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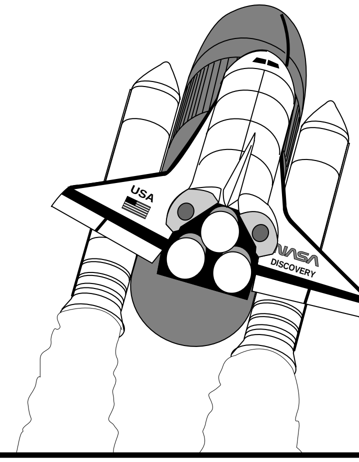


Voyage of Endeavour - *Then & Now*

Video Resource Guide

VRG-006-9/92

Topic: History, Social Studies, Technology
Video Length: 19:05
Description: Comparison of the vessels and voyages of the sea-going *Endeavour* and the Space Shuttle *Endeavour*.

Shuttle Mission Facts
Orbital scenes were taken during the STS-49 mission.
Orbiter: *Endeavour*
Mission Dates: May 7-16, 1992
Commander: Daniel C. Brandenstein, Capt., USN
Pilot: Kevin P. Chilton, Lt. Col., USAF
Mission Specialist: Richard J. Hieb
Mission Specialist: Bruce E. Melnick, Cmdr., USCG
Mission Specialist: Pierre J. Thuot, Cmdr., USN
Mission Specialist: Kathryn C. Thornton, Ph.D.
Mission Specialist: Thomas D. Akers, Lt. Col., USAF
Mission Duration: 8 days, 21 hours, 17 minutes
Kilometers Traveled: 5,950,590
Orbit Inclination: 28.35 degrees
Orbits of Earth: 141
Orbital Altitude: 366 km
Payload Weight Up: 14,648 kg
Orbiter Landing Weight: 82,885 kg
Landed: Concrete runway 22, Edwards Air Force Base
Payloads and Experiments:
INTELSAT VI F3 reboost
Assembly of Space Station by EVA Methods
Commercial Protein Crystal Growth
Medical Experiments
Earth Observations

Background

The Space Shuttle *Endeavour*'s First Flight

The maiden flight of NASA's newest Space Shuttle, *Endeavour*, captured the excitement, spirit, and flexibility of manned space flight. The seven crew-members experienced a roller coaster of emotions throughout their 9-day flight while trying to capture the stranded *INTELSAT VI* satellite and perform an Extravehicular Activity (EVA) to evaluate Space Station *Freedom* construction techniques.

In March 1990, the *INTELSAT VI F-3* communications satellite was carried to space by a commercial Titan launch vehicle. A problem with the upper stage vehicle stranded the satellite in a 560-kilometer-high orbit instead of deploying it in its planned geostationary orbit of 36,000 kilometers above Earth. Since its failed launch, the 4,064 kilogram communications satellite had been orbit-ing Earth in an orbit unusable for communications.

One of the primary objectives of the STS-49 mission was to capture *INTELSAT* and fit it with a new rocket motor. Once attached, the new motor would propel the satellite to its proper orbit where it would begin service by providing a relay link for the equivalent of 120,000 two-way simultaneous tele-phone calls and three television channels. The capture would be an even greater challenge since *INTELSAT* was not designed to be retrieved by the Space Shuttle.

After the trouble-free launch of *Endeavour*, flight controllers in Washington, D.C. commanded the *INTELSAT* satellite to fire its thrusters for the first of four maneuvers to lower and circularize the spacecraft's orbit. The *Endeavour* crew also performed maneuvers to begin closing the distance between the orbiter and the satellite. During the first 3 days of the mission, while Dan Brandenstein and Kevin Chilton maneuvered *Endeavour*, other crewmembers completed checkout of the four Extravehicular Mobility Units (EMUs) to be used during the unprecedented three planned spacewalks. Led by Bruce Melnick, the crew also checked out the orbiter's 15-meter-long Remote Manipulator System (RMS), or robot arm, that would be used in the capture of *INTELSAT*.

The first attempt to capture the stranded satellite occurred on the fourth day of the mission. Two crewmembers in EMUs, Pierre Thuot poised at the end of the RMS and Rick Hieb positioned in the orbiter payload bay, planned to attach a capture bar which would provide a grapple fixture for later use by the RMS. However, the satellite proved to be more sensitive to external forces than previously thought. After several attempts at capture, *Endeavour* maneuvered away so that the satellite could be stabilized prior to the next attempt.

Additional attempts on the fifth day again proved unsuccessful. Although the satellite was stabilized after the first attempt, the capture bar still was unable to grab hold. The crew was then given one day off before attempting a third try. During the day off, the crew suggested a plan to use three crewmembers to grab and hold the satellite by hand. Although a three-person EVA had never been attempted before, a team of flight controllers, engineers, and fellow astronauts on the ground developed, evaluated, and verified the entire procedure in one day.

Throughout the day between rescue attempts, the crew was busy with a variety of activities. In addition to participating in the development of the rescue plan for *INTELSAT*, they conducted medical tests evaluating the human body's performance in microgravity.

The public interest and excitement about the mission began to grow after the first rescue attempt. NASA received a deluge of suggestions on possible ways for the crew to grab the satellite. These ideas included: using magnets attached to the EVA crewmember's feet, using bungee cords, lassoing the satellite, using a large glove-like device to haul in *INTELSAT*, and applying velcro to the satellite.

The third attempt at capture added crewmember Tom Akers to the original team of Thuot and Hieb in the first ever three-person EVA. The crewmembers positioned themselves 120 degrees apart in the orbiter's payload bay, forming three stable legs for the capture. Commander Brandenstein gently maneuvered *Endeavour* directly under the 4,064 kilogram satellite so that the three crewmembers could reach up and grab it by hand. Hieb and Thuot attached the grapple fixture as Akers continued to stabilize the satellite. Then, Melnick, operating the orbiter's robot arm, was able to complete the grapple of the satellite.

Following capture, the satellite rescue operation proceeded as planned. A new rocket motor was connected to the *INTELSAT* satellite and the satellite was sent to geostationary orbit. This third EVA was the first time more than two EVAs were conducted on a Shuttle mission. It was also the longest EVA in history, 8 hours 29 minutes, surpassing the record of 7 hours 37 minutes held by the Apollo 17 astronauts.

Still, STS-49 was not finished breaking records. With *Endeavour* performing almost flawlessly, NASA mission managers decided to extend the mission two days to complete more mission objectives and allow the crew enough time to prepare for landing. This allowed two crewmembers, Tom Akers and Kathy Thornton, to perform the Assembly of Station by EVA Methods (ASEM) experiment, the fourth EVA on the flight and another first. The spacewalkers built a pyramid-shaped truss structure and then docked a pallet to it using *Endeavour's* robot arm operated by Bruce Melnick — thus simulating the installation of a crew module node to a space station truss structure. These activities took longer than had been estimated prior to the mission and pointed to the need for further evaluation of assembly concepts on-orbit. The crew also tested a self-rescue device for an EVA crewmember who may become untethered from Space Station *Freedom*. Although originally scheduled for two EVAs and now limited to one, most of the objectives of ASEM were met by the *INTELSAT* spacewalks and this fourth spacewalk.

The STS-49 crew also conducted the mid-deck Commercial Protein Crystal Growth (CPCG) experiment. The CPCG experiment provides a means of producing large, high-quality protein crystals. Larger, higher quality crystals can be grown in space due to the absence of distortions produced on the ground by gravity. Knowing the precise structure of these complex molecules provides the key to understanding their biological function.

Landing of *Endeavour* provided another first, the use of the orbiter drag chute which reduced landing roll-out distance and orbiter tire and brake wear. The drag chute was just one of many improvements made to *Endeavour*. *Endeavour* features updated avionics systems, mechanical systems, and modifications for future use as an Extended Duration Orbiter (EDO). Although not used on STS-49, the EDO modifications would allow *Endeavour* to remain in space for as long as 28 days.

The maiden flight of *Endeavour* included many firsts, but above all, it demonstrated the flexibility of the Space Shuttle program and the ability of the ground control and flight crew team to rise to meet the challenges of space flight operations.

Captain Cook's *Endeavour*

Excerpt from: Thorne, M., ed. (1992), From Ship to Shuttle, EP-276, National Aeronautics and Space Administration, Washington, D.C.

When the Lords of the Admiralty and The Royal Society agreed to sponsor a joint voyage of exploration to the South Pacific in 1768, the Royal Navy purchased a Whitby-built collier, *Earl of Pembroke*, to make the journey and chose Lieutenant James Cook to command it.

The colliers were sturdy ships, flat-bottomed with bluff bows, and broad-beamed, to carry large cargoes in the North Sea coal trade. Renamed *Endeavour*, Cook's small ship (length, 29.6 m; beam 8.8 m; depth of hold 4.6 m; 329.4 metric tons) also was refitted. When it set sail in August 1768, *Endeavour* carried extra sails and rigging; carpenter and blacksmith shops; food, including livestock for fresh meat; guns and ammunition; medical equipment; delicate scientific instruments; a variety of artist's supplies; and "trifles and tringits" for trading.

Cook, known as an experienced and able seaman, navigator, cartographer, and amateur astronomer, captained a complement of 93 men, including crew, marines, and 11 scientists and artists with their servants. He left England with specific objectives: for the Royal Society, to observe the Transit of Venus at Tahiti, June 3, 1769; for the Admiralty, under secret orders, to seek the Great Southern Continent thought to exist in the southern hemisphere and to chart the coast of New Zealand and any lands discovered.

After completing the astronomical observations, Cook sailed southwest. He found no southern continent, but circumnavigated New Zealand and proved it was two islands. Continuing westward, Cook reached the southeast coast of New Holland (Australia). Following the coast north, he named Botany Bay for the abundance of vegetation and specimens found there, and the Endeavour River for the place where his ship ran aground. It was through this event that Cook discovered the Great Barrier Reef. En route back to England, Cook rounded the northern coast of Australia and confirmed that the continent was separate from islands in the north.

Cook made one voyage in *Endeavour*. His achievements were many and impressive and set standards for those who followed. He crossed the South Pacific as no one had before him; his surveying and charting produced extremely accurate maps of New Zealand and the east coast of Australia; and the recorded astronomical and hydrographical data were invaluable. He also was the first to take scientists and artists to observe, examine, and record plants and animals, to collect specimens, and to illustrate their findings. Through the thousands of specimens of new plant species, innumerable sketches and paintings of wildlife, and portraits of natives, he enriched European knowledge of the Pacific. And he set a precedent. Teams of scientists and artists became accepted members of ships' crews, and with their chemicals, containers for specimens, and artists' equipment, the ships of exploration that followed Cook came to be described as "floating laboratories."

Cook's immediate recognition came from his contributions to the health of men at sea. A prevention and cure for scurvy had been published several years earlier, and Cook tested the suggested diet and health regimens on the *Endeavour* voyage. He experimented with citrus and other fruits, sauerkraut, onions, grasses, and fresh food when possible. He enforced cleanliness in both personal hygiene and the ship's environment. He endorsed exercise whenever they were near land. Men were lost by accidents and other illnesses, but not one from scurvy.

Cook returned to England in July 1771. He was promoted to commander, and a year later returned to the South Pacific with two ships. Of *Endeavour*, Cook said, "A better ship for such a service I never would wish for." After 1771, *Endeavour* saw service in the Falkland Islands and perhaps in the North Sea before being sold to the French. In the 1790's, she ran aground on a reef off Newport, Rhode Island. The University of

Rhode Island's Graduate School of Oceanography has a sternpost remnant of Cook's *Endeavour*. At the rollout ceremony of the orbiter *Endeavour*, the School presented NASA with a piece of the original ship. The artifact was carried aboard the orbiter *Endeavour's* first voyage.

NASA Orbiter-Naming Program

The name *Endeavour* resulted from a nationwide orbiter-naming competition. Authorized by Congress in 1987, the program called for a name to be selected "from among suggestions submitted by students in elementary and secondary schools." The competition was open to all students in the 50 states, District of Columbia, and U.S. jurisdictions and agencies. There were two entry divisions: Division 1 included students from kindergarten - grade 6, and Division 2, grades 7-12.

The program had two components: the name suggested and a relevant classroom project. Continuing the tradition established for the first orbiters, the name had to be that of an exploratory or research sea vessel. To enter the competition, students formed teams with a member of the school faculty as coordinator.

In May 1989, President George Bush selected and announced the winning name—*Endeavour*—based on recommendations of the NASA Administrator. The name was suggested by the winning team of both divisions: Senatobia Middle School, Senatobia, Mississippi (Division 1) and Tallulah Falls School, Inc.,Tallulah Falls, Georgia (Division 2).

In addition to suggesting the name *Endeavour*, fifth-grade students in the Gifted and Talented class of Senatobia Middle School created a "space camp simulation" in the school gymnasium for younger students. The simulation included activity stations on the Space Shuttle, space clothing, space food, medicine and space, sleep and exercise, working in space, and space communications. Secondary level students at Tallulah Falls School created a math magazine. The magazine, *Math Exploration with James Cook*, emphasized the importance of Cook's contributions to world and natural science exploration. The magazine included problems for student readers in grades 1 - 12. Tallulah Falls students also wrote and performed a play titled *Where on Earth?*, which compared 18th-century exploration of the sea to 20th-century exploration in space.

Terms

Booster - Small rocket used to raise satellites from low to high orbit.

Captain James Cook - Sea captain and explorer who commanded the English sailing ship *Endeavour.*

Commander - The leader and chief pilot of a Space Shuttle crew.

Endeavour - The name of a sailing ship commanded by Captain James Cook and the name of the newest Space Shuttle orbiter.

Geologist - Scientist who studies the physical processes that form the rock and soil of the solid portions of Earth.

INTELSAT - Communications satellite.

Mission Specialist - Astronaut who specializes in scientific experiments, payload handling, and spacewalking on Space Shuttle missions.

Oceanographer - Scientist who studies the physical processes at work in the world's oceans.

Pilot - Second in command of a Space Shuttle mission.

Sextant - Device that is used to measure angles of the Sun and stars in order to make latitude determinations.

Space Station *Freedom* - NASA's planned international space station for the end of this century.

Star-tracker - Device for determining the position of Space Shuttle orbiters by measuring angles to selected stars.

Transit of Venus - An astronomical event in which the Sun, Venus, and Earth are in direct line so that the silhouette of Venus is seen crossing the disk of the Sun.

Classroom Activities

The following hands-on activities can be used to demonstrate some of the concepts presented in this videotape.

Sea and Space Voyages

<u>Materials</u>
Pins and string
World globe
Rubber band (large)
World map
Reference books (see reference list)

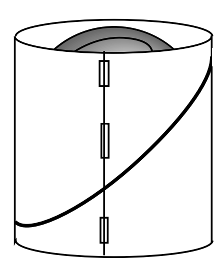
<u>Procedure</u>
Compare the historic voyage of Captain Cook's *Endeavour* with the first flight of the Space Shuttle *Endeavour*. Plot Cook's route on the world map using pins and string. Plot the Space Shuttle *Endeavour*'s first orbit on the same map. Begin by placing a rubber band around the globe. The band should cover the Kennedy Space Center in Florida and slant towards the northeast while intersecting the equator at 28 degrees. The rubber band represents one orbit of the Space Shuttle *Endeavour*. Transfer this orbit to the world map. To do this, follow the 75 degree west longitude line on the world globe up from the equator and note which latitude line the orbit crosses. Plot these coordinates on the world map, insert a pin, and connect the two points with a string. Do the same for 60, 30, and 15 degrees west, 0 degrees, 15 degrees east, and so on. After you plot 90 degrees west on the map, connect that point with the Kennedy Space Center pin. This represents one orbit of the Space Shuttle *Endeavour*. (See note.) Why is the orbit in the shape of a sine curve on the world map? (See next activity.)

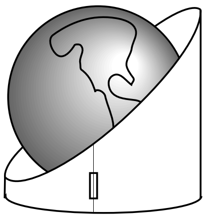
Note: The Space Shuttle *Endeavour*'s first orbit did not actually return to the Kennedy Space Center. Each orbit lasted approximately 90 minutes. When *Endeavour* returned to the point in space over its launch site, Earth had rotated eastward 22.5 degrees. Consequently, *Endeavour*'s first orbit was completed over Mexico. The second orbit was completed over the Pacific Ocean and so on. How does Earth's rotation help orbiting spacecraft study Earth's surface from space?

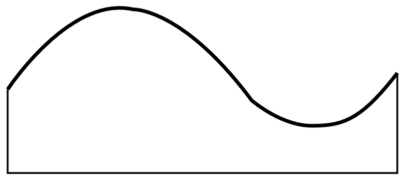
Sine Curve Orbits

<u>Materials</u>
World globe
White paper
Marker pen
Cellophane tape
Scissors

<u>Instructions</u>
Demonstrate why orbital maps show orbits as sine curves by making out of white paper and tape a cylinder large enough to surround a world globe. Use the marker pen to draw a heavy line representing a Space Shuttle orbit. When viewed from the side, the line will appear to be straight. Using the scissors,





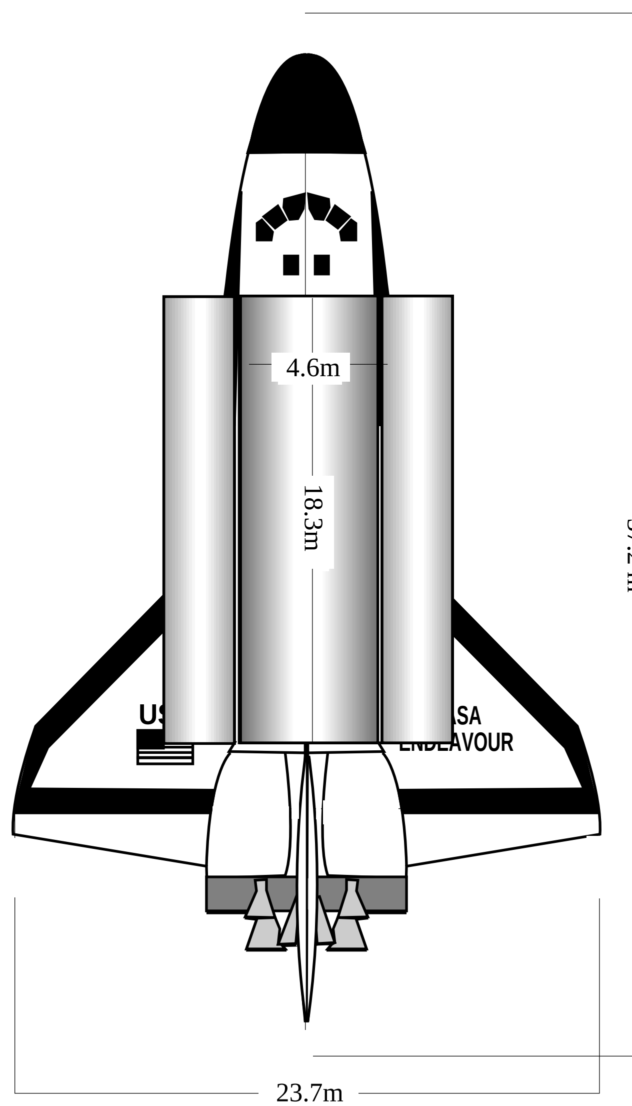


cut the cylinder on the line you drew. Discard the upper part, and place the bottom part of the cylinder over the globe. Show that the cut edge of the paper represents an orbit. Next, separate the lower half of the cylinder along the taped edges and flatten out the paper. The orbit will now show as a sine curve.

Sailing/Space Ship *Endeavour*

<u>Materials</u>
Chalk
Tape measure
Asphalt playground
School bus (optional)
Reference books (see reference list)

<u>Procedure:</u>
Using the chalk and a tape measure, draw an outline of the Space Shuttle *Endeavour* on an asphalt playground. Use the diagram below for shape and dimensions. Taking information from reference books, draw an outline of Captain Cook's *Endeavour* next to the first drawing. Compare the size of the two vessels. If a school bus is available, have the driver drive the bus on to the playground and park completely within the outline for the Space Shuttle *Endeavour*'s payload bay. If the playground isn't large enough to draw both models, draw them to half scale. In this event, do not use the school bus for comparison.



References

Allen, Oliver E., The Windjammers, Alexandria, VA: Time-Life Books, 1978.

Delpar, Helen, ed., The Discoverers: An Encyclopedia of Exploration, New York: McGraw-Hill, 1980.

Brosse, Jacques, Great Voyages of Discovery: Circumnavigators and Scientists, 1764-1843, Paris: Bordas, 1983.

Finney, Ben R., Hokule'a: The Way to Tahiti, New York: Dodd, Mead and Company, 1979.

Fradin, Dennis B., Explorers, Chicago: Children's Press, 1984.

Fritz, Jean, Where Do You Think You're Going, Christopher Columbus? New York: Putman, 1980.

Grosseck, Joyce and Elizabeth Attwood, Great Explorers, Grand Rapids, MI: Gateway Press, 1988.

Hicks, Jim, ed., The Explorers, Chicago: Time-Life Books, 1984.

Morison, Samuel Eliot, The Great Explorers: The European Discovery of America, New York: Oxford University Press, 1971.

Thorne, M., ed. (1992), From Ship to Shuttle, EP-276, National Aeronautics and Space Administration, Washington D.C.

Warner, Oliver, Captain Cook and the South Pacific, New York: American Heritage Publishing Company, Inc., 1963.

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STS-49 Crew Biographies

Commander: Daniel C. Brandenstein (Capt., USN). Dan Brandenstein was born in Watertown, Wisconsin. He earned a bachelor of science degree in mathematics and physics from the University of Wisconsin, River Falls. After graduation, he became an aviator (USN) and flew 192 combat missions in the Vietnam War. Brandenstein later tested weapons systems and tactics aboard the A-6 aircraft. Following graduation from the U.S. Naval Test Pilot School, he conducted tests of electronic warfare systems in various Navy aircraft. Brandenstein has logged 6,300 hours flying time and made 400 carrier landings. He has previously flown as a pilot on the STS-8 mission and as the commander on the STS-51G and STS-32 missions. He was Chief of the Astronaut Office from1987-1992.

Pilot: Kevin P. Chilton (Lt. Col., USAF). Kevin Chilton was born in Los Angeles, California. He earned a bachelor of science degree in engineering sciences from the USAF Academy and a master of science degree in mechanical engineering from Columbia University. After graduating from Air Force pilot training, he served as a combat-ready pilot and instructor in the RF-4 Phantom II and the F-15 Eagle. Following graduation from the USAF Test Pilot school, he conducted weapons and systems tests in the F-15 and F-4. He has logged over 3,000 hours of flight time in more than 20 different types of aircraft. This was his first space flight.

Mission Specialist: Richard J. Hieb. Richard Hieb was born in Jamestown, North Dakota. He received a bachelor of arts degree in mathematics and physics from Northwest Nazarene College and a master of science degree in aerospace engineering from the University of Colorado. Following graduation, he joined NASA and worked in many different areas of flight operations, including crew development and spacecraft rendezvous procedures. Hieb flew previously on the STS-39 mission as a mission specialist.

Mission Specialist: Bruce E. Melnick (Cmdr., USCG). Bruce Melnick was born in New York, New York, but considers Clearwater, Florida, to be his hometown. He earned a bachelor of science degree in engineering from the U.S. Coast Guard Academy and a master of science degree in aeronautical systems from the University of West Florida. He served 7 years as a Coast Guard rescue pilot and later conducted many of the tests on the Coast Guard's HH-65A "Dolphin" helicopter. He has logged over 4,900 flying hours, mostly in helicopters and T-38 aircraft. Melnick flew previously as a mission specialist on Mission STS-41.

Mission Specialist: Pierre J. Thuot (Cmdr., USN). Pierre Thuot was born in Groton, Connecticut, but considers Fairfax, Virginia, and New Bedford, Massachusetts, to be his hometowns. He received a bachelor of science degree in physics from the U.S. Naval Academy and a master of science degree in systems management from the University of Southern California. He flew the F-14 Tomcat and made deployments to the Mediterranean and Caribbean Seas aboard the carriers USS John F. Kennedy and USS Independence. He has also worked as a project test flight officer at the Naval Air Test Center. Thuot has recorded over 2,700 flight hours, and made more than 270 carrier landings. He flew previously as a mission specialist aboard Mission STS-36.

Mission Specialist: Kathryn C. Thornton (Ph.D.). Kathryn Thornton was born in Montgomery, Alabama. She earned a bachelor of science degree in physics from Auburn University and master of science and doctorate of philosophy degrees in physics from the University of Virginia. She was awarded a NATO Postdoctoral Fellowship at the Max Planck Institute for Nuclear Physics in Heidelberg, Germany, and later worked as a physicist at the U.S. Army Foreign Science and Technology Center. Thornton was also a mission specialist aboard Mission STS-33.

Mission Specialist: Thomas D. Akers (Lt. Col., USAF). Tom Akers was born in St. Louis, Missouri, but considers his home to be Eminence, Missouri. He received bachelor and master of science degrees in applied mathematics from the University of Missouri. He worked four years as the high school principal in Eminence before joining the Air Force. As a flight test engineer, he worked on several weapons development programs while flying F-4 and T-38 aircraft. Akers served previously as a mission specialist aboard STS-41.

Voyage of Endeavour *- Then & Now*

Videotape and Video Resource Guide
Evaluation

The National Aeronautics and Space Administration would appreciate your taking a few minutes to evaluate the *Voyage of* Endeavour - *Then & Now* videotape and accompanying guide. Your feedback will be of great assistance in helping to develop new educational materials. When completed, please fold on the dotted line, and staple or tape, and return it to us by mail. Thank you.

SA - Strongly Agree
A - Agree
D - Disagree
SD - Strongly Disagree

<u>Please circle one</u>

1. *Voyage of* Endeavour - *Then & Now* is easy to integrate into the curriculum. **SA A D SD**
2. *Voyage of* Endeavour - *Then & Now* is appropriate for the grade level(s) I teach. **SA A D SD**
3. *Voyage of* Endeavour - *Then & Now* just the right length for my students. **SA A D SD**
4. The video resource guide is a useful supplement to the videotape. **SA A D SD**
5. The instructions and background information in the video resource guide are complete and easy to understand. **SA A D SD**
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7. I teach the following subjects: ____
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