



### JOHN F. KENNEDY SPACE CENTER

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**January 2, 1990**

**KSC Contact: Bruce Buckingham**

**KSC Release No. 137-89**

#### **KSC CLOSSES OUT 1989 AND GEARS UP FOR THE COMING NEW DECADE**

"We begin the new decade with dedication to our mission and pride of our past accomplishment."

--- Center Director Forrest McCartney.

As America's space program steps boldly into a new decade, KSC's accomplishments in 1989 will be the cornerstone upon which the dreams and hopes of this country's space future will be built.

Spearheading the successes of the past year were the five Space Shuttle missions. The shuttle flights included two planetary missions, two Department of Defense dedicated launches, and a mission to deploy a Tracking and Data Relay Satellite.

In addition to the shuttle launches, KSC played a leading role in the successful launch of the Cosmic Background Explorer (COBE) by a Delta rocket from Vandenberg AFB, Ca., and the launch of a FLTSATCOM from Cape Canaveral Air Force Station on an Atlas/Centaur booster (AC-68).

At the beginning of the year, NASA had laid out an aggressive launch schedule for KSC. In order to continue the success of the previous year -- when the world witnessed the shuttle's successful return to space -- 1989 would have to provide an even more impressive show of resiliency.

#### **ECONOMIC IMPACT AND CONTRACT EXTENSIONS**

The Kennedy Space Center continued to be a major factor in the Central Florida economy. During the past year, KSC employed over 18,000 workers, both civil service and contractor. Contracts and employment generated a \$1.24 billion boost to Florida's economy, of which approximately \$750 million remained in Brevard County.

The major contractors at KSC continued to provide valuable services to the nation's space effort. Lockheed Space Operations, Co., the Shuttle Processing Contractor, had its contract extended for three years through September 1992. EG&G Florida, Inc., the Base Operations Contractor, had its existing contract extended for the eighth year, making it effective through the end of 1990. The Payload Ground Processing Contract, awarded to McDonnell Douglas Space Systems Co. in 1987, was extended for the first time, adding an additional three years to the existing contract. McDonnell Douglas will continue to provide ground

support, test and integration for payload operations at Kennedy Space Center through the end of 1992.

## **BUILDING, MODIFICATION, AND REFURBISHMENT PROJECTS**

Numerous building projects continued at KSC through 1989, the largest of them being the Operations Support Building which will be opened for occupancy four months ahead of schedule in early 1990. This 300,000-square-foot facility will provide office space for about 1,800 employees currently working out of temporary trailers and renovated boxcars.

On Cape Canaveral Air Force Station, construction began on a new spacecraft x-ray facility. The \$1.9 million contract --awarded to David Boland, Inc. of Titusville, Fla. -- will also cover the building's design for non-destructive x-ray testing of various spacecraft hardware, such as upper stage motors used to boost spacecraft into higher orbits.

On the human side, KSC identified a special need of its employees and worked vigorously to see the solution come to pass. Through the NASA/KSC Exchange Council, an agreement was reached in June 1989 with Tutor Time International, Inc. of Salt Lake City, Utah, for the design, construction, staffing and operation of a child day care center at KSC. In September, ground was broken for the 6,600 square foot facility to be located outside the security perimeter in the KSC Industrial Area. The establishment of a full-time child day care center at KSC was the result of an employee suggestion. It is expected to open in January 1990.

In the shuttle processing arena, the Orbiter Maintenance and Refurbishment Facility was targeted for modification and eventual upgrade to Orbiter Processing Facility status. In preparation for this improvement, work platforms, service structures and other equipment were shipped in from Vandenberg AFB, arriving at KSC on Nov. 10. By using the existing structures from the California facility, NASA is expected to realize a saving of about \$3.7 million.

The most challenging modifications were those made at launch pad 39-A which underwent 138 significant modifications at a cost of about \$50 million. Pad A was the launching point for the first 24 successful shuttle missions. The complex was temporarily deactivated following the Challenger mishap as mission managers chose to concentrate efforts to first modify Pad B for the resumption of flight. Some of the modifications to Pad A include:

- \* improvements to the environmental control system in the payload changeout room on the RSS;
- \* addition of a heater to the solid rocket joint umbilical;
- \* added safety features to the crew emergency egress system and the addition of two slidewire baskets;
- \* improvements to the slidewire bunker area;
- \* service umbilicals to support the orbiter Columbia's fifth cryogenic fuel cell.

In addition to the resumption of pad A's support for shuttle launches, KSC's third mobile launcher platform was declared ready to support the agency's aggressive 1990 schedule. Pad A will next be used for launch of the STS-32 mission in

January.

A key component in meeting the 1990 launch schedule is the ability to quickly replace orbiter tiles damaged late in the flow. KSC's Thermal Protection System Facility upgraded its capabilities this past year and began on-site production of high and low temperature reusable surface insulation tiles. In order to avoid having to fly replacement tiles in from production facilities in California, KSC now has the tools necessary to make its own tiles from scratch, thus saving the agency up to three days turn around time.

### **ORBITER MODIFICATIONS AND PROCESSING**

Flying on the orbiter Columbia in January 1990 will be the first tile produced at KSC. But with that tile, about 258 modifications new to Columbia since early 1986 will also be flown. Of those modifications, including the list of critical return-to-flight vehicle improvements, about 16 modifications are unique to the agency's oldest orbiter.

Return-to-flight modifications were conducted on Columbia throughout the past year. These included upgrades to the electrical system, cockpit computer keyboards, new on-board cryogenic fuel cells and new auxiliary power unit controllers. Also, in order to decrease brake wear, the orbiter's axles were stiffened on the landing gear and a dozen extra clamps were added to Columbia's hydraulic braking lines. Also, larger protective tiles were installed on the elevons leading edges and the trailing edges of the wings. Columbia's payload bay doors and fuselage, originally covered with over 2,300 small white diced tiles, were eventually recovered with thermal protective blankets. In addition, a reinforced carbon-carbon chin panel was installed to replace about 40 tiles between the nose cap and nose landing gear doors.

### **FIVE SUCCESSFUL LAUNCHES, FIVE SUCCESSFUL MISSIONS**

Five successful flights of the Space Shuttle highlighted the center's accomplishments in 1989. Each mission ended successfully at Edwards AFB, Ca., after five days in orbit (with the exception of STS-30's four day mission).

The following is a brief summary of each mission:

\* STS-29 -- The year's first mission began with the launch of Discovery on March 13 and the successful deployment of the third Tracking and Data Relay Spacecraft (TDRS-4). This spacecraft will allow near continuous communication links with earth and low-orbiting spacecraft.

\* STS-30 -- Less than two months later, Atlantis was launched on May 4. Atlantis deployed the nation's first planetary spacecraft, Magellan, in over 10 years. Magellan is now speeding on its way to map the surface of Earth's closet planetary neighbor, Venus.

\* STS-28 -- Columbia was launched on the year's first Department of Defense dedicated mission on Aug. 8. This marked the first flight of Columbia since Space Shuttle mission 61-C in January 1986.

\* STS-34 -- The second planetary mission of the year was sent on its way by the orbiter Atlantis. On Oct. 18, the Galileo spacecraft began its six-year journey to the planet Jupiter. As Galileo approaches the solar system's largest planet, a probe

will be released to parachute toward the Jovian surface sending valuable information back to earth until it is crushed by the enormous pressure of Jupiter atmosphere.

\* STS-33 -- The year's last shuttle mission was another DOD mission. The orbiter Discovery was launched on Nov. 22.

### **PAYLOADS PROCESSING AT KSC**

As the three orbiters were being processed and readied for flight, the payload world was also extremely active. Here, technicians spent hours upon hours testing and retesting components that will experience the extreme heat and cold of space. Of the payloads processed and launched at KSC during the past year, all are still performing perfectly. The TDRS communications spacecraft (launched on mission STS-29) is now in its proper orbit and functioning without error.

The planetary spacecraft, Magellan and Galileo, are also performing without problem and both are speeding toward their intended encounters with their respective planets, Venus and Jupiter. These very specialized scientific spacecraft were sent through extensive testing and scrutiny at KSC, first in the center's Spacecraft Assembly and Encapsulation Facility (SAEF-2) and then in the Vertical Processing Facility (VPF).

Magellan, launched aboard STS-30 and deployed for its journey to Venus, marked the resumption of the United States' reach to another planetary body since 1978. It kicks off a core program of solar system exploration involving NASA and organizations from the U.S. and the international community. The Magellan Venus Radar Mapper will yield the most detailed and comprehensive picture to date of the cloud covered planet. Mission objectives include learning more about the structure and geological history of the planet; its geophysics, such as density distribution; and its small-scale surface physics, such as temperature and roughness. By year's end, Magellan will be halfway to its rendezvous with our sister planet. Magellan is expected to reach Venus in August 1990.

Galileo was launched aboard the orbiter Atlantis on mission STS-34. Fueled by nearly 48 pounds of plutonium-238 for the generation of heat for electrical power, Galileo began its six year long journey to our Solar System's largest planet, Jupiter. Throughout the trip, Galileo will examine the celestial bodies it encounters including the asteroid Gaspra and the planet Venus when it performs a gravitational assist flyby.

As Galileo approaches Jupiter in 1995, a probe will be released to parachute into the dense Jovian atmosphere. The probe's instruments will measure atmospheric temperatures, light and radio frequency interference from lightning.

On the Galileo mother ship, cameras will capture details of the planet and her moons at a resolution many times greater than that seen during the Voyager spacecraft flybys in the 1970s. As Galileo prepares to enter orbit around Jupiter, it will pass within 22,000 miles of Europa and 620 miles of Io, two of the large Galilean moons.

The Deep Space Network (DSN) at the Jet Propulsion Laboratory, California, will monitor the progress of both Magellan and Galileo with the support of the huge 230-foot-diameter antennas at Goldstone, Ca., Spain and Australia. However, KSC is the home of a DSN station with a much lower profile. The terminal, referred to

as "MIL-71," is located at the MILA tracking station at KSC. Using the tracking antennas of MILA and linked to the other DSN stations through the NASA Communications Network (NASCOM), the MIL-71 station supported both the Magellan and the Galileo missions from the closure of the orbiter's payload bay doors, through spacecraft deployment, the upper stage burns, and finally spacecraft separation.

### **FUTURE PAYLOADS PROCESSING AT KSC**

Concurrently, several payloads slated for future missions also began their KSC processing in 1989. The SYNCOM-IV communications satellite built for the Navy by Hughes Aircraft, utilized the AstroTech facilities south of Titusville, Fla., for its initial checkout phase. It was later transferred to the Vertical Processing Facility's airlock in the KSC industrial area prior to being installed into the orbiter Columbia at Pad A. SYNCOM-IV is the fifth and final satellite in its class. Once on station in a geosynchronous orbit, it will be known as LEASAT-5.

Just prior to SYNCOM's move to the VPF's airlock, perhaps the most significant scientific payload slated for launch next year arrived at KSC's shuttle landing facility and was transported with great care to the VPF's clean room. The Hubble Space Telescope (HST), the world's largest and most sophisticated orbiting telescope, finally arrived at KSC after years of delay.

At the VPF, HST began a series of rigorous tests and validations. Under the protective covering of a translucent bag, HST passed a significant test when it was first powered-up at KSC and underwent a series of functional checks of its on-board science instruments on Oct. 28. Power was also applied to the telescope via satellite from the HST control facility at Lockheed in Sunnyvale, Ca. A return data stream confirmed to controllers that the power was on. Performance testing was also conducted on the five science instruments, the telescope's pointing control system, and the fine guidance sensors. Testing was completed Dec. 8.

On Dec. 20, the Wide-field Planetary Camera was installed on HST. This camera, which weighs 600 pounds, will be used to photograph individual planets in our solar system or hundreds of galaxies at once. HST, our window to the universe, will allow scientists a view of the universe 10 times greater than that now available on Earth. HST is slated for launch on Space Shuttle mission STS-31 in March 1990.

Also undergoing tests at KSC is the ASTRO-1 (STS-35) payload in the Operations and Checkout Building high bay. ASTRO-1 is a payload consisting of 4 optical instruments capable of performing independent or simultaneous observations of selected targets.

### **EXPENDABLE VEHICLES AND THEIR PAYLOADS**

At 4:56 a.m. on Sept. 25, teams from NASA and General Dynamics worked together to launch Atlas/Centaur (AC-68) from Cape Canaveral Air Force Station's Complex 36. This was NASA's last launch of the Atlas/Centaur vehicle carrying the FLTSATCOM-8 into earth orbit for use by the Navy. In the future, NASA will contract with either the Air Force or the vehicle manufacturer to procure expendable launch vehicles such as the Atlas/Centaur and related launch services. NASA will, however, retain oversight responsibilities for the vehicles which carry NASA payloads.

The two-stage, liquid-fueled Atlas/Centaur has a long history and was used to launch a variety of technological and scientific spacecraft, including Surveyors to the moon, Mariners to Venus, Mercury and Mars, and Pioneers to Jupiter and Saturn.

On its final mission for NASA, Atlas/Centaur sent the FLTSATCOM-8 spacecraft on its way to serve as part of a versatile, high-capacity worldwide military communications system operated by the United States. FLTSATCOM, one of a series of six satellites now operating in orbit, will be used to provide instant communications between the President of the United States and his commanding officers located in remote stations around the world. FLTSATCOM's orbit is geosynchronous and it is stationed at about 22,238 miles above the equator.

Last year also saw the last launch of a NASA owned and managed Delta rocket when, on Nov. 18, Delta 183 was launched from Vandenberg AFB, Ca. The launch was successful in its attempt to place into orbit the Cosmic Background Explorer (COBE), the 66th spacecraft in the Explorer series. KSC workers had been involved for over two years in preparing the west coast facility for COBE. Finally, following the processing of the first and second stages of the Delta at KSC's Hanger M, the electrical mating of the two components, and a test which simulated in-flight events, the sections were shipped to Vandenberg for launch.

Under KSC's supervision, much work went into preparing the Space Launch Complex 2-West for COBE and NASA's last Delta vehicle. Extensive refurbishment activities lasted over a year. Work included corrosion repair, sand-blasting and painting; replacement of deteriorated pad support equipment; recertification of pad cranes used to lift the launch vehicle and COBE spacecraft; repair of pad lighting systems and recertification of pressure vessels for helium and nitrogen used for the hydraulic and pneumatic systems.

The launch went perfectly and COBE is currently working on its assignment -- a one year to two year mission to gather information to possibly answer questions like: Was there a primeval explosion that started the universe expansion? What started the formation of galaxies? What caused galaxies to be arranged in giant clusters?

The Delta launch vehicle was originally designed and built for NASA as an improved version of the Air Force's Thor-Able. Delta first flew in 1960. There have been more NASA Delta launches than all other launch vehicles in its class combined.

### **SPINOFFS, CELSS, AND OTHER FUTURE PROJECTS**

As a result of the intense experimentation in the world of payloads and the increased awareness of continued safe manned flight, science has reaped marvelous benefits from various spinoff technologies.

But to simply reap the benefits is not enough. A way was needed to carry the word from NASA to the outside commercial community. As a result, KSC and the State of Florida signed a Memorandum of Understanding for the transfer of NASA technology. This agreement was formalized during a meeting by Center Director Forrest McCartney and Florida Governor Bob Martinez on July 18 at KSC. It provides for the continuation of the ongoing NASA Technology Utilization program to transfer NASA technology to Florida's governmental and industrial organizations in a timely manner.

Examples of possible benefits spun-off from NASA derived inventions and technology include: advanced breathing packs for fire fighters; running shoes that lessen stress on legs; heat pipe technology that assisted a candy maker; sun glasses that decrease the risk of late-life blindness by diminishing ultraviolet rays; home solar energy applications; insulation for both home and camping; and an aerial color infrared mapping system used for inventory of Florida citrus groves.

NASA technology developed during experimentation at KSC has also provided improvements to the health and life styles of the aging. During an in depth three day conference co-sponsored by NASA/KSC from Jan. 30 - Feb. 1 at Lake Buena Vista, Fla., several KSC technical managers presented a forum for discussing various issues ranging from communications to health care services for space colonization.

Later in the year, NASA/KSC announced the reaching of a preliminary understanding with the medical community by the creation of a new Space Medicine Institute. This agreement will enhance NASA's role in responding to research in health needs and create closer ties between the health and space communities. Sharing of knowledge and the ability to match health problems with existing technology is the primary goal of the partnership. The unique match will improve health care here on earth and in space.

Another agreement was reached between KSC/NASA and the Florida American Cancer Society. This agreement calls for the transfer of technology from the space program to the medical profession and industry to assist in solving problems associated with cancer prevention, detection and treatment.

Continuing studies in rocket triggered lightning research entered the seventh year in 1989. The NASA-sponsored program resumed from the pad on the shore of Mosquito Lagoon, 8 miles north of the Vehicle Assembly Building. A space age version of Ben Franklin's key-on-a-kite-string, the program entails launching three-foot-tall solid fueled rockets into thunderstorms while trailing a wire to the ground. The research program grew out of NASA's desire to improve lightning protection systems for KSC facilities and forecasting lightning potential during launches.

First in January then again in August, Kennedy Space Center scientists from the Controlled Ecological Life Support System (CELSS) project, harvested their second and third crops of dwarf wheat -- and it was grown without soil in a computer controlled biomass chamber.

The two-story, bubble-shaped sphere, located in Hanger L on Cape Canaveral Air Force Station, was once a test chamber for the Mercury and Gemini programs. Using the specially developed environment, strictly controlled by computers, KSC scientists and technicians learned how to deliver nutrients to seedlings and monitor the growth and gaseous outputs of dwarf wheat plants with minimum human intervention. Following successful wheat crops, the CELSS scientists began chamber research with soy beans.

Since future spacecraft will not have enough room to grow traditional plants in soil, the CELSS experimenters carefully analyzed the interaction of plants, nutrients, computer controls, lighting, nutrient delivery systems and even how humans affect the system by their mere presence. In the later case, the system was

designed to adjust for even the slightest increase in carbon dioxide in the air from technicians breathing.

Efforts by other KSC workers in 1989 should provide answers to other scientists who are questioning the circulation of air in zero-gravity. The Chromosomes and Plant Cell Division in Space experiment (CHROMEX) was designed to create an atmosphere exchange system that circulates cabin air around plants inside the CELSS chamber. This accomplishment will bring scientists a step closer in understanding how to grow plants in space.

Still ahead are needed answers to intriguing questions like: Can several types of plants be grown in one chamber or will space age farms require the separation of plants? Answers to this and other extremely important questions will need to be found before building lunar bases or sending men to Mars. KSC's Biomedical Operations and Research Office will be studying the multitude of possible solutions to this dilemma in the coming year.

### **APOLLO 11 20TH ANNIVERSARY**

But as NASA marched on into the future, triumphs of the past were remembered. July 16, 1989 marked the launch of the Apollo 11 20th Anniversary which landed the first humans on the moon and returned them safely to earth. In remembrance of this monumental occasion, KSC hosted the return of the original Apollo 11 crew. Neil Armstrong, Buzz Aldrin and Mike Collins were greeted by thousands of cheering KSC employees and open house guests as they recalled the experience of the century. The day-long celebration reminded all Americans of the incredible, unequalled feat of the Apollo program.

### **LOOKING AHEAD**

Now, as KSC looks to the future, the possibilities seem endless. Just around the corner is the Space Station, and further ahead a possible lunar base and human mission to Mars. When the time comes for these grand explorations, their beginnings may be from KSC.

KSC will undertake the challenge of the future one step at a time. Next year, NASA plans a record number of Space Shuttle missions. Over 55 astronauts are scheduled to begin their journey into space from KSC's Launch Complex 39 and a long list of important payloads and experiments will be serviced here. Astronomical sciences will be the focus of later missions. Hubble Space Telescope (STS-31) will bring into clear view by 10 fold a new look at our universe. Then two star-searching devices -- Astro-1 and the Broad Band X-Ray Telescope (STS-35) will be deployed. The Gamma Ray Observatory (STS-37) will study stellar and intergalactic phenomena through deep space. Two final DOD missions (STS-36, STS-38) are also scheduled for launch next year. Then, scientific research will focus on the Sun with the deployment of the Ulysses (STS-41) spacecraft. Spacelab Life Sciences-1 (STS-40) and the International Microgravity Laboratory (STS-42) will round out the year.

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# NASA News Release

ONLINE



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## JOHN F. KENNEDY SPACE CENTER

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November 7, 1990

2:00 P.M. EST

**KSC Contact: Lisa Malone**

### **Launch Advisory**

#### **LAUNCH ADVISORY FOR SHUTTLE MISSIONS STS-38 AND STS-35**

NASA managers today set Nov. 15, 1990 as the new target launch date for Shuttle mission STS-38, a dedicated Department of Defense mission. Launch of Atlantis and the STS-38 mission was delayed from its original target date of Nov. 9, 1990, due to payload problems.

Start of the 4-hour launch opportunity period remains the same at 6:30 p.m. EST. This will be the 7th flight of Space Shuttle Atlantis and the 37th Space Shuttle mission.

Preparations for the launch of Space Shuttle Columbia and the STS-35/Astro-1 mission continue on schedule at Pad 39-B. The flight readiness review (FRR) for STS-35 is currently scheduled for Nov. 26-27, 1990. Following analysis of performance data from STS-38 and the standard review of mission status at the FRR, a target date for the Astro-1 mission will be announced.

"Processing of Atlantis for the STS-38 mission is going well", said Space Shuttle Director Robert Crippen. "If the remaining scheduled work for STS-38 goes as planned and no unexpected obstacles arise, I'm confident that we will launch on Nov. 15th and that we'll be flying Columbia sometime in early December."

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### JOHN F. KENNEDY SPACE CENTER

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**September 12, 1990**

**KSC Contact: Lisa Malone**

#### **LAUNCH ADVISORY FOR SHUTTLE MISSIONS STS-35 AND STS-41**

NASA managers today set Tuesday, Sept. 18, 1990 as the launch date for Space Shuttle Columbia and the STS-35 Astro-1 mission. The decision on the new launch date follows the removal, replacement and testing of the liquid hydrogen recirculation pump package in Columbia's main propulsion system.

Launch of Columbia and the STS-35 mission was scrubbed on Sept. 5 when high concentrations of liquid hydrogen were detected in the aft compartment of the orbiter. Subsequent tests showed the leak came from the vicinity of the recirculation pump package.

During leak check operations following installation of the new recirculation pump package, technicians found a crushed seal on the prevalve of the main propulsion system. The seal is part of a detent cover. The prevalve is the main hydrogen valve which supplies hydrogen to Space Shuttle Main Engine Number 3. The detent holds the prevalve in place in the open position.

Helium leak checks indicated the seal was within specification, however, this particular detent cover had an order of magnitude greater leak than other detent covers. Alert technicians and engineers decided to investigate further and discovered the damaged seal.

Engineers believe the location of the seal and the nature of the damage to the seal make it a prime suspect as the cause of the hydrogen concentrations seen in the aft of Columbia during tanking operations.

The seal in question was replaced following Columbia's last flight, STS-32 in January 1990, when an inspection for possible corundum contamination of the main propulsion system was conducted. Engineers believe the seal was damaged during the post-inspection installation and remained undiscovered until yesterday.

Countdown for the launch of Columbia is scheduled to begin on Saturday, Sept. 15 at 1:00 a.m. EDT at the T minus 43 hour mark. The 1 hour, 39 minute launch window on Sept. 18 opens at 1:28 a.m. EDT and closes at 3:07 a.m.

Space Shuttle Discovery and the STS-41 mission will be launched as early in the launch window (Oct. 5- 23, 1990) as possible. Current scheduling indicates a likelihood of launching on Oct. 8 or 9, but a few days either side are possible, depending on actual test and preparation times needed. The actual launch date for Shuttle mission STS-41 will be set at the flight readiness review, currently scheduled for Sept. 24-25.

Discovery's freon cooling loop number 1, which has given indications of a small leak since leaving the Orbiter Processing Facility, has undergone special testing. After review of the test data, Shuttle managers have determined that this condition can be safely flown in its present state. Launch preparations will include topping off the freon system of Discovery a few days before launch which will keep the freon level well above the amount needed to support Shuttle operations during the 4-day mission.



# NASA News Release

ONLINE



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## JOHN F. KENNEDY SPACE CENTER

**November 20, 1990**

**KSC Contact: Lisa Malone**

**Mission Advisory:**

**STS-38 SPACE SHUTTLE LANDING**

Shuttle managers have decided to use Kennedy Space Center as the primary landing site for today's landing of Shuttle Mission STS-38. Landing is scheduled to take place at approximately 4:43 p.m. EST.

This will be the sixth landing at KSC for the Shuttle program and the first since return to flight.

Coverage of the landing will be carried on NASA Select television. Live commentary of the mission will begin at 3 p.m. EST. News media in the KSC area should plan to be at the Launch Complex 39 Press Site no later than 3 p.m. in order to be escorted to the Shuttle Landing Facility.

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# NASA News Release

ONLINE



## JOHN F. KENNEDY SPACE CENTER

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**September 25, 1990**

**KSC Contact: Lisa Malone**

### **Launch Advisory:**

#### **STS-41/ULYSSES LAUNCH DATE SELECTED**

NASA managers today selected Oct. 6, 1990, as the launch date for Space Shuttle mission STS-41 to deploy the European Space Agency's Ulysses probe on a 5-year journey to study the sun.

"This date is a little success oriented and is dependent on not encountering any unusual problems," said Space Shuttle Director Robert L. Crippen. "But I think the Shuttle team has a good chance of making the 6th."

The launch window for Oct. 6th extends from 7:35 a.m. to 10:05 a.m. EDT.

NASA received Office of Science and Technology Policy nuclear launch safety approval for the Ulysses mission on Monday, Sept. 24, 1990.

STS-41 will be the 36th Space Shuttle mission and the 11th of the orbiter Discovery. The mission is slated to last just over 4 days with a planned landing at Edwards Air Force Base, Calif.

The flight crew for STS-41 is Commander Richard N. Richards, Pilot Robert D. Cabana and Mission Specialists William M. Shepherd, Bruce E. Melnick and Thomas D. Akers.

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# NASA Facts

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## JOHN F. KENNEDY SPACE CENTER

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### LIGHTNING AND THE SPACE PROGRAM

KSC Release No. 72-90

June 1990

(Revised 1995)

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#### **Lightning Research by NASA, other Governmental Agencies**

Kennedy Space Center, due to the need to protect Space Shuttles and other launch vehicles, has performed extensive research into lightning strikes, their causes, and what can be done to prevent them from harming personnel and equipment. The Federal Aviation Agency (FAA), the U.S. Air Force, NASA's Langley Research Center and New Mexico Technological University have conducted aircraft-based lightning experiments at KSC as a part of the facility's Rocket Triggered Lightning Research Program, now concluded. Many other investigators from other governmental agencies, leading universities, utilities and international organizations have also conducted ground-based and airborne lightning experiments as a part of this program, which began in 1984. The French government was a major participant in the KSC lightning investigation program, since it pioneered this type of research along with the United States.

NASA Langley scientists have studied aircraft-triggered lightning by flying specially instrumented and weather-hardened aircraft right through thunderstorms in Virginia and Oklahoma. Much of what is known about this phenomenon was discovered through work with a F-106B fighter airplane. During eight years of research, this airplane was struck by lightning more than 700 times. It was found that nearly all these strikes were the result of its presence in an electrical field rather than being in the path of an already- formed bolt. Both the FAA and the Air Force have conducted similar experiments to determine how to better protect aircraft electronics.

#### **Lightning - Nature's most Violent Force**

At any given instant, there are more than 2,000 thunderstorms taking place throughout the world. All these storms combine to produce about 100 lightning flashes per second, each one with a strength of up to a billion volts and temperatures of more than 54,000 degrees Fahrenheit. At the height of a moderate-sized thunderstorm, it can generate several hundred megawatts of electrical power, or the output of a small nuclear power plant. With so much energy waiting to be released, it's little wonder that lightning has considerable potential to cause damage.

#### **Lightning on Other Planets**

These giant electric sparks are not unique to Earth. Among the mystifying and gargantuan storms that rage throughout Jupiter's atmosphere, cameras on NASA's Voyager I planetary explorer spacecraft found one familiar phenomenon -- lightning. This discovery was the first hard evidence that such violent electrical discharges take place on other planets. Detection of electrostatic discharges on Saturn and Uranus by Voyager 2, along with radio signals associated with lightning picked up by the Pioneer Venus orbiter, may indicate that lightning is commonplace on planets in our solar system with an atmosphere.

#### **Lightning Helps Maintain an Atmospheric Charge, Aids Plant Growth**

Although lightning on other planets may be too "far out" for some people, the fearsome flashes and explosions that accompany a midsummer night's thunderstorm here on Earth often seem a little too close to home for others. During a power blackout from a lightning strike, it's hard to remember that some good does come from the powerful bursts of electrical energy.

The global chain of thunderstorms serves as a worldwide circuit of recharging batteries. Through the activity of the lightning they produce, these batteries continually recharge and maintain the atmosphere's positive electric charge. Some researchers also think that the Earth's negative charge is maintained by electric fields in thunderstorm clouds.

When lightning bolts discharge, they ionize the air and produce nitrogen oxide. According to recent studies, this process could generate more than 50 percent of the usable nitrogen in the atmosphere and soil. Nitrogen is an essential plant fertilizer.

Lightning also plays a critical role in the natural cycle of forests by helping generate new growth. Areas that are burned by lightning-triggered fires are cleared of dead trees so that seedlings have the space and soil to take root.

### **Nature Takes Its Toll, Though**

With so many bolts of lightning, it's no wonder that people and structures get hit. Each year an average of 100 persons are killed and about 245 injured by nature's number one weather-related killer. Lightning-generated fires also destroy more than 30,000 buildings at a loss of hundreds of millions of dollars every year.

Airplanes and spacecraft are also vulnerable to the tremendous electrical forces that can build up in the atmosphere. According to the FAA, commercial aircraft are struck on the average of once every 3,000 flight hours, or about once a year. However, only one U.S. airliner has been confirmed as lost to lightning. Because of an airplane's metal construction, lightning flows along and away from its fuselage. Almost all lightning strikes on aircraft cause only superficial damage, and passengers are protected from injury.

On March 26, 1987, however, an Atlas/Centaur rocket and its satellite were lost when the unmanned NASA vehicle was struck by lightning. But it was an earlier strike, one that temporarily disabled the electrical systems on the Apollo 12 spacecraft onboard a Saturn V rocket on November 14, 1969, that prompted NASA to develop ways to protect its launch vehicles, and to create a better system to predict when and where lightning might strike.

### **Detection and Research are Keys to Reducing Lightning Damage**

NASA has completed the scientific investigation part of its program to protect KSC facilities and people against lightning strikes. The National Oceanic and Atmospheric Administration (NOAA), the FAA, various research and industry groups, and the governments of several foreign countries continue to investigate just how lightning develops, better ways to predict its occurrence, and means to reduce property damage when it does strike. To attempt to predict where the next strikes will occur, a National Lightning Detection Network has been established across the country. By the end of the century, satellites that can observe the whole planet will supplement the ground detectors of this system to increase its coverage of thunderstorm activity. Meteorologists can use this data to provide an alert to those people in potential strike areas. The more accurate the prediction of where and when lightning will occur, the better chance there is of lessening or eliminating the damage it causes.

### **Ground Equipment Needs the Most Protection**

Since lightning tends to strike the highest point in any given area, special care must be taken to protect tall structures from these high-voltage bolts. These structures are often power lines, microwave relay towers used in telephone communication, or buildings filled with sensitive electrical equipment. Without some sort of protection, a lightning strike could and sometimes does cause power line arcing, electrical fires and structural damage.

The U.S. Lightning Protection Code (NFPA-78) for structures calls for a pathway, or conductor, that will safely lead a lightning bolt's electrical energy to the ground. Additional protection is provided by circuit breakers, fuses and electrical surge arrestors. But sometimes even this equipment is not enough to prevent damage. New studies have

shown that lightning strikes so fast (within one-millionth of a second) and with such a high peak current (about 200,000 amperes) that conventional protection methods are unable to save complex electronic systems from damage. Utilities and high-technology industries, among others, are researching ways to find better means to protect vital electrical equipment.

### **Better Protection Begins with Better Knowledge of Lightning**

Although lightning has been known to be a discharge of electrical energy since Ben Franklin's kite-flying days, the way storm clouds build up an electrical charge is still not fully understood. Researchers at Kennedy Space Center and other facilities throughout the world have attempted to answer this and other questions so that improved means to detect these charges can be developed.

What is known is that a lightning bolt is the transfer of either a positive or negative electrical charge from one region of a cloud to another, or between the cloud and the ground. For such a transfer to take place, the two types of charges must be separate, or polarized, for the cloud to become electrified. But exactly how the charges separate themselves and what parts of the cloud they exist in are still not clear.

### **Is a Thundercloud Just Like a Battery?**

Two traditional and still current hypotheses concerning cloud electrification and polarization assume that thunderclouds are bipolar like a battery, with the positive charges accumulating on top and the negative charges forming at the bottom. These theories employ the mechanisms of either convection or precipitation. Other researchers not advocating either means feel that both of these processes are involved, since both are present in thunderstorm clouds.

### **Convection and the Formation of Thunderstorms**

Convection, or the rising of warm air currents, actually causes local thunderstorms to develop. This storm is the type that typically appears over Central Florida and KSC during a hot summer midafternoon. It begins with the rising of bubbles of warm, moist air. The higher the bubbles rise, the cooler the air they pass through gets and the lower the atmospheric pressure. These two conditions cause cooling and condensation of the bubbles' moisture, and the expansion of the bubbles to form white cumulus clouds.

These small clouds then merge into larger ones, which continue to grow and rise. At a certain height, the water droplets in the clouds become too large and heavy for the clouds' updraft of air to support them. That's when the droplets begin to fall as rain. At the same time, lighter, smaller droplets continue to rise until they reach a height where atmospheric temperatures cause them to freeze into ice particles.

The ice particles then fall back into the clouds, accumulating water droplets that freeze to them. When the particles reach air temperatures above freezing, they melt and join the raindrops. If they instead strike the colder air of a temperature inversion on the way down, they fall as hail.

### **The Precipitation Theory**

According to the precipitation theory, heavy raindrops, hailstones and ice particles called graupel in the thunderstorm are pulled down past smaller suspended water droplets and ice crystals. Collisions between the graupel and the stationary particles are thought to transfer positive charges to the suspended particles and a negative charge to the larger falling ones. The process of changing a particle's electric charge means that its atoms gain or lose electrons.

This model, one of many that attempts to explain the electrical structure of thunderclouds, shows a tripolar charge distribution while illustrating the updrafts of the convection process and the altitudes where various types of precipitation form. Current research indicates the structure to be much more complex, with large areas of positive and negative charged areas and a complex mix of smaller regions of both charges.

### **Thunderclouds Contain a Complex Mix of Positive and Negative Charges**

Current research indicates that there are large separate areas of positive and negative charges in a thunderstorm cloud, along with a complex mix of other, smaller charged areas of both types. It's thought that this mix develops because of the charge transfer between graupel particles and ice crystals, an activity originally part of the precipitation hypothesis, and action of wind currents within the cloud. Since many variations of this mix have been observed, research on the actual electrical make-up of a thundercloud continues to be conducted to develop a model cloud structure.

### **The Mechanics of a Lightning Strike**

Once a thundercloud's electrical charges have built up to the point where they exceed those in the surrounding atmospheric electric field, the gap between the cloud's positive and negative electric fields then can be jumped by the spark of a lightning bolt. Most lightning consists of intracloud or cloud-to-cloud discharges.

The destructive cloud-to-ground lightning bolt occurs much less frequently and can carry either a positive or a negative charge. Of the two, negative lightning is the most common type (about 90 percent) in a storm. The process involved in generating this type of lightning stroke explains why lightning always seeks out and strikes the highest point on the surface.

First, a negatively charged stepped leader from the cloud approaches the ground. During the approach, the leader's tip causes positive electric fields on the ground to increase in strength. Positive ions gather around pointed objects as small as pine needles and grass blades and then flow in streams towards the leader. When they get close enough, closure of the cloud-ground circuit takes place and the leader is neutralized. Now a much more powerful return stroke flows from the ground to the cloud through the grounded object selected as the focal point of the positive ion flow. That object, from tree to golfer with an upraised club, is considered "struck" by lightning. The whole process, from leader approach to discharge, takes place in less than a second.

The return stroke is the one visible to the human eye, with the brightness of more than 100 million light bulbs. Actually, this bolt may have traveled back and forth between the cloud and the ground more than a dozen times -- all in less than a second. The entire event is called a lightning flash.

Positive lightning carries a positive charge to the ground. It makes up less than 10 percent of a storm's lightning strikes and takes place at the end of the warm-weather storm or during one that accompanies a cold front. However, the positive lightning strike has the potential to cause more damage, since this type of bolt generates current levels up to twice as high and of longer duration than those produced by a negative bolt. It's the long-duration, or "continuing current" components of lightning that causes heating, burning and metal punctures. This phenomenon is known as "hot" lightning. For that reason, scientists are especially interested in developing ways to detect the areas of a thunderstorm that develops positive bolts.

### **Triggered Lightning - A Bolt from the Blue**

The phrase "a bolt from the blue" originated from observations of a seemingly inexplicable phenomenon -- a flash of lightning on a day without a stormcloud nearby. This event would be startling under any circumstances, but imagine the shock of seeing such a bolt strike the 363-foot high Apollo 12/Saturn V rocket while it was more than a mile above KSC. Perhaps being in an airliner while it was "zapped" by lightning at 20,000 feet would be more of a scare, though.

Why are rockets and airplanes struck while in flight? It was first thought that they just "got in the way" of a lightning bolt jumping from a positive to negative charged area of a thundercloud. Later research provided evidence that the build-up of strong electric fields at certain points of the aircraft were the culprit.

Such concentrated fields of electrical energy can develop before clouds actually form. When an aircraft or a rocket enters such a field, electrical charges are compressed and concentrate around the sharp edges and protuberances of the vehicle. If the electrical fields around the airplane's sharp and protruding parts build up to where there is an electrical breakdown of the air, lightning leaders form at two or more locations on the air- plane. The aircraft also contributes to the conducting path between a positive and negative electrical field, triggering the resultant lightning bolt.

In the case of Atlas/Centaur-67, a lightning strike caused the rocket's computer to upset and issue an extreme yaw command that led to the vehicle's breakup in flight. The area struck was where the greatest amount of electrical charge developed as the rocket flew through a highly charged atmospheric electrical field.

### **KSC's Rocket-Triggered Lightning Program**

The Rocket Triggered Lightning Program developed as part of research conducted at KSC to discover methods of improving lightning protection systems for Space Shuttle launch support facilities. Since KSC is located in the region with the second-highest number of lightning strikes in the country, the area was a logical choice for extensive research on this phenomenon.

In order to properly study lightning, it must be observed first-hand and monitored with instruments. Unfortunately, due to lightning's capricious nature, it is extremely difficult to predict just when and where a lightning strike will occur. Some method was needed to cause a lightning strike to take place where it could be studied, like an experiment created in a laboratory.

A modern-day method of triggering cloud-to-ground lightning involves the use of three-foot high sounding rockets attached to long copper wires. When a rocket is launched into a thunderstorm, lightning strikes it, vaporizes the trailing wire and follows its path to the ground. The strikes are measured and analyzed, along with the electric fields they come from, so that researchers can learn more about this insidious force.

### **The KSC Lightning Protection System**

KSC operates extensive lightning protection and detection systems in order to keep its employees, the 184-foot high Space Shuttle, the launch pads and processing facilities, from harm. While the protection system is exclusively on KSC property, the detection system incorporates equipment and personnel both at the space center and Cape Canaveral Air Station (CCAS), located just east of the Space Shuttle facility.

### **Predicting Lightning Before It Reaches KSC**

U.S. Air Force Weather Group -- The first line of defense for lightning detection is accurate prediction of when and where thunderstorms will occur. The Air Force Weather Group provides all weather information for the KSC/CCAS area. This information includes lightning advisories that are critical for day-to-day Shuttle processing, as well as launch day weather data essential in helping NASA determine when it is safe for the Space Shuttle to lift off. An Air Force staff meteorologist is permanently assigned to the NASA/ KSC test director's office. He is also in the Launch Control Center during Space Shuttle launch preparations and countdown.

KSC operations and Air Force weather personnel have worked closely for several years to develop the Cape Canaveral Forecast Facility (CCFF), a center for the forecasting and detection of thunderstorms and other adverse weather conditions. The CCFF houses the Meteorological Interactive Data Display System (MIDDS), which analyzes data from the National Meteorological Center, weather satellite imagery and local weather stations to assist in putting KSC area weather forecasts together. Two sources of local weather information are a weather radar that can identify and track storms occurring within a 150 mile range of Cape Canaveral and the Wind Information Display System (WINDS), a network of wind, temperature and moisture sensors. Wind measurements can reveal the updrafts and downdrafts that can lead to thunderstorm development.

**Lightning Detection Systems** -- The Launch Pad Lightning Warning System (LPLWS) and the LLP Lightning Surveillance System provide data directly to the CCFF on atmospheric electrical activity. These systems, along with weather radar, are the primary Air Force thunderstorm surveillance tools for evaluating weather conditions that lead to the issuance of lightning warnings.

The LPLWS is made up of 31 electric field mills uniformly distributed throughout KSC and Cape Canaveral. It serves as an early warning system for electrical charges building aloft or approaching as part of a storm system. These structures are ground-level electrical field strength monitors. Information from the LPLWS gives forecasters information on trends in electrical field potential and the locations of highly charged clouds associated with lightning.

The data is valuable in detecting early storm electrification and the threat of triggered lightning for launch vehicles.

The LLP detects, locates and characterizes negative cloud-to-ground lightning within approximately 60 miles of the CCFF. Electromagnetic radiation emitted from lightning is first detected by the system's three direction finder antennas located at Melbourne, Orlando, and in the northern area of KSC. Lightning positions are computed using triangulation from two of the sites, and relayed to a color display video screen in the CCFF. Once a lightning strike pattern evolves on a map, it becomes easier for the forecaster to predict just where the next lightning bolts will hit.

### **KSC's Lightning Policy**

When the Air Force weather staff reports the potential for lightning within five miles of designated KSC areas, a policy to enhance the safety of both the Space Shuttle and employees from lightning bolts or electrical shocks will go into effect. When the lightning policy is announced through a public address system at KSC, orbiter movement outside buildings is restricted, hazardous operations such as the loading of rocket fuel are not initiated, certain equipment is moved into covered facilities and work personnel are required to take shelter.

The Lightning Policy is defined by the KSC Lightning Safety Assessment Committee. This group is also responsible for seeing that all structures at KSC, as well as the Space Shuttle, are adequately protected. Structures that particularly need protection against lightning strikes are those that contain ignitable, explosive or flammable materials, and personnel.

### **Protection at the Pad**

Some of the facilities at KSC that incorporate extensive lightning shielding devices include the service structures at Launch Pads 39A and 39B, the Vehicle Assembly Building (VAB) and the hanger-like Orbiter Processing Facility.

An 80-foot fiberglass mast on top of the Fixed Service Structure at each pad is the most visible means of protecting the structure itself, the Shuttle while it is on the pad and the enclosed launch equipment. The mast supports a 1-inch stainless steel cable that runs over its top. This cable stretches 1,000 feet in two directions to where each end is anchored and grounded. Its appearance is similar to that of a suspension bridge tower and its supporting cables. A 4-foot-high lightning rod on top of the mast is connected to the cable. The rod's purpose is to prevent lightning current from passing directly through the Space Shuttle and the structures on the pad. Any strikes in this area would be conducted by the cable, called a Catenary Wire because of its shape, to the grounded anchor points.

Other grounding systems in the Launch Complex 39 area include a network of buried, interconnected metal rods called the counterpoise that run under the launch pads and surrounding support structures. All structures in the area are grounded, including the VAB.

Additional protection devices at the pads include a grounded overhead shield cable to protect the crew emergency egress slidewires attached to the Fixed Service Structure. Grounding points on the pad surface connect the pedestals that support the Mobile Launcher Platform (MLP) to the pad counterpoise. The MLP itself has electrical connections in its twin Tail Service Masts that make contact with the Space Shuttle. These connections complete the system that conducts any lightning-related electrical discharges safely away from the spaceplane.

Overhead gridwire systems protect hypergolic fuel storage areas at the pads. The huge 900,000-gallon liquid hydrogen and oxygen tanks also at each pad are constructed of metal and do not need overhead protection, since they provide their own grounds.

Away from the pad, the Shuttle is well protected from both inclement weather and lightning when it is in the VAB. This 525-foot-high structure, one of the largest in the world, has its own system of eleven 25-foot-high lightning conductor towers on its roof. When lightning hits the system, wires conduct the charge to the towers, which then direct the current down the VAB's sides and into its foundation pilings that are driven into bedrock.

After leaving the VAB on its way to the launch pad, there is a possibility that the Space Shuttle's external tank could be struck by lightning while on the crawlerway. In this unlikely event, however, shielding and electronic circuit

protection devices throughout the spaceplane are designed to keep its computers and other electrical equipment from serious damage.

The screen for the Meteorological Interactive Data Display System (MIDDS) in the Cape Canaveral Forecast Facility nearby KSC provides a synopsis of weather information from weather satellite imagery as well as local weather stations. The lighter areas on the screen show intense rain showers at 10,000 feet above the KSC area. The Air Force provides continuous weather data for NASA before and during Space Shuttle launches.

### **Launch Pad Detection Systems**

A lightning measuring system is located at the launch pads so that any electrical activity in the immediate area can be continually observed, recorded and assessed. Data gathered by its sensors and cameras is sent directly to the Launch Control Center so that NASA personnel can determine when it is safe to launch the spaceplane.

One of the monitors closest to the Shuttle is the Catenary Wire Lightning Instrumentation System (CWLIS). This system senses any lightning currents in the wire and evaluates them to see what potential they may have for causing damage to sensitive electrical equipment. The CWLIS current sensors are located at each end of the Catenary Wire and detect and record lightning flashes to provide potential damage assessment data for the CWLIS system.

Another launch pad monitoring system, the Lightning Induced Voltage Instrumentation System (LIVIS), detects and records any transient electrical charges that might exist in Space Shuttle electronic systems or on the vehicle's skin. This system is installed in the MLP and monitors conditions while the Shuttle is on the way to the launch pad via the crawlerway and at the pad itself. Two additional LIVIS sensors monitor the induced effects of any lightning activity in the Payload Changeout Room inside the Rotating Service Structure.

Data recorded by both the CWLIS and LIVIS systems are compiled and sent to the Launch Control Center through the computers of the Lightning and Transients Monitoring System (LATMOS).

Visual detection of lightning activity is also essential. A network of video cameras positioned to observe the Fixed Service Structure's lightning mast and the top of the Shuttle's External Tank are linked to television monitors in the Launch Control Center. Any lightning flashes can be seen on the screen and recorded for later analysis.

### **Does It all Work?**

The elaborate lightning detection and protection systems at KSC have proven their worth the hard way. The lightning masts at Launch Pads 39A and 39B have been struck at least five times with a Space Shuttle on the pad -- with no damage to any equipment. In 1983, lightning struck the launch pad with the Shuttle on the pad before three of the four launches. To this date, no NASA KSC employee has ever been injured by lightning -- due in part to the Lightning Protection Policy. Thanks to the extensive weather and electrical field detection systems, no Space Shuttle has ever been endangered during launch, although several launches have been delayed due to reported weather conditions.

To make sure that this track record continues, KSC plans to periodically check out the lightning protection systems of various structures with a recent high-tech acquisition - a lightning simulator. This device generates a high-voltage electromagnetic field. Its use will also help to verify the accuracy of the lightning detection systems at KSC and Cape Canaveral Air Station and to verify the adequacy of facility lightning protection.

### **The Future of Lightning Prediction, Detection and Research**

#### **KSC System Additions**

Improvements to the KSC area lightning prediction and detection system are to be made in the near future through a 5-year weather forecasting enhancement program. Some of the advanced equipment that will be added to the present system during this time include a clear air Doppler radar, an acoustical sounding system, and upgraded lightning locating systems.

## **Lightning Research from The Space Shuttle**

Thunderstorms around KSC have also been observed from the Space Shuttle while in space through photos the astronauts have taken and the cameras of the Mesoscale Lightning Experiment in the orbiter payload bay. These cameras take night photos of lightning near KSC and other sites throughout the country with lightning detection systems so that data from both sources could be compared. The goals of this experiment are to track thunderstorms, measure the amount of lightning produced from the tops of clouds and to study lightning in areas of intense activity and over water. The photos taken could help NASA researchers at Marshall Space Flight Center determine if an increase in lightning means an increase in storm size, if there is a link between the amount of rainfall and the frequency of lightning, and help provide a better understanding of the way lightning is generated. This experiment could also help in the development of lightning detecting sensors on satellites.

### **Development of Satellite-based Lightning Sensors**

Just such a lightning-sensitive device is now being developed through Marshall's Lightning Mapper Sensor program. This system's optical sensor will be a part of the Geostationary Operational Environmental Satellite-M to be launched before the year 2000. This sensor will allow research personnel to view lightning on a global basis.

At a geosynchronous altitude of 22,300 miles, a weather satellite can usefully monitor a third of the Earth's globe. All of the lightning in this area generated by storms six miles wide or more will be viewed at one time. One advantage of this wide viewing area, available only from space, is that scientists will be able to observe and track large storms for long distances, and study their life cycles. Another advantage is that weather forecasters will be able to provide immediate and accurate severe storm warnings over a large area of the planet.

### **Lightning Research Must Continue**

As society becomes more dependent on computers and other electronic devices, more effective ways must be developed to protect this equipment against high-voltage shock. Future aircraft constructed of non-conductive composite materials and that "fly by wire," or by computer command instead of manual hydraulic systems, will need advanced protection systems. As the global population expands, the increase of people and property calls for improved lightning prediction and detection through advanced weather equipment and methods.

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# NASA News Release

ONLINE



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## JOHN F. KENNEDY SPACE CENTER

September 24, 1990

KSC Contact: Karl Kristofferson

KSC Release No. 157-90

### TITUSVILLE FIRM AWARDED KSC CONTRACT

NOW Construction, Inc., Titusville, Fla., has been awarded a \$76,644 contract for the construction of maintenance and storage facilities at Kennedy Space Center.

Under the fixed price contract, the firm will have 135 days to complete a shed for storage of petroleum products, a mobile electrical generator maintenance area and a wash pad for the generators. The wash pad system will recycle the water used to clean the generators and store it for future use. All of the facilities will be located on Contractor Road, south of the Logistics Building in the Launch Complex 39 area.

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# NASA News Release

ONLINE



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## JOHN F. KENNEDY SPACE CENTER

September 24, 1990

KSC Contact: Karl Kristofferson

KSC Release No. 158-90

### TAMPA FIRM AWARDED KSC CONTRACT

Marsten/THG Leasing Co., Tampa, Fla., has been awarded a \$102,981 contract to provide a modular office building for the Life Sciences program at Kennedy Space Center.

Under the firm fixed price contract, the small business firm will have 30 days to deliver the 2,700- square-foot housing unit for installation near Hanger L at Cape Canaveral Air Force Station. Once in place, the structure will provide housing for experimenters from around the world who will have life sciences payloads flying aboard the Space Shuttle.

Hanger L is the headquarters for KSC's's Life Sciences Program. This program researches human physiology in space and advanced life support systems for long-range space missions.

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# NASA News Release

ONLINE



## JOHN F. KENNEDY SPACE CENTER

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**September 19, 1990**

**KSC Contact: Patricia Phillips**

**KSC Release No. 160-90**

### **Note to Editors and News Directors:**

#### **CELSS PROJECT HOLDS PRESS SHOWING FOR EXPANDED FACILITY**

The Controlled Ecological Life Support System (CELSS) project will hold a ribbon-cutting ceremony and press showing at 11 a.m. Tuesday, Sept. 25, to mark the inauguration of newly expanded facilities at Hangar L.

KSC Deputy Director Gene Thomas will use symbolic garden shears to cut the ribbon marking the facility expansion. Dr. Paul Buchanan, Director, KSC Biomedical Operations and Research Office, will provide a brief overview of the importance of the upgraded research areas.

The approximate \$800,000 expansion provides about 3,500 square feet of additional space and laboratories, including a Class 100,000 clean room area to support the biomass chamber. In the chamber, scientists are learning how to grow plants in nutrient solutions for future long-term space missions.

The media visit will also include a brief tour of the expanded areas, such as a new laboratory designed for research into waste recycling. One area of research will include the profitable use of non-edible plant waste such as stems and leaves.

Media wishing to attend the event should be at the Launch Complex 39 press site no later than 10 a.m. on Sept. 25. Transportation will leave the News Center at 10:15 a.m., with return scheduled for about noon. Media without credentials should contact the News Center at 407-867-2468 to obtain badging.

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**October 30, 1990**

**KSC Contact: Lisa Malone**

**KSC Release No. 177-90**

#### **ENDEAVOUR SPACE SHUTTLE MAIN ENGINE ARRIVES AT KSC**

One of the three main engines for NASA's newest shuttle orbiter, Endeavour, is scheduled to arrive at Kennedy Space Center today. This engine, like Endeavour, features many upgrades, and is the first piece of flight hardware to arrive at KSC for the fifth orbiter.

Engine number 2032 has passed all acceptance testing at Stennis Space Center, near Bay St. Louis, Miss., and is being shipped by truck to KSC. Upon arrival, the engine will be uncrated and inspected in the space shuttle main engine shop located in the Vehicle Assembly Building. The engine will be stored in the engine shop until Endeavour arrives in May of next year.

Some of the improved features on this engine are a new controller with a larger memory capacity and improved wire harnesses.

Press representatives need to be at the KSC Press Site by 1:30 p.m. tomorrow for a viewing of the engine. John Plowden, Rocketdyne Launch Site Director, will be available to answer questions.

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# NASA News Release

ONLINE



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## JOHN F. KENNEDY SPACE CENTER

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**November 16, 1990**

**KSC Contact: Patricia Phillips**

**KSC Release No. 185-90**

### **Note to Editors and News Directors:**

#### **KENNEDY PARKWAY GROUNDBREAKING NOV. 21 MARKS FUTURE TRAFFIC RELIEF**

A traffic bottleneck for both KSC workers and Spaceport USA visitors will be eased next summer when an approximate 2.7-mile long portion of Kennedy Parkway South on Kennedy Space Center is upgraded from a two-lane road to a four-lane highway.

The work on Kennedy Parkway will link up with the Brevard County portion of State Road 3, which is also being widened. The KSC portions of the road improvements are being done by Goodson Paving of Sharpes, FL. The local firm recently was awarded the approximate \$1.3 million contract and has 250 calendar days to complete the work.

KSC Center Director Forrest S. McCartney will lead the 11 a.m. groundbreaking ceremonies on Wednesday. Also participating will be James D. Phillips, KSC's director of Engineering Development, and Tom Goodson, President, Goodson Paving.

News media who wish to cover the event should be at the Launch Complex 39 Press Site no later than 10:00 a.m. for a 10:15 departure via NASA transportation. Media without credentials should contact the Press Site at 407-867-2468 by 4 p.m. Nov. 20 to arrange badging.

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### JOHN F. KENNEDY SPACE CENTER

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**December 28, 1990**

**KSC Release No. 205-90**

#### **KSC ROUNDS OUT 1990 WITH SUCCESS AND PREPARES FOR 1991**

In the world of Space Shuttles and payloads at Kennedy Space Center, 1990 proved to be a year of numerable successes and challenges. Six Shuttles were launched from and returned to KSC, including one unplanned end-of-mission KSC landing. But challenges ranging from liquid hydrogen leaks on Columbia (STS- 35) and Atlantis (STS-38) to a record number of launch delays on mission STS-36 kept engineers and managers on the edge of their seats.

KSC began the year with a mission to retrieve the Long Duration Exposure Facility (LDEF) and concluded with the ASTRO-1 observatory mission. Between these missions were the long anticipated launch of the Hubble Space Telescope, the deployment of the Ulysses spacecraft to study the polar regions of the Sun, and two Department of Defense dedicated missions. Of the six Shuttle's launched from KSC in 1990, three were nighttime launches.

All missions were scheduled to land at Edwards Air Force Base, Calif. All but one did. Atlantis, returning from its DOD mission in November, made an unscheduled but perfect landing at KSC's Shuttle Landing Facility. This was the first KSC end-of-mission landing in over five years and it demonstrated the ability of the KSC landing crews to prepare for a dramatic touchdown with little notice.

Challenging the launch team and hundreds of support personnel this summer were elusive liquid hydrogen leaks on orbiters Columbia and Atlantis. After four special tanking tests and a rollback to the Vehicle Assembly Building for destack, Atlantis was finally cleared for launch on mission STS-38.

Columbia, prior to mission STS-35, underwent four launch scrubs, two rollbacks to the VAB, and two special tanking tests. Special "leak-buster" teams ultimately were formed utilizing over 700 NASA and contractor employees, all with a "can-do" attitude, to outfit Columbia's aft compartment with hazardous gas detectors and cameras for the special tanking tests. It took most of the summer, by their hard work paid off when all of the leaks were eventually pinpointed and repaired.

#### **1990 SPACE SHUTTLE MISSIONS:**

The following is a brief summary of the 1990 shuttle missions (all times are Eastern):

STS-32 -- Columbia was launched at 7:35 a.m. on Jan. 9. It landed at Edwards Air Force Base, Calif., at 4:35 a.m. on Jan. 20.

MISSION: The primary mission objectives were the deployment of the SYNCOM IV-F5 Navy synchronous communications satellite and the retrieval of NASA's Long Duration Exposure Facility (LDEF). SYNCOM was successfully deployed on the second day of the mission. Orbiter rendezvous with LDEF occurred on Jan. 12, followed by the dramatic grapple by the Remote Manipulator System and berthing in the payload bay for return to Earth. LDEF was later returned to KSC where the 57 experiment trays housed on the satellite were removed for inspection.

LDEF had been stranded in space for over five years and was in imminent danger of burning up in the Earth's atmosphere if not recovered soon. Its retrieval had been placed on hold following the Challenger mishap.

STS-36 -- Atlantis was launched at 2:50 a.m. on Feb. 28. It landed at EAFB at 1:09 p.m. on March 4.

MISSION: This was the sixth mission totally dedicated to the Department of Defense. Originally scheduled for launch on Feb. 22, Atlantis experienced six launch delays due to adverse weather and illness of the crew commander.

STS-31 -- Discovery was launched at 8:33 a.m. on April 24. It landed at EAFB at 9:49 a.m. on April 29.

MISSION: The mission was devoted to the successful deployment of the Hubble Space Telescope approximately 24 hours after launch. HST is the first of the four great observatories which will aid in astronomical explorations. HST is the largest telescope ever put into space. It will study the universe in both visible and ultraviolet light.

The primary mirror on the Hubble Space Telescope is 94.5 inches in diameter. It is capable of detecting objects 12 to 14 billion light years distant and with at least 10 times the clarity of ground based telescopes. Producing images at a rate of about 20 a day and more than 7,000 a year, over 100,000 pictures are expected to be taken over the telescope's 15 year life span.

HST, however, is not without its problems. Shortly after deployment and initial check out, it was discovered the primary mirror had been made with a flaw, a spherical aberration. A future Shuttle mission, planned for July 1993, is scheduled to rendezvous with HST to correct the error.

HST consists of five primary instruments: A high resolution spectrograph, the wide field/planetary camera, the faint object spectrograph, the high speed photometer, and the faint object camera developed by the European Space Agency (ESA).

For mission STS-31, a significant modification was made to Discovery's braking system -- the installation of newly designed carbon brakes on the main landing gear. These carbon brakes are able to withstand longer distance braking and higher braking temperatures of up to 2100 degrees F. The normal temperature operating range is 1200 degrees F. for the older beryllium brakes. The carbon brakes can be used for 20 or more landings before replacement is needed, saving time for orbiter turnaround processing. This a key step in making landings at Kennedy Space Center a regular occurrence. Plans are underway for the installation of carbon brakes on the remaining orbiters.

STS-41 -- Discovery was launched at 7:47 a.m. on Oct. 6. It landed at EAFB at 9:58 a.m. on Oct. 10.

MISSION: The Ulysses spacecraft was deployed successfully from Discovery about six hours after launch, embarking on a five-year mission to explore the uncharted regions of the Sun's north and south poles. The ESA-built explorer was boosted out of Earth orbit using the attached IUS and PAM-S upper stages. Its initial trajectory will take it out to the planet Jupiter for a gravitational assist necessary to sling the 809-pound spacecraft into its solar polar orbit. The Jupiter encounter is scheduled for February 1992, south solar pole pass in June 1994, north solar pole pass in June 1995, and end-of-mission in September 1995.

Ulysses is the third interplanetary probe launched by the Shuttle. The project is a cooperative endeavor between NASA and the European Space Agency. Ulysses was designed and built by the Federal Republic of Germany.

STS-38 -- Atlantis was launched at 6:48 p.m. on Nov. 15. It landed at Kennedy Space Center at 4:43 p.m. on Nov. 20.

MISSION: This was the seventh and final classified mission totally dedicated to the Department of Defense.

Atlantis was originally scheduled for launch in July 1990. However, a precautionary liquid hydrogen tanking test conducted at the pad on June 29 indicated a hydrogen fuel leak on the external tank side of the orbiter/ET 17-inch quick disconnect umbilical. Two subsequent liquid hydrogen tanking tests determined the leak could not be fixed at the pad and the vehicle was returned to the VAB on Aug. 9 for destack operations. Atlantis was returned to the Orbiter Processing Facility and new seals were placed in the 17-inch liquid hydrogen disconnect umbilical. Meanwhile, a new external tank was attached to the solid rocket boosters in the VAB. The Shuttle was returned to the pad and a fourth tanking test was performed on Oct. 24. This test proved the fix had stopped any significant leakage of liquid hydrogen and the vehicle was cleared for flight.

STS-35 -- Columbia was launched at 1:49 a.m. on Dec. 2. It landed at EAFB at 12:54 a.m. on Dec. 11.

MISSION: The payload aboard Columbia, ASTRO-1, consisted of four unique, yet complementary, telescopes that captured the universe in the ultraviolet and x-ray spectrums. Three telescopes were dedicated to study the ultraviolet: the Hopkins Ultraviolet Telescope, the Wisconsin Ultraviolet Photo-Polarimeter Experiment, and the Ultraviolet Imaging Telescope. The Broad Band X-Ray Telescope (BBXRT) was made for viewing in the x-ray wavelength. The seven member crew divided into two shifts and were able to operate the telescopes around the clock. The mission was not without problems, however, when both instrument pointing system data display units failed and pointing of the ultraviolet telescopes had to be controlled from the ground. BBXRT was unaffected and the quality of the ASTRO images continued to be good.

This was the first Shuttle mission to be controlled by three NASA installations. Columbia was directed as usual from Mission Control at Johnson Space Center, Houston, Tx. But the three ultraviolet telescopes in the observatory were directed from the Payload Operations Control Center at Marshall Space Flight Center, Huntsville, Al. The Broad Band X-Ray Telescope and its separate pointing system were operated by a special team at Goddard Space Flight Center, Greenbelt, Md.

STS-35 was scheduled for a May 30 liftoff, but launch was scrubbed when high

concentrations of liquid hydrogen were detected during propellant loading near the 17-inch umbilical line connecting the orbiter and the external tank and in the orbiter's aft compartment. After rollback to the Vehicle Assembly Building and destack, the 17-inch liquid hydrogen umbilical was replaced with the umbilical from the Shuttle Endeavour (currently under construction in California). Columbia was then returned to the pad and prepared for another launch attempt in late August. Due to a problem with the BBXRT payload, launch was delayed for six days. During the tanking for launch attempts on Sept. 6 and Sept. 18, the liquid hydrogen leak again manifested itself in the orbiter's aft compartment. A fix at the pad was attempted and the subsequent tanking test on October 30 proved the repairs were effective.

Columbia awaited the launch of Atlantis on mission STS-38 from the adjacent pad and was then launched 17 days later.

### **1990 NASA SUPPORTED EXPENDABLE VEHICLE MISSIONS**

In addition to shuttle launches, NASA/KSC supported the launch of ROSAT on a Delta expendable vehicle and the Combined Release and Radiation Effects Satellite (CRRES) on an Atlas Centaur.

The following is a brief summary of these missions.

ROSAT: Roentgen Satellite (ROSAT) Project is a cooperative program involving NASA, the Federal Republic of Germany, and the United Kingdom. The primary objectives of the ROSAT project are to make a detailed all-sky survey of X-ray sources, and perform detailed follow-up studies of some 1,000 of the anticipated 50,000 - 100,000 sources that will be detected in the survey.

ROSAT was launched aboard an Air Force Delta II expendable launch vehicle from Cape Canaveral Air Force Station Complex 17 at 5:48 p.m. June 1, 1990.

CRRES: The Combined Release and Radiation Effects Satellite (CRRES) is a joint NASA/U.S. Air Force mission to study the effects of chemical releases on the Earth's ionosphere and magnetosphere and to monitor the effects of space radiation environment on sophisticated electronics. The CRRES satellite will use chemicals released to briefly trace invisible magnetic field lines and waves with luminous particles.

CRRES was launched aboard a General Dynamics commercial Atlas/Centaur (AC-69) expendable vehicle from Cape Canaveral Air Force Station Complex 36 at 3:21 p.m. July 25, 1990.

### **ECONOMIC IMPACT**

Again, KSC played a leading role in bolstering the local economy. Space-related employment and contracts at KSC generated a \$1.37 billion boost to the Florida economy during fiscal year 1990. This represents an increase of about \$132 million over the previous year.

Employment numbers at KSC also rose. Permanent federal employees now number over 2,600. On-site contractors nudged the 12,700 mark while 3,250 individuals were employed through construction and tenant jobs. All in all, the total number of workers employed at KSC at the end of FY90 totaled approximately 18,500.

## NEW FACILITIES AND MODIFICATIONS

A giant step was made this year in moving several thousand KSC employees from made-over box cars, trailers and prefabricated modules to a well equipped office building. In March, the 300,000-square-foot Operation Support Building (OSB) was officially dedicated and opened to over 1700 employees. The new OSB was built by W&J Construction Corp. of Cocoa, Fla. at a cost of about \$28,000,000.

Contained in the six-story facility, along with much needed office space, are a technical documentation center, photo analysis facility, technical libraries, multi-purpose conference rooms, a barber shop, concession areas, and a fully equipped exercise facility.

\* \* \* \*

Understanding a growing need many employees have at KSC, the NASA/KSC Exchange Council reached an agreement with Tutor Time International, Inc. for the design, construction, staffing and operation of an employee child care center. The idea resulted from an employee's suggestion and work by several organizations and employees through a specialized committee set up to plan a facility.

Tutor Time was selected to operate the facility and construction was completed this December. The single-story, 6,600-square-foot building will initially provide care for up to 140 children ranging in age from infants through preschoolers. The child care will be open for operation Jan. 2, 1991.

\* \* \* \*

Funds amounting to \$3.2 million were also allocated to complete the four-lane widening of Kennedy Parkway South (State Road 3), one of KSC's busiest highways. Final Congressional approval was received, paving the way for long awaited relief of severe traffic congestion during rush hour. The ground breaking occurred in November and construction is scheduled for completion by mid-1991. This, coupled with Brevard County's commitment to widen its portion of the much traveled Route 3, will help insure KSC employees of a safer and quicker drive to and from work.

\* \* \* \*

In February, a dedication ceremony for NASA's new Spacecraft Solid Rocket Motor High Energy X-Ray Facility was held. This new facility, located on Cape Canaveral Air Force Station, will be used for a variety of high energy radiography testing, including the capability to verify propellant integrity on spacecraft solid rocket motors.

The facility, which consists of a high bay exposure cell with a reinforced concrete wall 6 feet, 7 inches thick, represents a significant upgrade in KSC's abilities to meet current and projected new payload requirements. It was constructed at a cost of \$2.9 million.

\* \* \* \*

At Kennedy Space Center's Spaceport USA, another ground breaking took place. NASA and the Astronauts Memorial Foundation (AMF) began the construction of

the monument titled, "Space Mirror," dedicated to the fallen astronauts who have lost their lives in training and in space. In addition, an educational facility for teachers and students will be constructed as a "living memorial" to provide quality information and materials of instruction in the field of aeronautics and space in support of America's space program.

The projects will be funded in part by AMF's portion (50 percent) of the proceeds from the sale of Challenger license tags. Additional funding will come from private and corporate donations. The educational facility will be located adjacent to the astronaut's memorial, scheduled for completion early next year.

\* \* \* \*

As a result of the series of liquid hydrogen leaks on the orbiters this summer, an external tank/orbiter umbilical hydrogen dispersion system was designed for installation on the three mobile launcher platforms. The dispersion system is designed to provide a nitrogen rich air flow around the hydrogen 17-inch disconnect line between the orbiter and external tank. The system will reduce hazardous concentrations of hydrogen should they form during tanking operations and not be dispersed through normal ambient conditions. Firing room personnel will be able to control the dispersion system from the Launch Control Center.

### **SCIENCE AND TECHNOLOGY**

Technology transfer has always been important to managers at KSC. NASA invests a great deal of time and resources toward the goals of exploring the universe and finding better ways to live and operate in the hostile environment of space. But unless this technology is transferred to the everyday activities of life on earth, the vast majority of the world's population will never experience the practical applications of space technology.

One example of this spin-off technology returned to KSC this year. While designing an upgrade to the Space Station Logistics and Resupply section of the Payload Support Building, engineers concluded that space derived heat pipes would be applicable to assist in lowering energy costs associated with cooling the facility.

Heat pipes were initially used as an efficient cooling method for satellites in space. Later they were adapted to assist in the air conditioning and dehumidification of earth-bound buildings. Now, heat pipes will be used at KSC, and with a substantial amount of energy savings.

\* \* \* \*

Kennedy Space Center also continues to be a leader in the fields of plant and medical research.

The Controlled Ecological Life Support System (CELSS) has distinguished KSC as a front runner in searching for ways to grow plants in the microgravity environment of space. Earlier this year, the Hanger 'L' Life Sciences Facility was expanded by 3,500-square feet. This additional room will allow the Biomedical Operations and Research Office to upgrade research capabilities.

An example will be the continued ability to "farm" proven forms of space harvests such as lettuce and soybeans. It will also provide additional capabilities for

studying the closed aquaculture system -- including a "fish pond" -- for use in future long term space habitation.

\* \* \* \*

NASA/KSC and the American Cancer Society continued a cooperative cost sharing agreement to provide funding and technology transfer to the University of South Florida, Tampa, Fla., for research in cancer prevention, detection and treatment.

Under a Memorandum of Understanding, NASA/KSC activities include: make available necessary laboratories and equipment; coordinate assistance from other NASA centers and outside organizations; provide technical evaluations; and provide qualified personnel to serve as project leaders.

### **MILESTONES REACHED**

In April, during the rollout of the Space Shuttle Columbia from the Vehicle Assembly Building to pad 39-A for the launch of mission STS-35, Kennedy Space Center's Crawler Transporter number 2 passed the 1,000-mile landmark. Weighing in at over 3,000 tons, it took the tracked vehicle 25 years to roll the odometer at a pace of less than two miles per hour. Over the past quarter century, the giant transporter has been operated by 10 different drivers and has supported Apollo, Skylab, and Space Shuttle missions. The crawler transporter provided continuous service to the nation's space effort in the four decades from the 1960s into the 1990s.

The crawler transporter was the dark horse in the competition of concepts to provide a means to deliver the launch vehicle from the assembly building to the pad. But in 1962, following a full year of study, the cross-land tracked vehicle was voted the most feasible. As the largest land vehicle ever built, the six-million-pound, 131-foot-long, 114-foot-wide, and 20-to-26 foot adjustable height transporter has proven itself as an invaluable asset to the space program.

\* \* \* \*

Also celebrating a historic milestone were the American and Soviet crew members of the Apollo-Soyuz Test Project. Their reunion at KSC on July 26 marked the 15th anniversary of their 1975 flight. The ASTP mission was history's first international joint manned space flight. The link-up of the Apollo and Soyuz spacecraft occurred on July 17-19, 1975.

### **WHAT'S AHEAD**

As KSC ponders the future, 1991 seems to hold an abundance of opportunity for the nation's space program. Two primary payloads have already been delivered to the launch facility for processing for missions next year. They are the four unclassified DOD payloads for mission STS-39 and the Gamma Ray Observatory, slated for mission STS-37.

Next year NASA has scheduled seven Space Shuttle missions to be launched from Kennedy Space Center and one expendable vehicle launch from Cape Canaveral Air Force Station. The current manifest calls for an Air Force Delta 2 to launch NASA's Extreme Ultraviolet Explorer (EUVE) in early fall. This spacecraft will identify, map, and catalog extreme ultraviolet sources in the universe.

The seven Shuttle missions scheduled for 1991 are (in launch order):

STS-39 -- Discovery on a DOD unclassified mission. Payload: Air Force Program-675 (AFP-675), designed to collect infrared data to support the Strategic Defense Initiative program; Infrared Background Signature Survey (IBSS), designed to obtain infrared measurements on rocket plumes, shortwave infrared Earth-limb, Shuttle environment, and chemicals released from the payload bay while detached in proximity to the Orbiter; Space Test Program (STP-01), the first in a series of secondary experiments; Multi- Purpose Experiment Canister (MPEC), an extended Hitchhiker-G, GAS canister capable of deploying an internally stowed payload.

STS-37 -- Atlantis will deploy the Gamma Ray Observatory (GRO), the second in a series of four great observatories. GRO will explore the most energetic part of the spectrum across a much greater wavelength range than earlier observatories.

The GRO will enable us to determine if most of the known gamma radiation arriving from the universe originates from quasars and pulsars, or whether there are other sources of gamma ray emissions. The focus of GRO will be to investigate gamma ray sources emitted by stars and distant galaxies.

STS-40 -- Columbia will carry the Space Life Sciences Laboratory (SLS-1) to investigate the effects of weightlessness on man and animal specimens. (This will be Columbia's last mission prior to being ferried to California for extensive modifications. Modification operations are expected to last about a year.)

STS-43 -- Discovery will carry into orbit a NASA Tracking and Data Relay Satellite (TDRS-E). This satellite will replace the partially functional TDRS west satellite currently in orbit.

STS-44 -- Atlantis will deploy a Defense Support Program (DSP) satellite. Atlantis will also carry additional Department of Defense payloads on board.

STS-48 -- Discovery will deploy the Upper Atmosphere Research Satellite (UARS) to improve man's knowledge of the atmosphere above the troposphere. This satellite will study chemical processes acting within and upon earth's stratosphere, mesosphere, and lower thermosphere.

STS-42 -- Atlantis will carry into orbit the first International Microgravity Laboratory (IML-01). Housed in a Spacelab long module, this mission will be devoted to material and life sciences studies.

\* \* \* \*

Also, NASA's newest shuttle orbiter, Endeavour, is scheduled to be delivered to Kennedy Space Center early next summer.

Endeavour will arrive at KSC atop NASA's newest modified 747 Shuttle Carrier Aircraft. Endeavour's first flight will be in May 1992 on Space Shuttle mission STS-49, a mission to retrieve, repair and redeploy a communications satellite for the International Telecommunications Satellite organization (INTELSAT). STS-49 will also feature the first extravehicular activity by man since return-to-flight in 1988.

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