- "Gompers Kids Will Go Sky High with Shuttle," *The San Diego Union-Tribune*, 5 January 1995.
- "A 'Satellite' for Kids," *Technology Today*, 18 July 1995.
- "KidSat: From Space Shuttle to the Classroom," *JPL Universe*, 3 November 1995.
- "KidSat Brings Real Life Images," *The Hoofbeat*, Millard North High School, Omaha, Nebraska, 17 November 1995.
- "Students Explore Space Via Internet," *NSTA Reports*, December 1995/January 1996.
- "KidSat," *Wired*, December 1995.
- "Students Get Ready to Fly Cameras Aboard STS-76," *JPL Universe*, 12 January 1996.
- "Kids Photograph the Earth from Space," *Ad Astro*, January/February 1996.
- "Student Researchers Learn about Space through KidSat and EarthRISE," *Gather/Scatter*, January-March 1996.
- "Project: YES," *La Cañada Valley Sun*, 22 February 1996.
- "Student Project to Direct Camera aboard Atlantis," *Sentinel*, Cape Canaveral, March 1996.
- "Kids Create a Place in Space Final Frontier," March/April 1996.
- "Students Get in on Action," *Star News*, 13 March 1996.
- "KidSat Pre-Flight Briefing at JPL Shows Cooperative Efforts among NASA, Educators, and Students," *La Cañada Valley Sun*, 14 March 1996.
- "LCHS Students Briefed at JPL," *La Cañada Valley Sun*, 14 March 1996.
- "Students Prepare for KidSat Mission," *JPL Universe*, 22 March 1996.
- "Kids Control High-Flying Space Camera," *The Christian Science Monitor*, 26 March 1996.
- "What a View!" *Institute News*, The Johns Hopkins University, Spring 1996.
- "NASA's KidSat Program," *Satellite Tool Kit's In View*, April 1996.

- "Explore Above and Beyond," *YES (Youth Excited about Success),* April 1996.
- "KidSat Cameras Perform Flawlessly During STS-76," *JPL Universe*, 5 April 1996.
- "Classrooms in Space, Kids Control Space Experiments," *Weekly Reader*, 5 April 1996.
- "A Student's View of KidSat in Space," *La Cañada Valley Sun*, 5 February 1996.
- "KidSat Payload," *The Technology Teacher*, May/June 1996.
- "Taking Note: KidSat," *The Science Teacher*, September 1996.
- "KidSat Program Allows Students to Participate in Space Mission from the Classroom, " *EOM, Geographic, Mapping, Earth Information*, May 1996.
- "IAAY and Partners Give Students the World—from Space," *Institute Journal*, Johns Hopkins University, 1997.
- "KidSat Due for Shuttle Liftoff Sunday," *JPL Universe*, 10 January 1997.
- "Students Perform Mission: Camera On Atlantis Shuttle Is Their Baby," *Star News*, 18 January 1997.
- "UCSD Links Students with Space Shuttle," *La Jolla Village News*, 24 January 1997.
- "Students at Ames View Earth from Space Shuttle," *The Ames Astrogram*, 24 January 1997.
- "KidSat Pilot Program Reaps Wealth of New Shuttle Images," *JPL Universe*, 24 January 1997.
- "KidSat, Students Exploring Earth from Space," *Imagine*, January/February 1997.
- "Global Snapshot: Venice, Italy," *Space News*, 10 February 1997.
- "A Kodak Moment in Space," *California Education*, March 1997.
- "A Shuttle-Eye View for Kids," *Aerospace Technology Innovation*, March/April 1997.
- "Students Plan For Space; NASA Program Lets Kids Direct Shuttle Cameras," *North Coast, Arcata* September 1997.
- "Preteens Make Connection with Space Shuttle Atlantis," *The Post and Courier*, Charleston, South Carolina, September 30, 1997.
- "KidSat: Students Partner with JPL, NASA and Johns Hopkins University," *The Compass*, La Cañada Unified School District, Fall 1997.
- "Virtual Voyagers," *Star News*, 4 October 1997.
- "Final KidSat Flight Launches aboard Atlantis," *JPL Universe*, 3 October 1997.
- "Blast off to Knowledge," *Times Standard*, 30 October 1997.
- "IAAY Develops KidSat Curriculum," *IAAY Magazine*, Spring 1998.
- "Investigating the Earth from 250 Miles Up!" *Humboldt Highlights*, Fall 1998.
- "KidSat Students Get a New View of the World," *Humboldt Highlights*, Fall 1998.

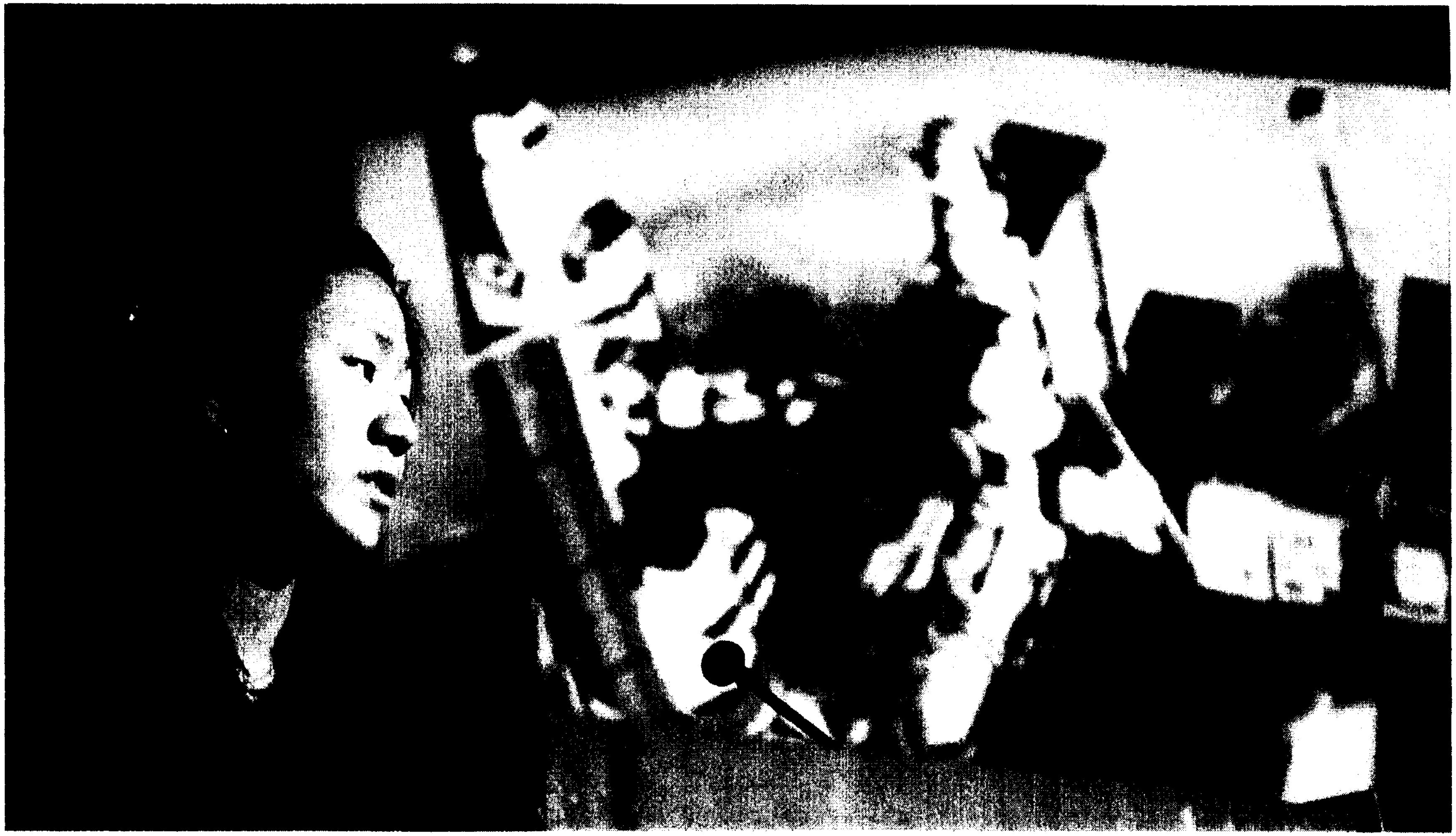


*Figure 71: Moon Young Choi, La Cañada High School student, speaks on the KidSat Project at the STS-76 pre-launch press conference. Photograph from the Pasadena Star News article of 13 March 1996 (photograph courtesy of the Pasadena Star News).*


*Figure 72: Students in Von Kármán Auditorium at the pre-launch press conference for STS-76, which was broadcast on NTV.*

*Figure 73: Moon Young Choi and Jenny Shanley (students from La Cañada High School) in the press room at KSC for the launch of STS-76*

## 9.4 Awards

KidSat drew a lot of attention over the years of the pilot program because it was of interest to a great portion of the public, was an exciting program that had students as the key participants, and was of great benefit to the community. Many achievement awards have been given to KidSat students for their contributions, especially in the use of the Internet as a core operation mechanism. Below are a few of these awards.

### *9.4.1 FEDnet Webbie Award*

Jeff Lawson, who was then a member of the Data System team, accepted the FEDnet '96 Webbie Certificate of Achievement awarded to the National Aeronautics and Space Administration for the most innovative Web site. The award was presented by FEDnet and Reed Exhibition Companies on October 22, 1996. The Webbie award is given to government Web sites that demonstrate excellence in network computing. KidSat was nominated by the Eastman Kodak Company for its success in using the Internet to assist students' education through the use of space photography.

### *9.4.2 The Computerworld Smithsonian Awards*

In 1997, KidSat was selected as one of five finalists from a pool of 300 nominees in the Education and Academia category of the Computerworld Smithsonian award, the Face of Innovation. This award is for outstanding users of information technology. It was given to the Jet Propulsion Laboratory, and was received by John Baker, KidSat Flight System manager, and Austin Leach and Joshua Lane, members of the KidSat Flight team from La Cañada High School. JPL was nominated by Eastman Kodak company. Although KidSat was not the first place winner, a permanent exhibit at the National Museum of American History, Division of Information Technology, was dedicated to the project. KidSat also became part of an Internet archive of all the nominees and award winners at the Innovation Network (http://innovate.si.edu). As a finalist, KidSat received a limited edition medallion from the Smithsonian Institution.

## 9.5 First-Day Cover

The JPL Stamp Club usually does first-day covers for JPL-related missions. They did one for KidSat.

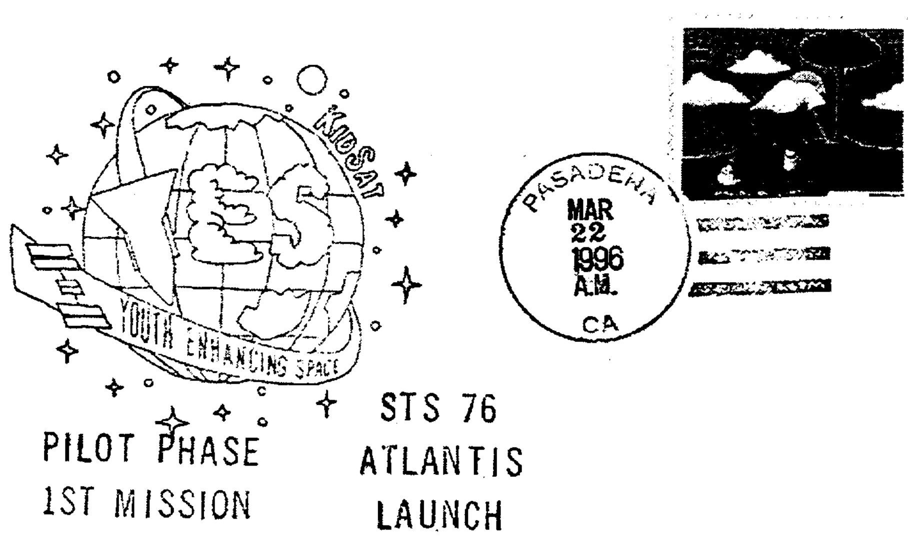



*Figure 74: First-Day Cover for STS-76 as presented by the JPL Stamp Club.*

# X. Image Results

## 10.1 Images and Results from STS-76

The following pages present a few of the highlights from STS-76. Below is a list of some other great images from this flight:

*Table 13: Some Images Taken from STS-76*

| MET | Location | Subject |
|---|---|---|
| 00212713 | India | Ganges River Delta |
| 01002440 | Saudi Arabia | Center pivot irrigation fields |
| 01010339 | Kenya | Southern Lake Rudolf, Rift Valley |
| 01061750 | Minnesota/Ontario | Ice on Lake Superior, Thunder Bay |
| 01080323 | Trinidad | Internal ocean waves |
| 06214832 | Saudi Arabia | Center pivot irrigation fields |
| 06214838 | Saudi Arabia | Center pivot irrigation fields |
| 06232512 | Sudan | White Nile |
| 07021513 | Newfoundland | Ice on the St. Lawrence River |
| 07021524 | Newfoundland | Ice on the St. Lawrence River |
| 07065535 | Nevada/Oregon | Black Rock Desert |
| 07065610 | Nevada | Independence Mountains |
| 07065639 | Utah | The Great Salt Lake Desert |
| 07085457 | Chile/Argentina | Volcano in the Andes, south-east of Santiago |
| 07160738 | China/Mongolia | Snow-covered Altai Mountains |
| 07174718 | Tibet/India | Mishmi Hills, Himalayas |
| 07191729 | Afghanistan | Snowy mountains |

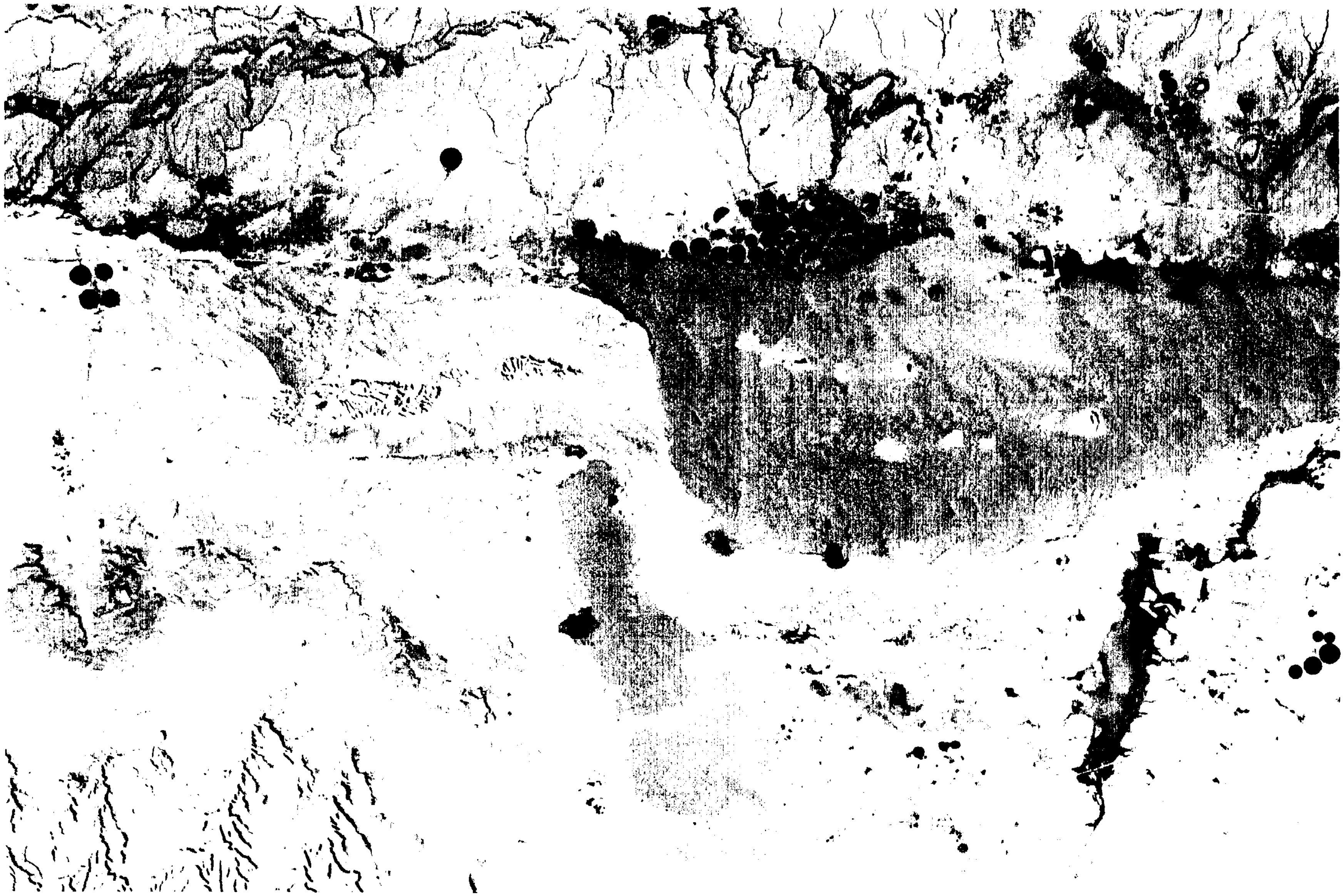


*Figure 75: Center pivot irrigation fields in Saudi Arabia, a favorite from STS-76, taken at MET 06/21:48:32.*

### *10.1.1 The Aral Sea*

In the KidSat image (STS076.00211835) of the Aral Sea, we can see the eastern coastline and an island on the western side of the image. The westward movement of the eastern shoreline of the Aral Sea has uncovered the former sea bottom. The former sea bottom is the source of toxic dust. On windy days, dust is picked up and blown across the farmland. The western shore has a much steeper embankment. Coastline changes are much less dramatic along the eastern shoreline.

The Aral Sea level has dropped by 12–15 m. This drop is due to the diversion of water from feeder rivers. Both the Syr Darya, from the east, and the Amu Darja, from the south, have been diverted. The rivers' water source lies in the mountain ranges west of the Himalayas, including the Hindu Kush, Pamirs, Tien Shan, Alayshiy Khrebet, and Kirghiz Khrebet. In the spring, melted snow from these mountains travels across an extensive arid region. The rivers are the only source of water to the Aral Sea. In the summer, demand for water from the rivers prevents any water from reaching the Aral Sea. On the KidSat image, standing water in both delta regions indicates that water may be flowing in the winter/spring. Kazakhstan and Uzbekistan, two countries that border the Aral Sea and four additional countries (Turkmenistan, Kyrgyzstan, Tajikistan, and Afghanistan) use the water from the Syr Darya and Amu Darja rivers. The water rights are the subject of a new international treaty between these countries. Images from space may help document how well this treaty is being enforced.

One of the most striking features in the KidSat image of the Aral Sea is the extent of ice that covered the entire sea during the season when this image was captured in March 1996. Although the Aral Sea is usually partially covered by ice in the winter, it is unusual that it is completely covered by ice at this time of year. As the sea shrinks, the winters have become colder and harsher. The winter of 1996–1997 was particularly cold and harsh.

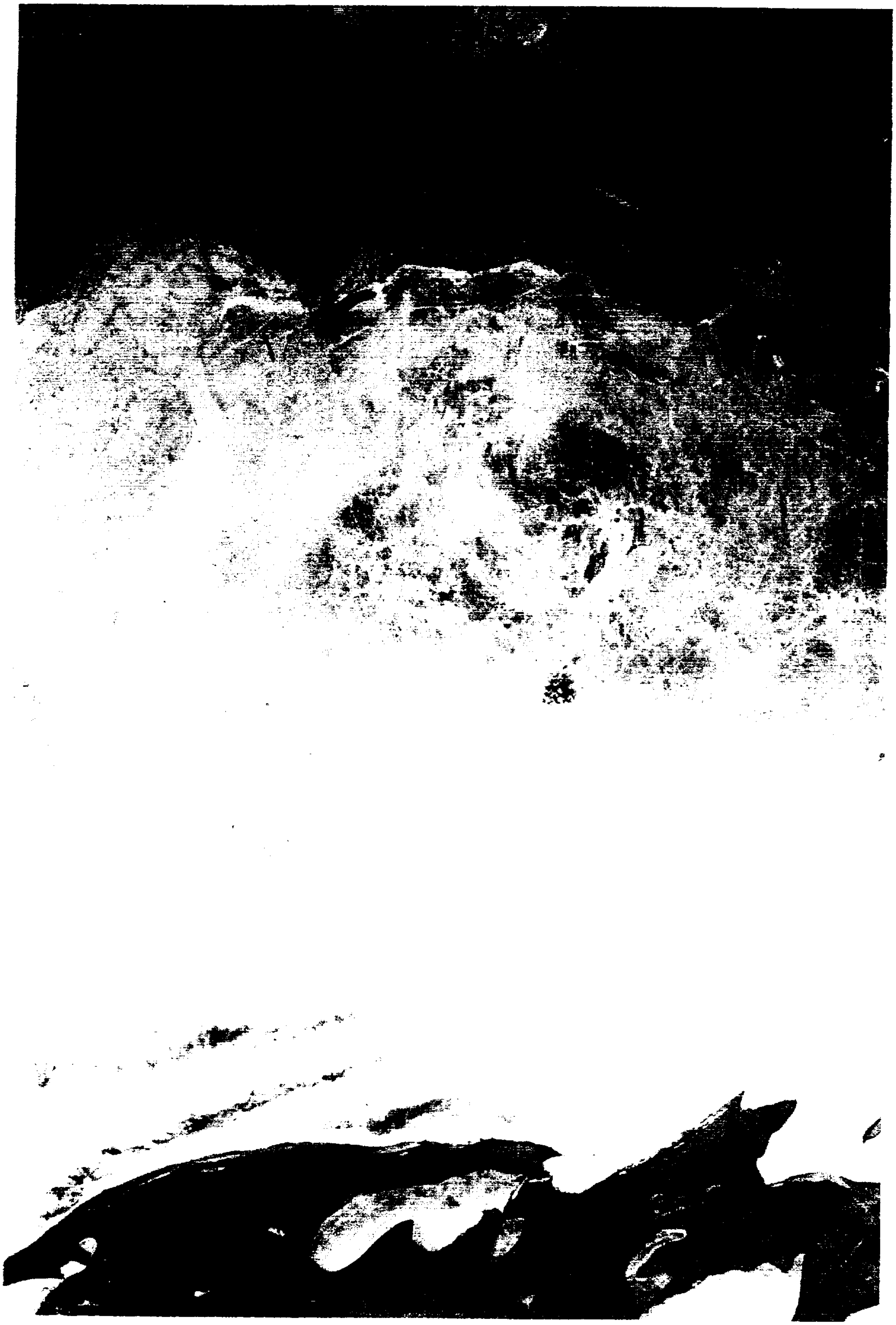


*Figure 76: The Aral Sea as viewed during STS-76 at MET 00/21:18:35.*

### *10.1.2 Volcanic Deserts of Saudi Arabia*

This image (STS076.01002520) of the north portion of the Arabian Peninsula was made into a simulated "fly over". The simulation was created using an elevation map and an image taken on March 23, 1996, centered at latitude 26°10'North and longitude 40°40'East. The elevation map identified the heights of each geographical feature. The heights were exaggerated by a factor of ten to enhance small-scale features. The image is then layered on the elevation map. Using computers and the two-dimensional image, the viewpoint was altered from one image to the next creating a sequence of three-dimensional images. This gives the viewer a sensation of flying over the region.

As the flight begins heading northeast, dark lava flows suggest volcanic activity related to the gradual opening of the rift beneath the Red Sea. This rift separates the Arabian plate from the African continental plate. The volcanoes on the Saudi Arabian side of the Red Sea do not appear on the Egyptian side. From a geological perspective, the volcanic activity is quite young. Many other outcroppings viewed in these images are fairly old landforms. Erosion by the wind and sand have either worn down or covered up parts of these landforms.

After the volcanic area, the flyby travels across dry river beds called "wadis". The wadis only drain off water when it finally rains. The climate of the region, however, is much milder than the harsh deserts surrounding it. After traveling across the wadis, small rocky hills come into view. Volcanoes once again appear in our view and a sharp contrast can be seen between the light-colored sand and the black volcanic rock. The sand is driven southeasterly from the An-Nafud desert in northwestern Saudi Arabia. This area is part of the northwestern face of the Najd Plateau. The plateau, high near the western coast, gradually drops off in the northeast where the sand can move past. Higher in elevation than the plateau, the volcanoes block the incoming sand which must work around them. This simulated flight across the Saudi Arabian desert demonstrates the interaction of volcanoes with sand dunes and deserts. The unique three-dimensional perspective provides a new way to learn and explore our Earth.

Much can be learned historically of this region as well. Many years ago, this area was known as the Hijaz region. The Hijaz region was filled with nomadic tribes and was centered at an important commercial link between Egypt, the Byzantine Empire, and the lands of the far east. Saudi Arabia is also the birthplace and heartland of Islam. Madina, a holy city near the area seen in this image, hosts the burial site of the great prophet of Islam, Muhammad. The Arabic lunar calendar was also invented in this area. This dynamic panorama acts as a springboard for student discoveries that will take them beyond their books and into real world applications.

Figure 77: Color image of Saudi Arabia as captured by KidSat on STS-76 at MET 01/00:25:20.

### *10.1.3 Kangaroo Island*

In 1790, 700 convicts were taken to the Australian continent, which was then thought to be a barren wasteland. This KidSat image (STS081.00214627), captured on STS-76, shows the pristine beaches and rugged coastlines these European outcasts discovered as they began to colonize the Yorke Peninsula. Visible on the left of the image is Investigator's Strait, the passage between Yorke Peninsula and Kangaroo Island and part of the route navigated by Captain James Cook. "This image makes me want to further investigate the reason why there are white areas on the Yorke Peninsula. Are the beaches and straits like they where when Captain Cook traveled through here?" asked a KidSat student investigator. This image, centered at 35.5°South and 138.0°East in the state of South Australia, was captured on March 23 by students in San Diego, California, using the KidSat digital still camera onboard STS-76, the first flight of KidSat. The image is 156 km by 104 km and was acquired using a 50 mm lens, from an altitude of 289 km.

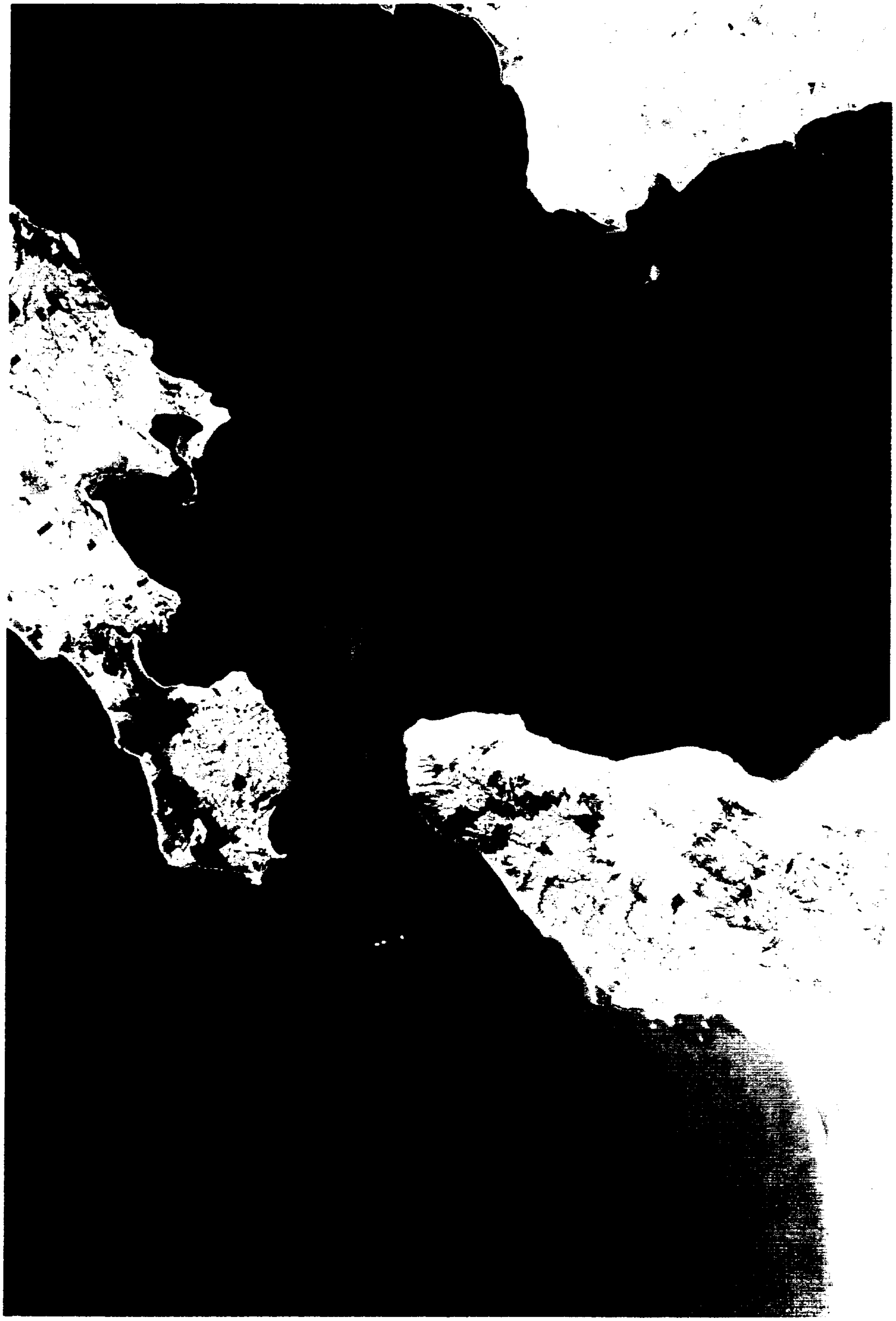


Figure 78: First annotated image of Kangaroo Island from STS-76, taken at MET 00/21:46:27.

## 10.2 Images and Results from STS-81

The following pages present a few of the highlights from STS-81. Below is a list of some other great images from this flight:

*Table 14: Some Images Taken on STS-81*

| Image ID | Location | Subject |
|---|---|---|
| 00215120 | Australia | Tasmania |
| 00224934 | Ukraine | Ice-covered land in Odessa |
| 01002012 | Italy | Venice |
| 01002024 | Colored ocean | Adriatic Sea, northern Italy |
| 01002618 | Israel | Dead Sea |
| 01003108 | Oman | Frankincense Routes |
| 01003120 | Oman | Trail of Frankincense |
| 01232854 | Over New Zealand | Limb view |
| 02002623 | Nile | El Fayum, Lake Moeris: Land reclaimed by regulating the flow of the Nile |
| 02062000 | Canada | Land clearing in Saskatchewan |
| 02062530 | U.S. | Appalachians |
| 02080707 | Venezuela | Peninsula da Paraguana, Golfo de Venezuela, Caribbean Sea |
| 02092847 | California | Mono Lake, Sierra Nevada Mts. |
| 08052046 | Bahamas | Grand Bahamas |
| 08192338 | Western Australia | Shark Bay |
| 09012719 | Angola | Skeleton Coast, Ocean Sun glint |
| 09012801 | Off Skeleton Coast | Sun glint |
| 09073800 | Chile | Atacama Desert |

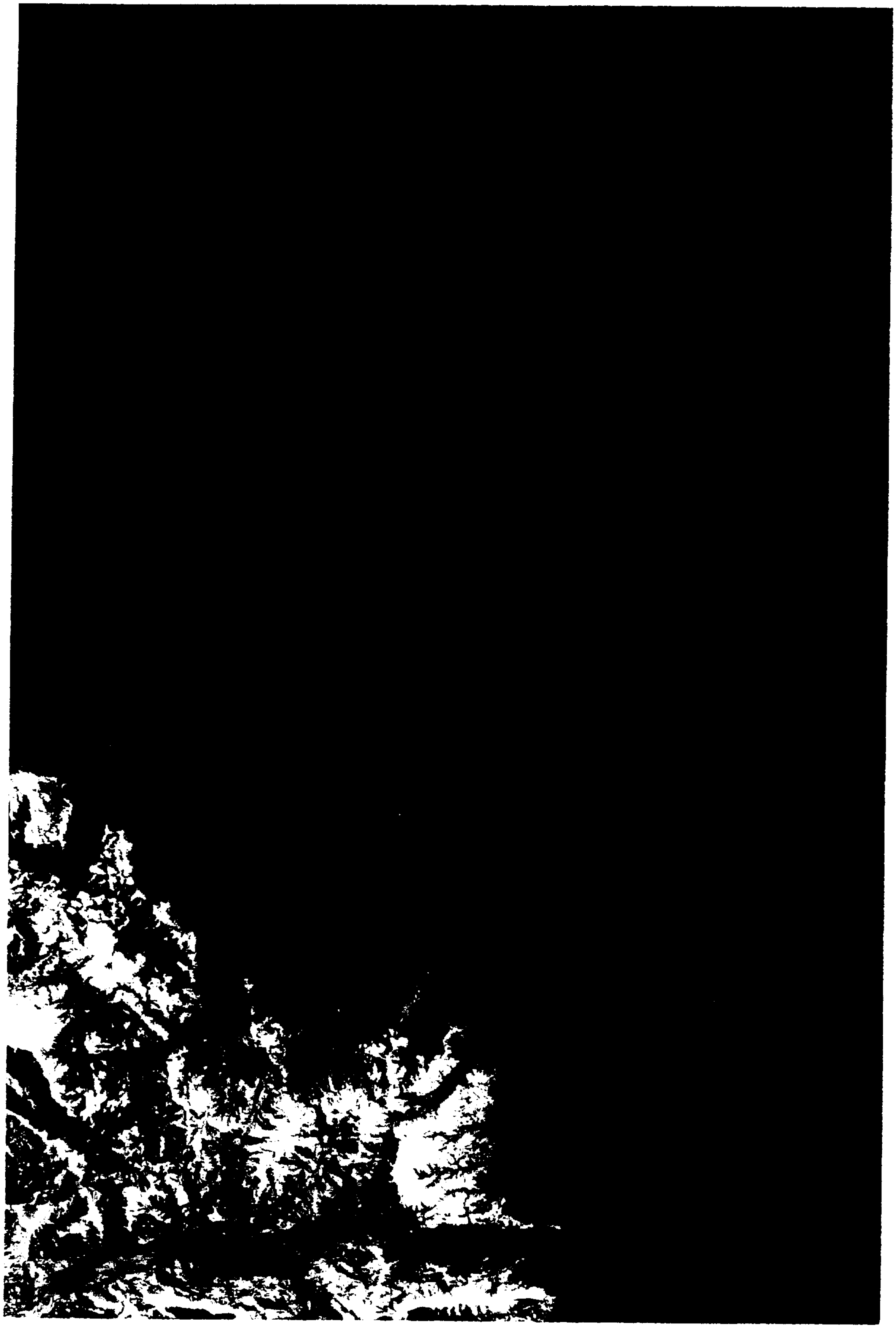


Figure 79: Venice, Italy, a favorite taken on STS-81 at MET 01/00:20:12.

### *10.2.1 The Ganges River Delta*

This image (STS081.00212933) shows an area that is located at 22.08° North and 89.56° East. It shows the Ganges river, which is about 1,550 miles long. The river flows from the Himalayan mountains near the border of China and continues in a southwestern direction through northern India. Many tributaries or mouths of the Ganges can be seen in this image.

Although Calcutta, Howrah, Baranagar, Khatpara, and other big cities are not seen in this image, they lie just inland of the Ganges river. The large amounts of sediment in the waters of the Ganges create intricate deltas that are visible. You can also see the Bay of Bengal in the upper left portion and submerged lands at the lower left.

The Ganges river is sacred to the Hindus of India. There are many holy sites along the Ganges' banks. The river is also important for practical reasons. as well. In India's West Bengal and in Bangladesh the people who live in the river's delta use the water from the river for agriculture and, hence, to make money. The Ganges provides these farmers with fertile land on which to grow crops. Indeed, the sediment deposited from the floods during monsoon season (or during the spring and summer) helps make the land very fertile. So the delta is covered with many small farms. In the image, the farmed areas are lighter in color while forests that have not been cut down for agriculture are darker in color. Unfortunately, during monsoons, powerful cyclonic storms can submerge farms, houses, and livestock. This occurs during the spring (April to June) and the summer (June to October). The entire delta becomes a lake, with some high elevated islands showing.

Figure 80: The Ganges River Delta as viewed during STS-81 at MET 00/21:29:33.

### *10.2.2 The Gaza Strip*

The Gaza strip is perhaps one of the most famous strips of land in the world. It is a narrow strip of land on the western shores of the Mediterranean Sea. In this particular image (STS081.01002601), North would be directed to the bottom of the page, with South being directed to the top of the page. Likewise, West would be to the left side of the image and East to the right. The border of the Gaza Strip can be distinguished in the image by the difference in vegetation patterns. The Egyptian side is less vegetated, perhaps due to the heavy use of the land for grazing. The 360-square kilometer area, slightly more than twice the size of Washington, D.C., is occupied by over 800,000 stateless Palestinians and approximately 4,800 Jewish settlers, according to a 1995 estimate.

The British took over Palestine after World War I, but promised the Arabs independence because of their help during the war against the Turks of the Ottoman Empire. Although the Turks were defeated, most Arabs did not gain independence. The occupied land was divided into six countries, four of which were still ruled by European countries. The only two nations to become independent were Saudi Arabia and Yemen. The Arab population began an undeclared war involving riots and protests. Between 1932 and 1946, the nations of Iraq, Lebanon, and Syria gained independence.

However, gaining independence for Palestine posed a different problem, because of the number of Jewish people living in the area. These people had fought on the side of Great Britain and were valuable to the scientific community. In 1948, the Jews moved West to the Jordan River and established the nation of Israel. The surrounding Arab countries objected and invaded Israel immediately, only to be driven out. When the war broke out, 450,000 Palestinians fled Israel. Unwelcomed by other Arab countries, these refugees settled along the west bank of the Jordan River and in an area along the Mediterranean Sea, known as the Gaza Strip.

Since 1948, the Arabs and the Israelis have fought four wars. Boundaries have shifted back and forth. To date, the only Arab country that has recognized Israel's right to exist is Egypt. Arab nationalists, headed by the Palestine Liberation Organization (PLO), have carried out guerrilla attacks on Israel. In return, Israel has bombed guerrilla bases and has invaded PLO strongholds in southern Lebanon. However, peace talks and negotiations have taken place recently between Israeli Prime Minister Benjamin Netanyahu and Palestinian Authority President Yasser Arafat.

On January 16, 1997 a deal was made between the leaders of the two countries concerning the redeployment of Israeli forces in the area of Hebron. The deal to withdraw Israeli troops from 80% of the occupied city and from other West Bank lands has been met with much opposition and concern. Negotiations concerning final borders and the future of the approximately 140 Jewish settlements in the West Bank and Gaza Strip were expected to be completed by 1998.

Figure 81: The Gaza Strip as viewed during STS-81 at MET 01/00:26:01.

Figure 82: Glaciers in the Andes—a favorite from STS-86 taken at MET 08/11:29:08.

*Figure 83: Fires near Manaus along the Amazon and Rio Negro rivers as viewed during STS-86 at MET 01/08:38:11.*

## 10.3 Images and Results from STS-86

The following pages present a few of the highlights from STS-86. Below is a list of some other great images from this flight:

*Table 15: Some Images Taken on STS-86*

| Image ID | Location | Subject |
|---|---|---|
| 00081702 | Brazil | Rio Sao Francisco (interesting to compare to STS-61A, Roll 52, Frames 36 and 37) |
| 00215624 | Sumatra, Indonesia | Fires associated with El Niño |
| 00215637 | Sumatra, Indonesia | Fires associated with El Niño |
| 00215701 | Sumatra, Indonesia | Fires associated with El Niño |
| 00220205 | Australia | Coast near Hamersley Mountains. |
| 00220435 | Western Australia | Desert south of Lane Wells |
| 01005410 | Arabia | Coast |
| 01041042 | South Africa | Johannesburg |
| 01083811 | Brazil | Fires in Manaus |
| 01101650 | Chile | Salta region, Andes |
| 08023638 | Australia | Coast of Queensland |
| 08023654 | Australia | Great Barrier Reef |
| 08040553 | Western Australia | Southern Gibson Desert |
| 08101513 | South Africa-Zimbabwe | Rural ghettos that are remnants of the Apartheid era in South Africa line the edge of the Kruger National Park, one of the largest in Africa. |
| 08112908 | Chile | Glaciers in the Andes |
| 08150455 | Atlantic | Limb over Atlantic |
| 08150610 | Over Africa | Limb view |
| 08150622 | Over Algeria | Limb view |
| 08162147 | Argentina | Salta Region |
| 08162940 | Brazil | Rio Gurupi |
| 08181017 | Over U.S. east coast | Limb view |

Figure 84: Great Barrier Reef, Australia, as captured during STS-86 at MET 08/02:36:54.

### *10.3.1 Fires in Indonesia*

As Atlantis flew over the Indonesian archipelago, middle school students across the country photographed the fires and smoke that blanketed Sumatra. At MET 00215343 – 00215750, the KidSat camera was used to image (STS086.00215637) a 140-km wide, 1950-km long strip that starts in the northwest (5.24°North, 97.11°East) and follows the Pegunungan Barisan range across the equator to the southern tip of Sumatra (7.44South, 106.1East). Smoldering underground fires raged uncontrolled for a few weeks in Southeast Asia. The fires, which are set to clear land for agriculture, are usually extinguished by the annual monsoon rains. However, that year, the rains did not come because of El Niño, which produced dry conditions in Indonesia. Due to the lack of trade winds, the seasonal warm waters in the eastern Pacific spread over to South America. Consequently, the water temperature in Indonesia dropped significantly. This decrease in temperature didn't produce enough warm water vapor to yield the seasonal showers that normally encompass the area.

The effect of the fires was astronomical. The fires were blamed for two fatal accidents and countless health hazards. At one point, the pollution index of the region reached 839. To put this number into perspective, a pollution index of 300 is equivalent to smoking 20 cigarettes a day. The smoke blanketed an area that was larger than the continental United States. The fires' rage was eventually quelled by winds and rain, which lifted the smog and dampened the fires. Over 100,000 firefighters were needed to stop the fire.

We can see the fires clearly in the images. The smoke plumes appear in the rain forests, east of the mountains where land is being cleared for palm plantations. The plumes indicate a prevailing wind to the northwest. Within a short distance, the region becomes completely blanketed in smoke, with only the peaks of the volcanoes rising above the gray haze layer.

Figure 85: Fires in Sumatra as viewed during STS-86 at MET 00/21:56:37.

## 10.4 Imaging in Series

Imaging in series allows you to view an entire region rather than be restricted by what can be seen on a single image. Images that overlap by about 10% or more can be mosaicked together to make a new, long image that crosses a mountain range or continent.

*Table 16: Imaging in Series Example*

| Mission | Start MET | End MET | No. in Series | Region |
|---|---|---|---|---|
| STS-76 | 01032627 | 01032652 | 3 | Clouds over Mali, Algeria, and Mauritania border |
| | 01051600 | 01051705 | 5 | Clouds over South Africa |
| STS-81 | 02061830 | 02062000 | 6 | Snow across Canada showing extensive land clearing |
| STS-86 | 00081702 | 00081736 | 3 | Rio Sao Francisco |
| | 00215343 | 00215750 | 16 | Sumatra's El Niño fires |
| | 00220205 | 00220435 | 9 | North coast of Western Australia including Millstream Chichester National Park |
| | 01040956 | 01041042 | 4 | Johannesburg, South Africa |
| | 01083727 | 01083811 | 4 | Manaus fires |
| | 08023638 | 08023718 | 4 | The Great Barrier Reef, Australia |
| | 08112848 | 08112908 | 3 | Glaciers in the valleys in Southern Chile |

*Figure 86: A poster of Sumatra showing the fires resulting from a delayed monsoon related to El Niño, held up by La Cañada students at the final awards ceremony.*

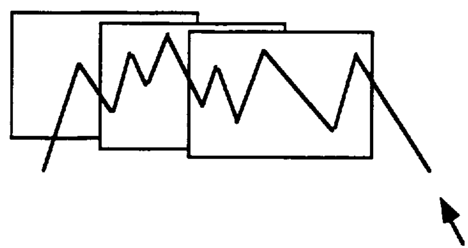
## 10.5 Limb Views

When scanning through photographs taken by astronauts, KidSat students are always fascinated by limb views. On STS-86, students captured their own limb views when the shuttle flew in a rolled attitude for a short portion of the mission. This attitude was selected to allow the shuttle to produce extra water. With a 20-45° roll, the shuttle's southern wing points out into space while the northern wing points at the Earth. Thus, the shuttle turns away from the sun and toward cold space. The cold allows the fuel cells to work harder, and, as a result, they produce more water, which can be delivered to Mir during docking.

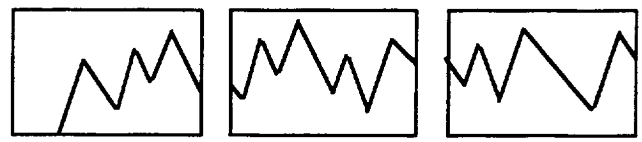
The limb photographs were all taken with an 85-mm lens, as the shuttle crossed the Atlantic to the northwest coast of Africa. The last near-nadir photograph was taken at 08/14:21:41. A series of out-of-focus photographs were then taken in an attitude of about 245° pitch, 7° yaw, and 340° roll, when the shuttle windows were pointed to deep space. At 08/15:01:01, the shuttle was maneuvered to an attitude of 40.97° pitch, 8.55° yaw, and 212.24° roll. Between 08/15:01:01 and 08/15:06:22, a series of limb views were taken as the shuttle slowly pitched to 61.12°. The shuttle was flying in a pitched payload-bay-to-Earth attitude but looking toward the south at the limb. By 08/16:19:06, the shuttle was in its nominal Z-axis Local Vertical (-ZLV) attitude (180° pitch, 0° yaw, and 0° roll).

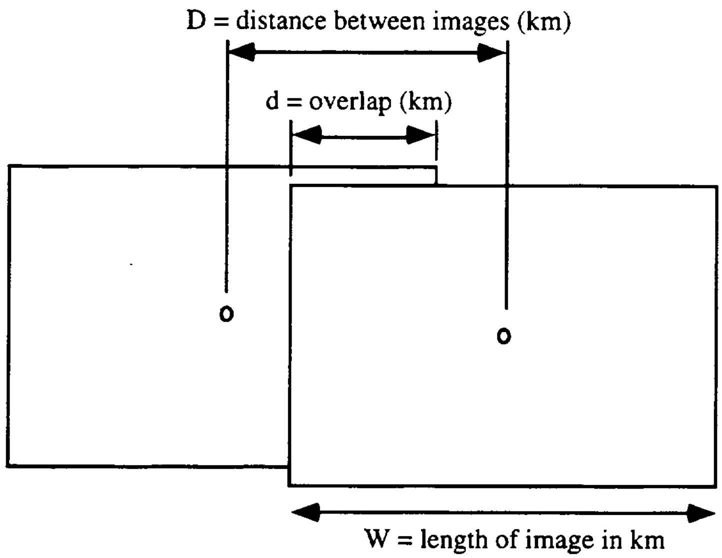
*Figure 87: Limb over the Atlantic, taken on STS-86 at MET 08/18:10:17.*

Images with 50% overlap:



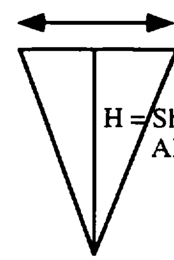

Images:






**Best Stereo:**

B/H = 0.5 Best
B/H > 0.5 Exagerated
H = 400 km
B = 200 km




**Calculating C, D and T (time between images):**
d = W x %overlap
D = W - d
t = D/v
v = Shuttle speed = 7.66 km/sec at 400 km altitude

| Lens (mm) | X (km) | % Overlap | d (km) | D (km) | t (sec) | Stereo? |
|---|---|---|---|---|---|---|
| 28 | 401 | 30 | 120 | 281 | 37 | Exagerated |
| | | 50 | 200 | 201 | 26 | Good |
| 50 | 225 | 30 | 68 | 157 | 20 | |
| | | 50 | 112 | 113 | 15 | |
| 85 | 132 | 30 | 40 | 92 | 12 | |
| | | 50 | 66 | 66 | 9 | |
| 180 | 62 | 30 | 19 | 43 | 6 | |
| | | 50 | 31 | 31 | 4 | |

*Figure 88: Stereo imaging.*

## 10.6 Stereo Images

Three-dimensional objects are seen in stereo because each eye sees the object from a slightly different direction. The optimum stereo view has a base-to-height (B/H) ratio of .5, where B is the baseline, or distance between your eyes, and H is the distance between the object and your eyes. To capture a stereo view of the Earth from space, the trick is to take two images of a three-dimensional object (like clouds or mountains) and force your eyes to look at each picture individually. To capture the images, the baseline must be about half the distance between your camera and the Earth. For the shuttle/Mir missions and for the Space Station, the camera altitude is about 400 km. Thus, your camera must take pictures separated by about 200 km.

If you happen to be on the shuttle and are holding your camera, or if you have the capability to tilt the camera remotely, you can point the camera at your chosen object 100 km before passing it, and 100 km after passing it. If your camera is fixed and can only look nadir like the KidSat camera, you must take overlapping images such that the overlapping portion of your image is in stereo. Since you need a baseline of 200 km, your images must be more than 200 km apart in the along-track direction to have both overlap and a separation that is adequate to see stereo. Since we know the shuttle travels at about 7.7 km/sec., the optimum timing offset is about 26 seconds. If you take your pictures 15 seconds apart, you will have a B/H ratio of about .3, which will allow you to get more overlap in your images.

Now that you have your stereo pairs, how do you see them? If you can see "Magic Eyes", it is likely that you will be able to hold up the images in front of you and see them in stereo by focusing each eye on a separate image. If not, there are several tools that are available, including a stereopticon that your grandparents might have (cardboard ones are available from a Web site located at http://www.3dviewmax.com/), or an anaglyph, which is a red/green image made from the stereo pair that may be viewed with red-green glasses.

### *10.6.1 Making Stereopticon Images*

Stereopticon images are easily made by downloading a stereo pair. The first step is to look for the overlapping portion of each image. The image with excess area on the right side should be relabeled "right" while the one with excess image on the left side should be renamed "left". The images should then be cropped to show the exact same area and should be pasted side by side in a single image, with the "right" image on the right and the "left" image on the left. The pair should then be rescaled so that the total dimension across the left and right images is six inches. The height does not matter, but will usually be about three inches, depending on the amount of overlap. The final product may then be printed, pasted onto cardboard, and placed in an antique or a cardboard stereopticon for three-dimensional viewing.

### *10.6.2 Directions for Making an Anaglyph*

An anaglyph is a color image made from a combination of stereo images, with each displayed in a different color. The anaglyph seen through a pair of red-green glasses allows your right eye to focus on the green part of the image and your left eye to focus on the red part of the image, which produces a three-dimensional view. To make an anaglyph, download a stereo pair of images and identify the overlapping portion of the images. Place the images in an overlapping position. The image with excess area on the right is the right-eye image and should be relabeled "right". The other image is the left-eye image and should be relabeled "left". The next step is to crop the images, so that the same area is shown in each view. The image size should be checked and the images should be cropped, so that they are the same pixel length and width. The images should then be rendered to grayscale and the right-eye image

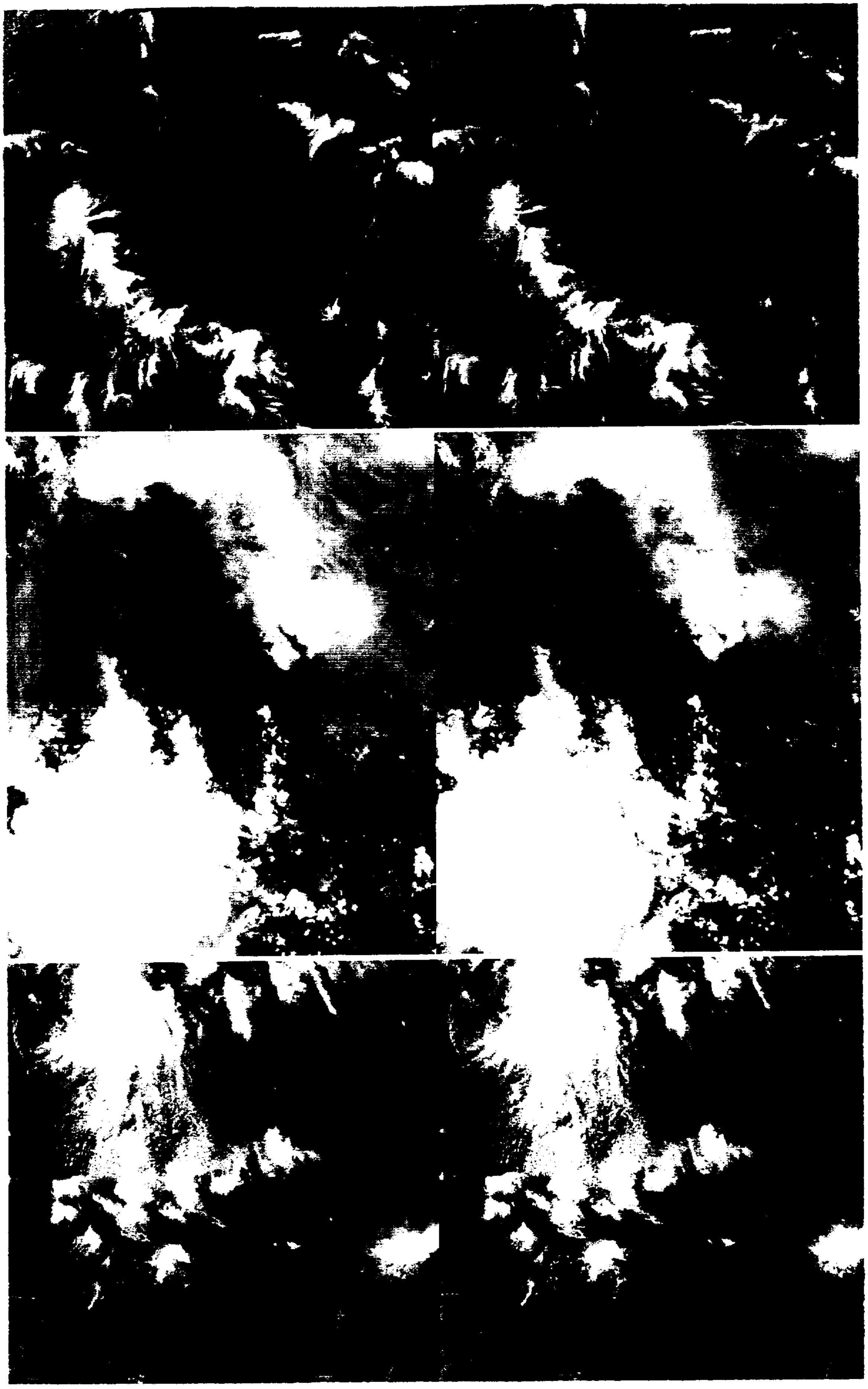


*Figure 89: Stereo pairs from STS-76 shown in a format that may be viewed using a stereopticon. Top: The Mediterranean Sea (01/01:51:23 - left, 01/01:51:13 - right); Middle: Thunderstorm over Sudan (01/02:01:39 - left, 01/02:01:24 - right); Bottom: Spain (01/01:51:12 - left, 01/01:50:06 - right).*

Figure 90: Anaglyph of a thunderstorm in Sudan captured during STS-76 at METs 01/02:01:39 and 01/02:01:24.

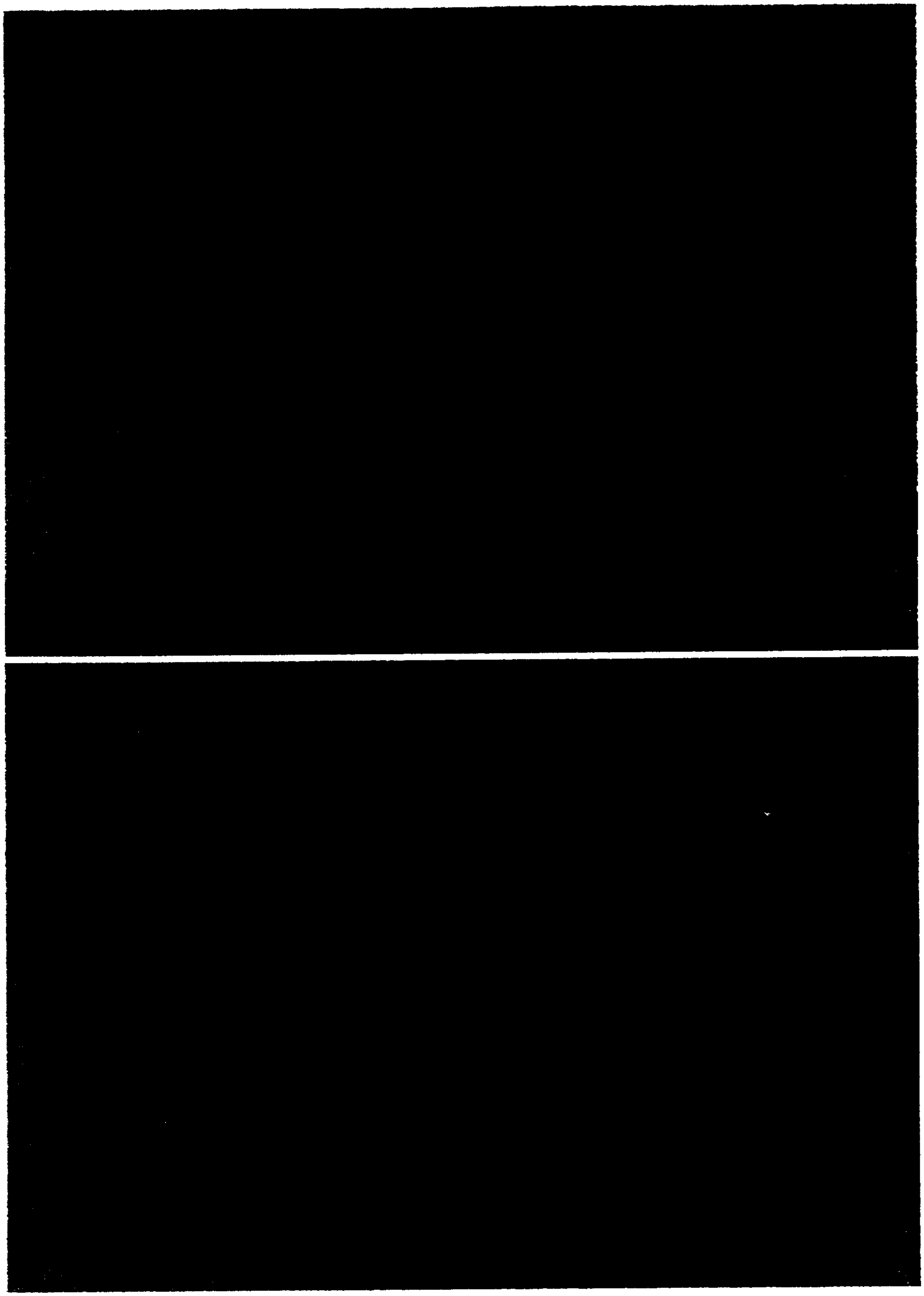


*Figure 91: Oman as imaged on STS-81 at MET 01/00:31:20 (left eye) and 01/00:31:08 (right eye).*

should be duplicated, and one copy labeled "blue". Finally, the images should be combined as an RGB (red/green/blue) color image, with the "right" image as the red layer, the "left" image as the green layer, and the "blue" image as the blue layer. The images are now viewable in three dimensions with red/green or red/blue glasses. Red-green glasses may be made using red and green cellophane taped onto a set of glasses made of cardboard.

Below is a partial list of KidSat students' favorite stereo pairs.

*Table 17: KidSat Students' Favorite Stereo Pairs*

| Mission | Left image MET | Right image MET | Region |
|---|---|---|---|
| STS-76 | 00212726 | 00212713 | Ganges River Delta |
| STS-76 | 00225427 | 00225412 | Plateau of Iran |
| STS-76 | 01015012 | 01015006 | Golfo de Valencia, Spain |
| STS-76 | 01015123 | 01015113 | North coast of Algeria/Mediterranean |
| STS-76 | 01020139 | 01020124 | Thunderstorm over Sudan |
| STS-76 | 01032644 | 01032627 | Tropic of Cancer |
| STS-76 | 01032652 | 01032644 | Tropic of Cancer |
| STS-76 | 01051615 | 01051600 | Southern Africa |
| STS-76 | 01051649 | 01051632 | Southern Africa |
| STS-76 | 01080351 | 01080335 | Trinidad clouds |
| STS-76 | 07071050 | 07071047 | Clouds over Amazon |
| STS-81 | 00215128 | 00215120 | Tasmania, Australia |
| STS-81 | 00225427 | 00225412 | Elburz Mountains, North Iran |
| STS-81 | 01001930 | 01001920 | Central Switzerland |
| STS-81 | 01001941 | 01001930 | Alps |
| STS-81 | 01003120 | 01003108 | Oman |
| STS-81 | 08173943 | 08173934 | Vietnam |
| STS-81 | 08221140 | 08221130 | Lake Nubia, Sudan |
| STS-86 | 00081115 | 00081103 | Surinam Coast, Atlantic Ocean |
| STS-86 | 00215424 | 00215417 | Sumatra |
| STS-86 | 00221526 | 00221520 | Clouds over New Zealand |
| STS-86 | 01005508 | 01005502 | Somalia |
| STS-86 | 01101720 | 01101705 | Salta Region, Chilean Andes |
| STS-86 | 08112908 | 08112859 | Glaciers in Chile |

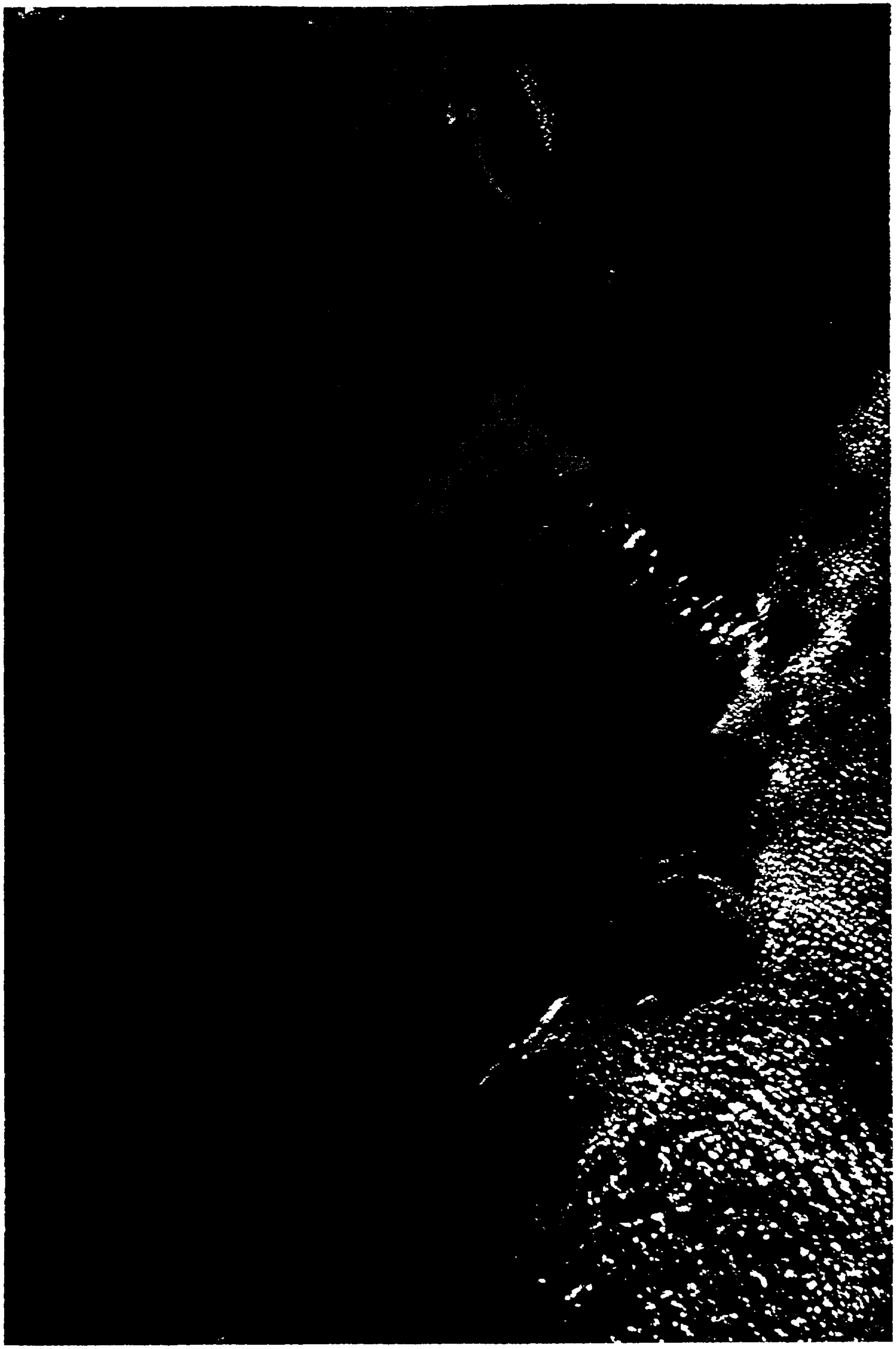


*Figure 92: Arabian coast imaged on STS-86 at MET 01/00:54:10.*

## 10.7 Poetry

A number of students found that the Earth images inspired poems. Below is a selection of these poems. For more work done on KidSat images and poetry, see Green, 1999.

### *Great Barrier Reef, Australia (see Figure 84)*

***Kristen Raymond***

The islands float in the deep blue ocean,
The ocean hides secrets of the reef that are not to be revealed,
Miles away the coast juts in and out,
Truly large beaches are nothing but white strips following the coastal pattern,
The bay lies dormant, the sun reflects off of its waves,
A town silently waits for what is to come,
The clouds cast their shadows as if watching,
The red brown land is still but for the gentle winds blowing
No one can predict what is to become of Australia.

### *Arabian Coast (see Figure 92)*

***Gabe Nelson***

There are rigid mountains, barren deserts, and burnt-reddish wastelands.
There are thick blunt coastlines, mangled dry riverbeds, and vast valleys, dark and black.
There is roughness:
Looming mountains, towering over the rest of the world.
Clouds splashing down in the sun-baked land below.
Barren wastelands covering the desert floor, eating all in its path.
And smoothness:
The dark, blackened ocean, beating away at the land's massive bluffs and cliffs.
Vast plains being unchallenged as they boldly sweep past the hills and valleys.
Dark, shadowy valleys, breaking apart hills and mountains with splitting force.
From up close, it would be barren, desolate, hot.
In space, it's cold, freezing, deadly.

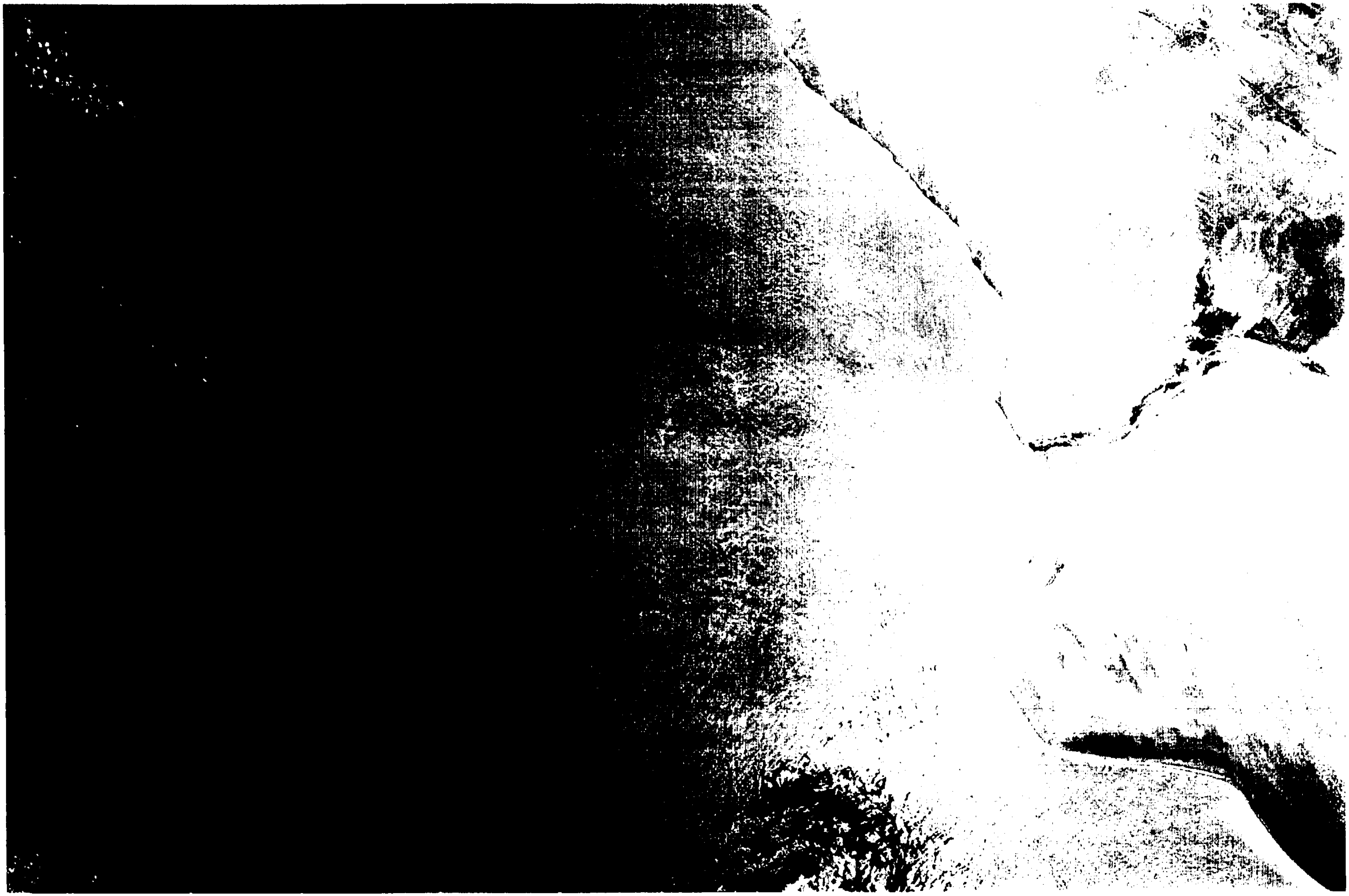


Figure 93: Sun glint off Namibia taken on STS-81 at MET 09/01:28:01.

## 10.8 Sun Glint and the Ocean

> *"Although the ocean's surface seems at first to be completely homogeneous, after half a month we began to differentiate various seas and even parts of oceans by their characteristic shades. We were astonished to discover that, during a flight, you have to learn anew not only to look, but also to see. At first the finest nuances of color elude you, but gradually your vision sharpens and your color perception becomes richer, and the planet spreads itself before you with all its indescribable beauty."*
> Vladimir Lyakhov in *Home Planet.*

Sun glint is the reflection of sunlight from the surface of the ocean. It represents forward scattering and is a function of the sun angle and the amount of small-scale surface roughness. Wind stress, currents, and waves control the ocean patterns that may be observed in sun glint. When the ocean is calm, the sun glint is strong and the area of bright ocean is small. When the ocean is rough, the scattered light is more diffuse and the bright area is enlarged by wave facets that produce reflections from many different directions. Thus, the sun glint can be related to physical phenomena that affect the ocean's surface such as wind stress, wave-current interactions, and biochemical properties that can create surface slicks. Viewing the ocean in sun glint is unique to the shuttle because other Earth remote-sensing platforms are placed in sun-synchronous orbits, and view the Earth several hours before or after noon to avoid sun glint.

The ocean is a very dynamic system and is strongly influenced by the atmosphere. The surface temperature of the ocean in turn has a significant effect on clouds, particularly in oceanic frontal regions. The sun glint photographs are sensitive to the manifestations of this dynamic air-sea system, specifically to capillary and small-scale gravity waves. Ocean features, especially waves and currents, modulate the distribution and character of the wind-induced, small-scale waves. This results in generally characteristic manifestations of these various features in the sun glint images. The principal ocean features seen in these images are ocean swell, internal waves, mesoscale and sub-mesoscale (spiral) eddies, current boundaries, sub-surface bathymetric features, and thermal fronts. In addition, sun glint highlights oil slicks, both from natural surfactants and anthropogenic sources, and ship wakes. The images provide a unique two-dimensional view of the ocean surface, due to resolution and to its sensitivity to the small-scale wave field, which is not captured by any other remote-sensing instrument, except imaging radar.

We usually think of the ocean/atmosphere system as two layers, ocean and atmosphere. To understand internal waves, think of the ocean/atmosphere system as having three density layers: the atmosphere, and two layers in the oceans, one below, and one above, the thermocline. The thermocline defines a boundary between the warm upper ocean and the cold lower ocean and is usually between 50 to 100 m deep (the upper layer is warmed by the sun in the summer.) In this system, two kinds of waves form at the boundaries: (1) surface waves caused by the wind, or wind forcing, at the surface between the upper ocean and the atmosphere, and (2) internal waves caused by tides, or tidal forcing, at the boundary between the two layers of ocean. The typical wave height for surface waves is 2–3 m, with a typical wavelength of 100–200 m. The typical wave height for internal waves is 15 m, with typical wavelengths of several kilometers.

If you are on a boat, you can see three kinds of waves: the smallest, most random-looking waves are capillary waves. The larger waves, often known as swells, are surface waves. The third kind of wave is internal waves. The internal waves seen off the coast of Namibia on STS-76 and STS-81 are gigantic. The internal waves off the coast of Trinidad seen on STS-76 are formed by tidal forcing onto the continental shelf. Other areas where you can look for internal waves are the Gulf of California, the Gulf of Mexico, the Straits of Gibraltar, and the New York Bite.

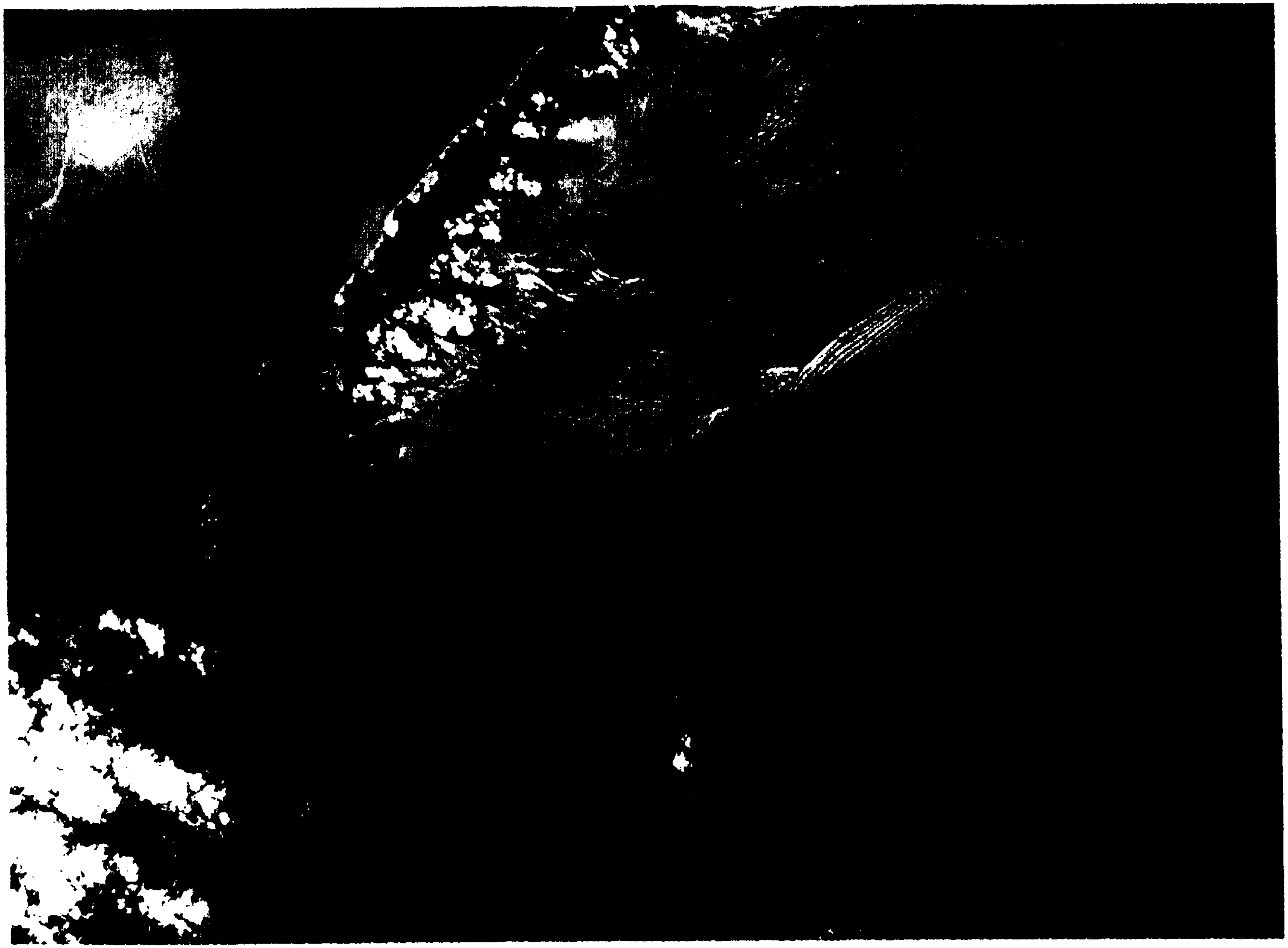


*Figure 94: Internal waves off the coast of Trinidad. This image was captured on STS-76 at MET 01/08:03:23. The upper left fourth of the image is shown here.*

Table 18: Some Images of Waves

| Mission | Image ID | Location |
|---|---|---|
| STS-76 | 01080323 | Internal waves were images off of Trinidad north of South America. |
| STS-76 | 07024218 | Internal waves off coast of Namibia |
| STS-81 | 09012801 | Internal waves off coast of Namibia |

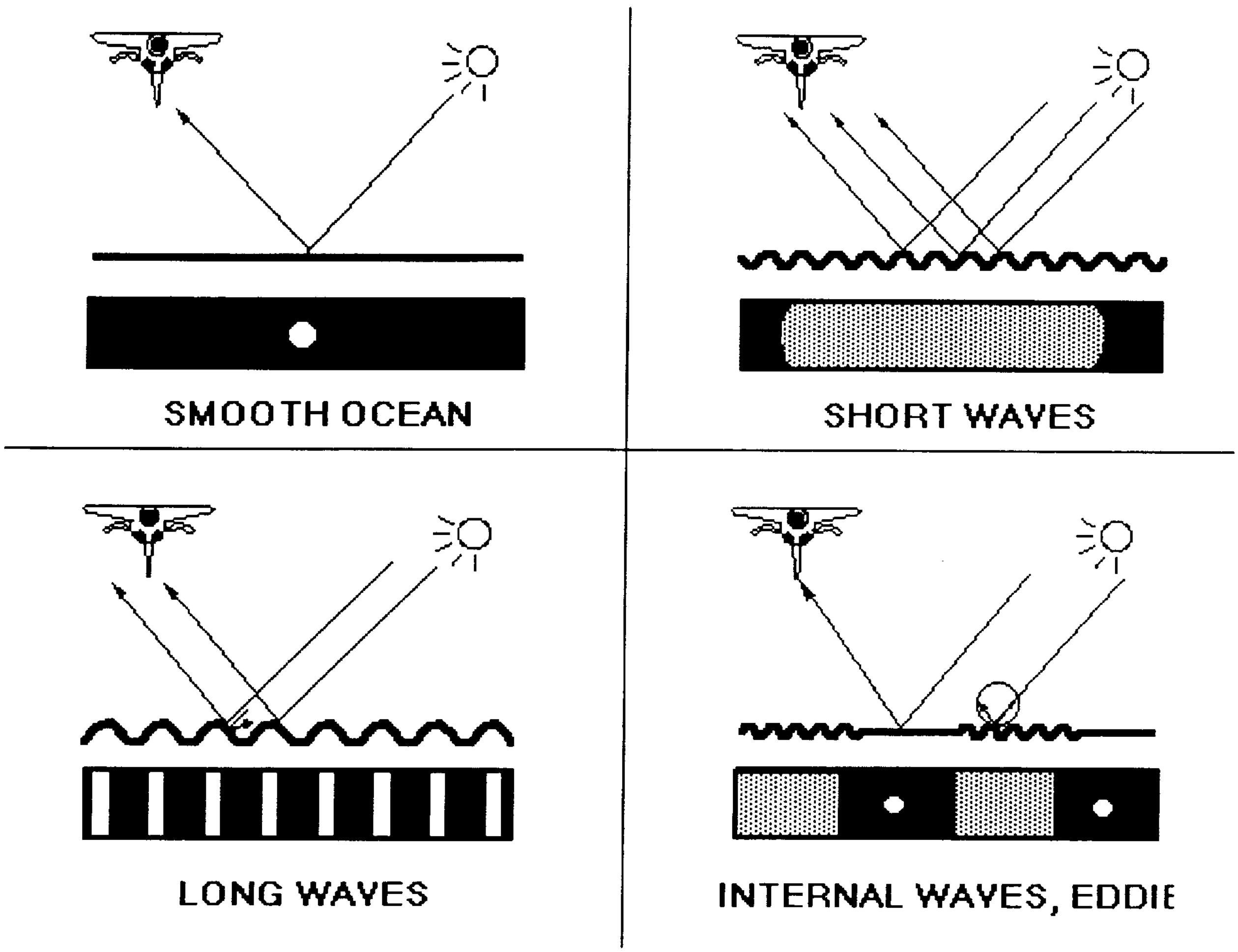



Figure 95: Ocean wave imaging in sun glint.

# XI. Conclusions

At the beginning of the three-year pilot phase, KidSat set out to develop an exciting program that would help educate students about the Earth, as well as other disciplines such as mathematics, history, geography, science, and computing. The Flight System accomplished its technical objectives and successfully integrated high school students and their communities into a flight project. The software and expertise developed by JPL for this project were transferred to UCSD and JSC for continued use. With the goal of involving middle school students in a mission directly from their classrooms, the Mission Operations team successfully designed and established a remote Payload Operations Control Center operated by students. The Data System team successfully developed a unique system for educational outreach and for other flight projects. This was the first data system to bring data to investigators in remote sites, within a few hours of acquisition, and the first to deliver supporting data with the initial image data. The Education team developed three curriculum modules and distributed them to 21 of the participating schools along with training and evaluation. A variety of science workshops followed each mission, a fact that indicates extensive post-mission use of the images. Based on this alone, it is worth continuing KidSat and expanding it so that more students have access to the program. KidSat can help children learn more because it allows them to feel in control of something that is incredibly exciting. Studying becomes interesting, rather than a chore.

Launching innovative educational programs in a resource-constrained environment, and with a long-term impact on society, requires vision and commitment by participants and their supporting organizations. Both financial and managerial resources are routinely available for large-scale public projects. It is therefore easy for a small-scale, large-impact pilot program to not receive appropriate attention and focus. Aligning organizations and personnel that have divergent interests has proven to be challenging. Continuously reinforcing common commitments and goals required a substantial time investment. As with any new development, resolving technical interface issues was crucial, given the number of partners and their respective skill levels. Simple interfaces were defined to allow students to participate in the development process and to accelerate the schedule. We completed a project, from start to launch, in less than a year. By working closely with technical staff at JPL, JSC technical and operations teams, participating school districts, JHU, and UCSD, technical obstacles were resolved.

## 11.1 Recommendations for the Future

- Continue the shuttle program on a frequent and regular basis, when there are flights with suitable orbit inclinations and shuttle attitudes
- Expand into more middle and high schools to allow a greater number of students to have access to the program
- Place a camera onboard a permanently piloted space platform so that pictures can be taken at any time and the greater demand for pictures (that more schools will bring) can be accommodated. The International Space Station will provide an ideal opportunity
- Allow more schools from around the world to participate in the program, including schools that are in countries that have no space program of their own.

Now the pilot phase is complete, the program is focused outside of JPL. However, the basic camera setup and the way it is run will remain essentially the same. The pilot phase was a step towards a national or even international program to help educate future generations.

*Figure 96: At the end of the bench review, the STS-76 crew members give KidSat a thumbs up.*

## List of Acronyms

| | |
|---|---|
| AIRS | Atmospheric Infrared Sounder |
| ATMOS | Atmospheric Trace Molecule Spectroscopy |
| AVHRR | Advanced Very High Resolution Radiometer |
| CalSpace | California Space Institute |
| Caltech | California Institute of Technology |
| CCD | Charge Coupled Device |
| CCDT | Core Curriculum Design Team |
| CCF | Camera Control File |
| CD-ROM | Compact Disk, Read Only Medium |
| CDR | Critical Design Review |
| CIR | Cargo Integration Review |
| CMD | Command |
| CST | Central Standard Time |
| CTP | Comprehensive Testing Program |
| CTVC | Color Television Camera |
| DAAC | Data Archive and Access Centers |
| DIAL | Digital Image Animation Lab |
| EOS | Earth Observing System |
| ERB | Education Record Bureau |
| ES | Environmental Specialist |
| ESC | Electronic Still Camera |
| EVA | Extra Vehicular Activity |
| FAM | Crew Familiarization Briefing |
| FAO | Flight Activities Officer |
| FIDO | Flight Dynamics Officer |
| FOV | Field of View |
| FTP | File Transfer Protocol |
| GA | Generated Annotation |
| GB | Giga Byte |
| GIF | Graphic Interface Format |
| GMS | Geostationary Meteorological Satellite |
| GMT | Greenwich Mean Time |
| GOES | Geosynchronous Operational Environmental Satellite |
| GZIP | Uncompressed file |
| IAAY | Institute for Academic Advancement of Youth |
| IP | Image Processor |
| IR | Infrared |
| ISS | International Space Center |

| | |
|---|---|
| JHU | Johns Hopkins University |
| JNC | Jet Navigation Chart |
| JPEG | Joint Photographic Experts Group |
| JPL | Jet Propulsion Laboratory |
| JSC | Johnson Space Center |
| kbps | Kilo bits per second |
| KCA | $K_u$-band Communications Adapter |
| KSC | Kennedy Space Center |
| LOS | Loss of Signal |
| LTP | Long-Term Planner |
| MB | Mega Bytes |
| Mbps | Mega bits per second |
| MCC | Mission Control Center |
| MCG | Mission Control Gateway |
| MEEP | Mir Environmental Effects Payload |
| MET | Mission Elapsed Time |
| MIDL | Mulipurpose Imaging Lab |
| MIPL | Multiple Image Processing Lab |
| Mir | The Russian Space Station |
| MISR | Multiangle Imaging SpectroRadiometer |
| MOD | Mission Operations Director |
| MOU | Memorandum of Understanding |
| MTS | Mission Targeting Specialist |
| NASA | National Aeronautics and Space Administration |
| NCTM | National Council of Teachers of Math |
| NIH | National Institute of Health |
| NSF | National Science Foundation |
| NSN | NASA Science Network |
| NSTA | National Science Teachers Association |
| NSTS | National Space Transportation System |
| NTV | NASA Television |
| OCA | Orbiter Communications Adapter |
| PAO | Public Affairs Office |
| PAO | Public Activities Officer |
| PCMCIA | Personal Communications Module Computer Interface Adapter |
| PDIP | Payload Data Interface Panel |
| PDR | Preliminary Design Review |
| PGSC | Payload Ground Support Computer |
| PIP | Payload Integration Plan |
| POCC | Payload Operations Control Center |

| | |
|---|---|
| PST | Pacific Standard Time |
| RAM | Random Access Memory |
| SAREX | Shuttle Amateur Radio Experiment |
| SCSI | Small Computer Systems Interface |
| SESPD | Space and Earth Sciences Program Directorate |
| SIM | Simulation |
| SMOC | Student Mission Operations Center |
| STK | Satellite Tool Kit |
| STS | Space Transportation System |
| SURF | Summer Undergraduate Research Fellowships |
| SVGA | Super Video Graphics Array |
| TDRS | Tracking Data Relay Satellite |
| TDRSS | Tracking Data Relay Satellite System |
| TIDE | Teaching and Interdisciplinary Education |
| TIFF | Tagged Image File Format |
| UCSD | University of California, San Diego |
| USC | University of Southern California |
| WALC | Washington Accelerated Learning Center |
| ZLV | Z-axis Local Vertical |

# Definitions

| | |
|---|---|
| Ascending node | The point where the shuttle's orbit crosses the equator going north. The longitude of this point is called the longitude of the ascending node. |
| Descending node | The point where the shuttle's orbit crosses the equator going south. The longitude of this point is called the longitude of the descending node. |
| Footprint | The area on the surface of the Earth that can be captured in a photograph taken by the KidSat camera. |
| Gateway | Located at UCSD in San Diego, California, also called the Mission Control Gateway (MCG). During a KidSat shuttle flight, the UCSD gateway receives and processes photograph requests from SMOCs and sends them to JSC to be uplinked to the KidSat camera on the shuttle. |
| GMT | Greenwich Mean Time. Also called UT—Universal Time. The reference point for GMT (and UT) is Greenwich, England. When it is midnight on the Prime Meridian, which passes through Greenwich, the GMT (UT) is 00:00:00. When it is noon on the Prime Meridian it is 12:00:00 GMT (or UT). |
| Inclination | The angle that describes the orientation of an orbit. Inclination measures the tilt of the orbital plane with respect to a plane that contains the Earth's equator. The inclination of the shuttle's orbit during KidSat is 51.6°. |
| JSC | Johnson Space Center located in Houston, Texas. The Mission Control Center at JSC communicates with the space shuttle during a mission. |
| KSC | Kennedy Space Center, located in Cape Canaveral, Florida. The shuttle launches and lands at KSC. |
| MET | Mission Elapsed Time or the amount of time that has gone by since the shuttle launch |
| Nadir | Look direction from the shuttle straight down to the Earth |
| Orbit | The path that the shuttle travels on as it moves around the Earth. |
| Orbital plane | The plane in which the orbit lies. |
| Prime meridian | An imaginary line at longitude 0° that runs through Greenwich, England; the starting point for measuring distances east or west on a map or globe. |
| Slider map | A large map of the world and a sheet of plastic overlay with an orbit ground track printed on it. The slider map is used in KidSat to select targets. |
| Target | A location on the Earth that a school chooses to photograph. |
| Targeting | The process of selecting potential photographic sites for KidSat using the slider map, the SMOC Web pages, atlases, etc. |
| URL | Uniform Resource Locator. An address used to access Internet resources. |
| UT | Universal Time, also referred to as Greenwich Mean Time, GMT. (See definition under GMT). |

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# Appendix A: Participants

## KidSat Project

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| Project Manager | Greg Goodson (STS 76) |
| | Michael Devirian (STS-81 and STS-86) |
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Marsh, Kevin
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Mattis, Daiva
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Tempel, Carol
Tharpe, Robert
Theberge, Bonnie
Thom, Brian
Thomas, Peter
Thompson, Elvia
Thompson, R. J.
Thornton, Marie
Thurber, Carol
Tiemann, Brian
Tilton, Lisa
Titov, Vladimir
Tobias, Nathan
Tolerson, Tom
Toste, Sarie
Townsend, Bill
Trafton, Wilbur
Treantafeles, Paris
Trifeletti, Rebecca
Trip Software International
Tsang, Conray
Tse, April
Tseng, Conray
Tsuchiya, Maria
Tucker, Compton
Tucker, Jim
Turchin, Jonathan
Tuttle, Jeff
Ulrich, Kim
Unstad, Joe
Unstad, Joe
Valdez, Diane
Valencia, Amelio
van Zyl, Jakob
Vanasin, Vanessa
Vanasin, Vince
Vandevelde, Eric
Vane, Deb
Vaughan, Art
Vaughan, Ellen
Vaughn, Otha "Skeet"
Vignes, Vera
Vigue, Michelle
Vogt, Greg
Vrungos, Shelly
Vu, Dylan
Walker, Cathy
Walkup, Matt
Wall, Steve
Walters, Richard
Walton, Amy
Ward, Doug
Warner, Tony
Watanabe, Keith
Watson, Bob
Watson, Don
Watts, Jeff
Weaver, Warren
Weber, Jennifer
Weisoff, Jeff
Welch, Marge
Weld, Aaron
Wensnahan, Mark
Westek
Wetherbee, James
Whalen, Mark
Whang, Donald
Whetsell, Jamie
White, Cara
White, Colleen
White, David
White, Louise
White, Nicole
Whitley, Rob
Wick, Todd
Wieder, Sarah
Wild, Flint
Wilkening, Laurel
Wilkenson, Justin
Williams, Doug
Williams, Mandy
Williams, Valerie
Williams, William
Williamson, Fred
Wilson, John
Winters, Kelly
Winters, Michael
Wiskerchen, Michael
Wisoff, Jeff
Wite, Coleen
Witt, Ron
Witte, Adam
Wolf, David
Wolf, Julie
Woo, Calvin
Woodring, Jon
Wormington, Bart
Wustner, Sarah
Wyrick, Ron
Yang, Nelson
Yates, Jacob
Yberra, Lea
Yee, Clinton
Yee, Tony
Yepez, Gail
Yiu, Lisa
Yoon, Moon-Hang
You, Catherine
Yount, Tom
Yu, Howard
Yumul, Rich
Zafar, Nafees
Zegadlo, Joe
Zeluck, Stephanie
Zenauskas, Tom
Ziegler, Rod
Zimmermann, Reiner
Zurek, Richard
Zwnauskas, Tom
Zygielbaum, Art

# Appendix B: KidSat Partners

The three partners responsible for the implementation of KidSat were JPL, JHU, and UCSD. In addition, JSC played a key role in the implementation on the shuttle and NASA Headquarters participated in a variety of ways.

## Jet Propulsion Laboratory, California Institute of Technology

The Jet Propulsion Laboratory (JPL), a NASA center and a federally funded research and development center, is operated by the California Institute of Technology. JPL is a national leader in the robotic exploration of the solar system, and has major programs in astrophysics, space physics, and Mission to Planet Earth, including the shuttle imaging radars, Atmospheric Trace Molecule Spectroscopy (ATMOS), Atmospheric Infrared Sounder (AIRS), and MISR. JPL also has expertise in the acquisition, archiving and distribution of Earth and planetary data and information. The Planetary Data System and the EOS ocean DAAC both reside at JPL. JPL is a world leader in image processing and scientific visualization, contributing such products as "L.A., the Movie", the first virtual flight around an image.
JPL's role was to oversee KidSat activities and team members. The Laboratory defined, developed, and implemented the KidSat functional requirements and exploration plan. JPL also coordinated the reporting of information to KidSat sponsors and to external interfaces. The JPL Flight element had the lead role in the development and configuration of the KidSat flight instrument, including the software, the integration and pre-flight testing of the hardware and software, monitoring the instrument health during a flight, and assessing its performance after a flight. JPL was responsible for working with JSC to develop the shuttle interfaces, working with NASA Headquarters on the scheduling of the KidSat flights, and laying the groundwork for future International Space Station deployment. JPL led effort to develop and implement the Data System, which allowed the pilot program schools to explore images.

## Institute for Academic Advancement of Youth, The Johns Hopkins University

The Institute for Academic Advancement of Youth (IAAY) has a long and successful history in using science to excite and motivate students. Its Western Regional Office shares the IAAY's commitment to identify high-ability children from diverse backgrounds and to help them fully explore their talents through rigorous academic opportunities. The Office assists with the execution of core activities such as talent search, academic programs, development and alumni relations, research, community outreach efforts, external relations, and public policy.

The IAAY was responsible for the educational element of KidSat. It served as the primary interface with school systems, coordinated the development and evaluation of curriculum modules, and provided training and resources for teachers and administrators in the pilot program districts. The IAAY established and oversaw curriculum design teams and a curriculum design technology. In addition, the Institute worked with the design teams to develop, create, and integrate KidSat curricula modules into local school curricula in order to ensure full acceptance and integration of KidSat at each site. The IAAY conducted staff development and teacher training on-site and through summer teacher training institutes, and coordinated and monitored site visits for feedback, curriculum modification, data collection, and evaluation.

## California Space Institute, University of California, San Diego

The California Space Institute (CalSpace), part of the University of California, was established to promote space-related science and engineering research and education throughout California. Over the past several years, CalSpace has initiated a number of projects involving students and space researchers from universities, the industry, and NASA centers. The focus of these projects was the participation of students in the acquisition, analysis, and scientific interpretation of space-derived data. In close cooperation with the NASA sponsored California Space Grant Program, CalSpace has gained considerable experience in incorporating remotely sensed images and shuttle photographs of the Earth into educational curricula (EarthRISE Project).

UCSD was responsible for the design and implementation of the Mission Operations system that enabled students to plan a sequence of KidSat images and transmit that information to the instrument in space, using the KidSat Mission Control Gateway (MCG) at UCSD. The system consisted of personal computer-based SMOCs in the schools, with links to the MCG via the Internet. The MCG was linked to the Mission Control Center at JSC via a dedicated line. Specifically, the University:

- proposed and documented the mission requirements for the MCG and SMOCs for approval
- developed and executed an MCG and SMOC system design, development, and implementation plan including interface specifications to other mission elements
- developed and executed an MCG and SMOC integration and test plan,
- developed a training and procedures program for all MCG- and SMOC-associated personnel
- supported the KidSat mission SIMs, supported launch and flight operations during the KidSat missions, including replanning functions and all operations procedures
- supported post-mission analysis associated with the MCG and SMOCs.

## Appendix C: KidSat STS-76 Video Compilation

AVC-96-236, *KidSat Flyovers and STS-76 Mission Coverage (77:40)*, may be ordered from Brad Brock by:

- writing to DG Systems Inc., 10545 Burbank Blvd., North Hollywood, CA 91601,
- calling (818) 753-3010,
- or e-mailing bbrock@dgsystems.com.

**Contents:**

KidSat—Youth Enhancing Space
Introductory video used in curriculum.

Mission Update—STS-76
Mission status report presented on NTV during STS-76.

STS-76 Crew Flight Film
Film made by the STS-76 crew, documenting their mission.

KidSat—Charleston County School District
A look into the Buist SMOC during STS-76.

Spotlight on JPL
Dr. Ed Stone presents KidSat in a short video for JPL.

Flybys:
Owens Valley from shuttle photographs
Owens Valley from nadir
Columbia River from shuttle photographs
Saudi Arabia from STS-76 KidSat image
Aral Sea as captured in video and as a KidSat image on STS-76.