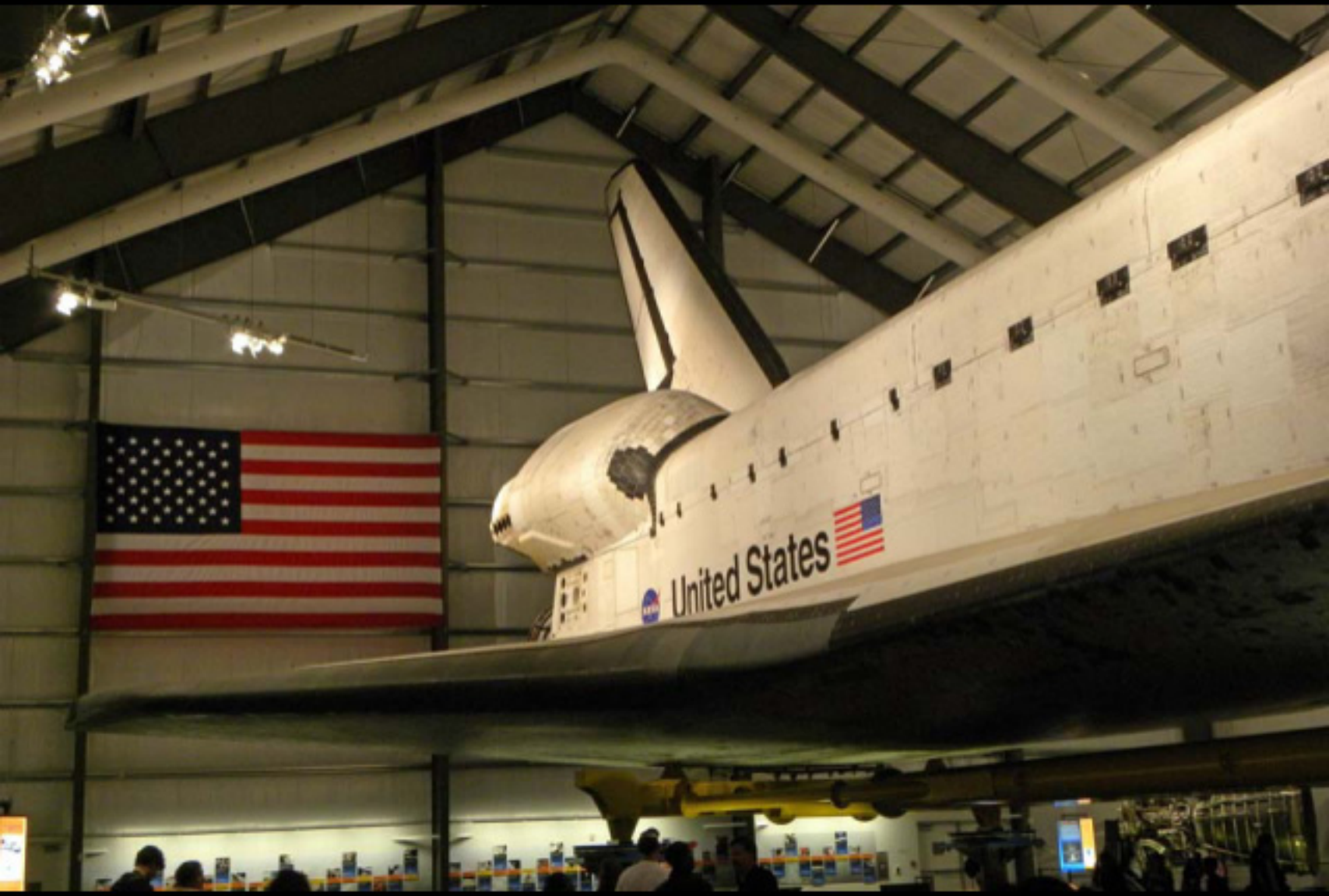

CaliforniaScienCenter
Samuel Oschin Air and Space Center
Future Home Of
ENDEAVOUR


Endeavour
United States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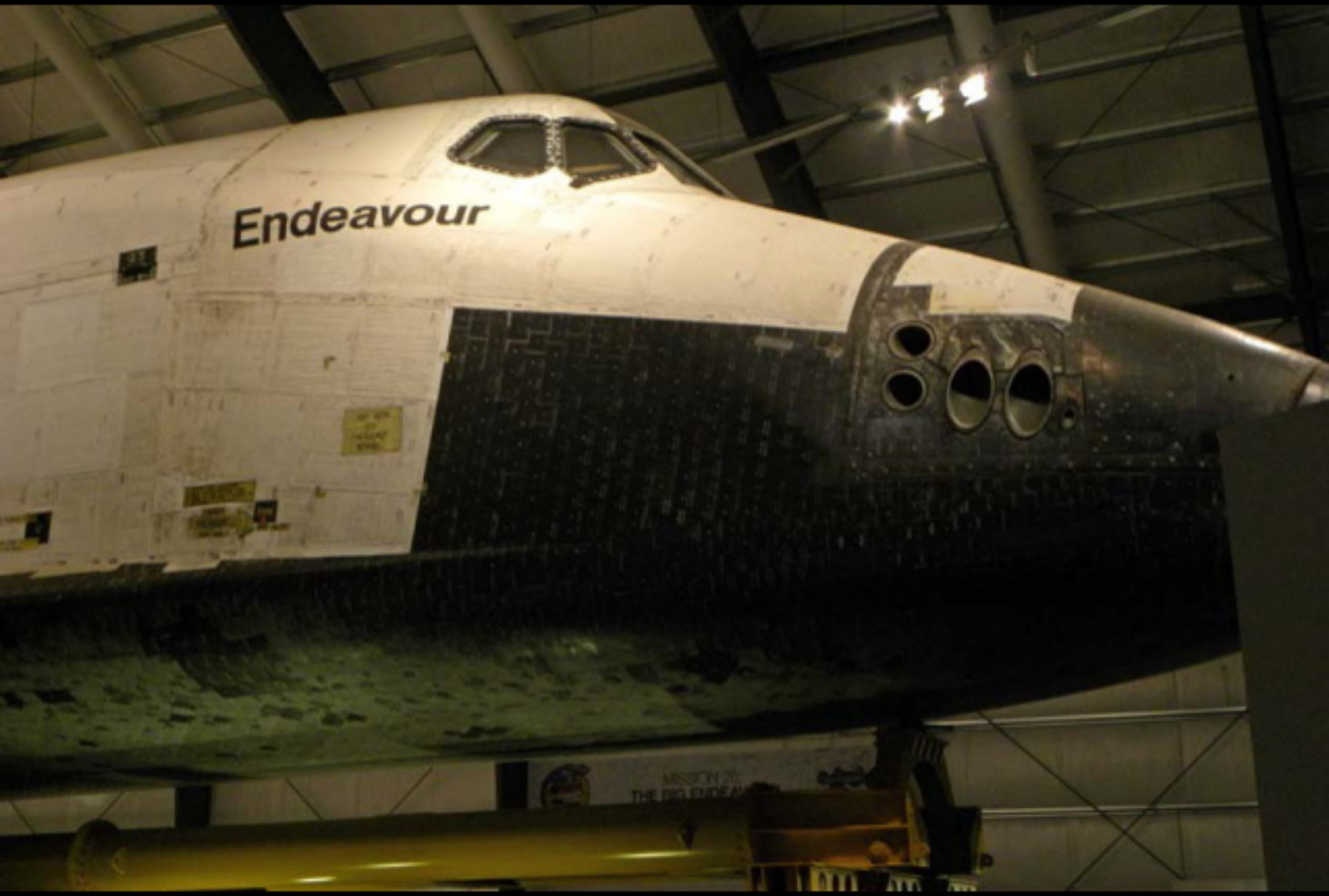
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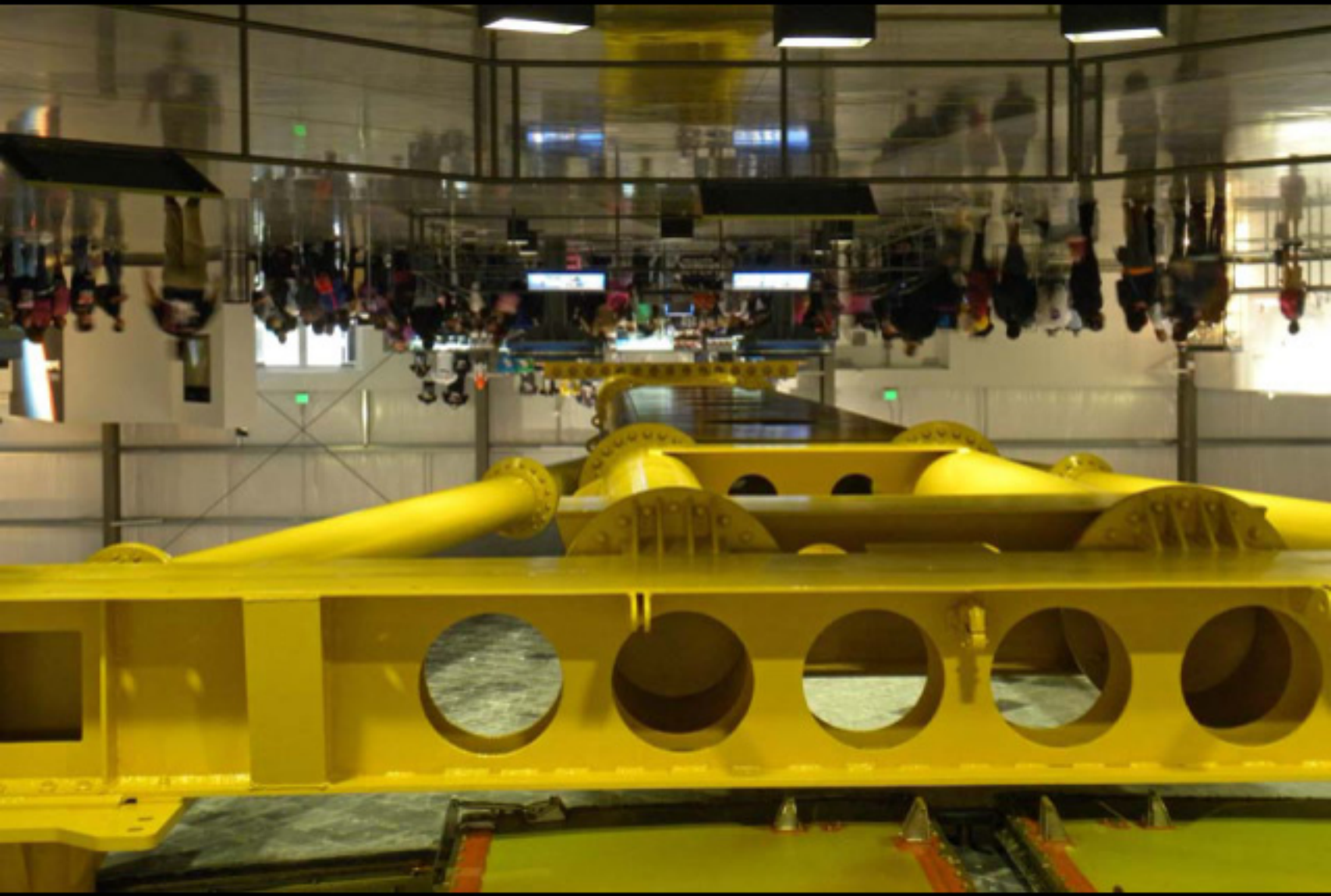


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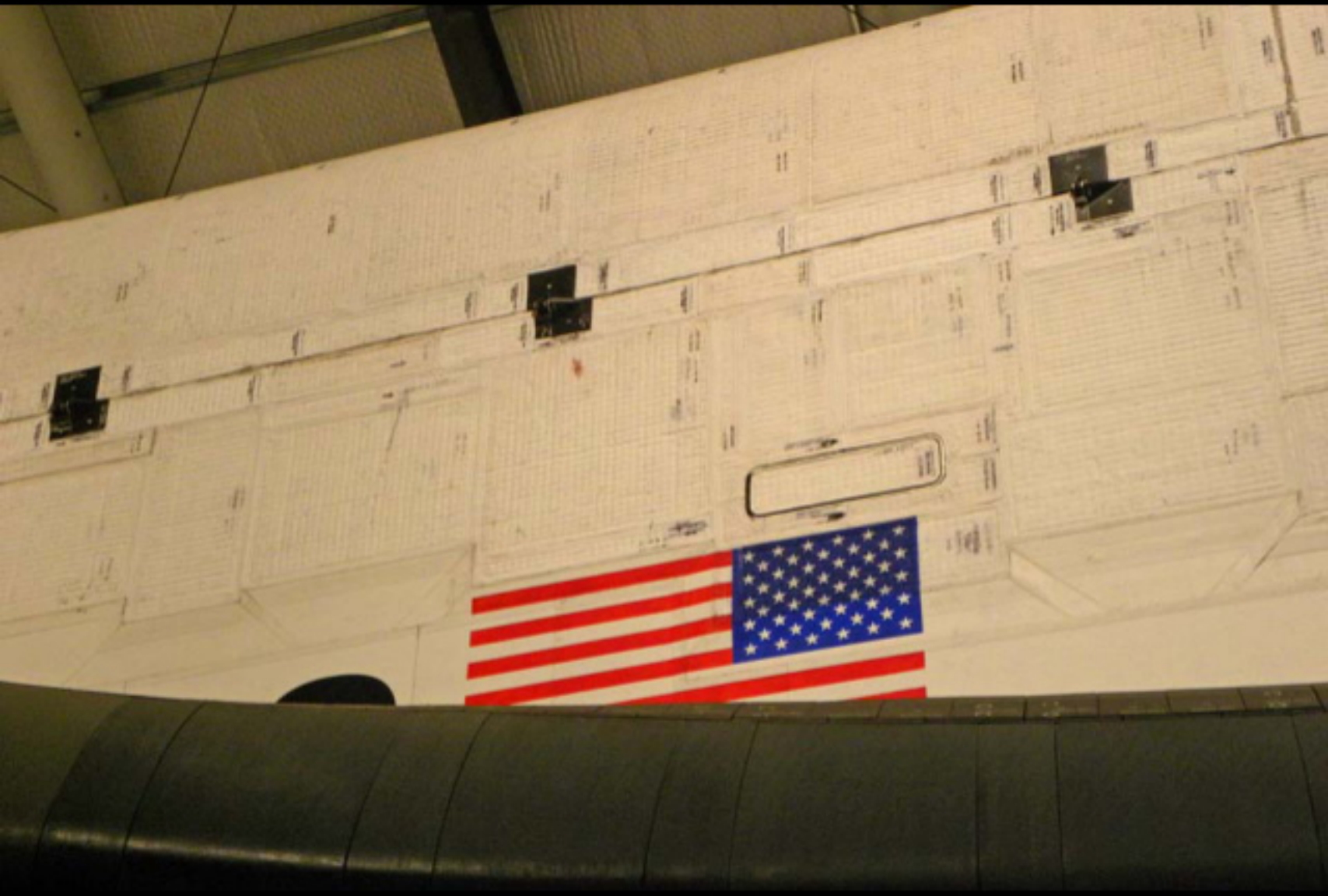


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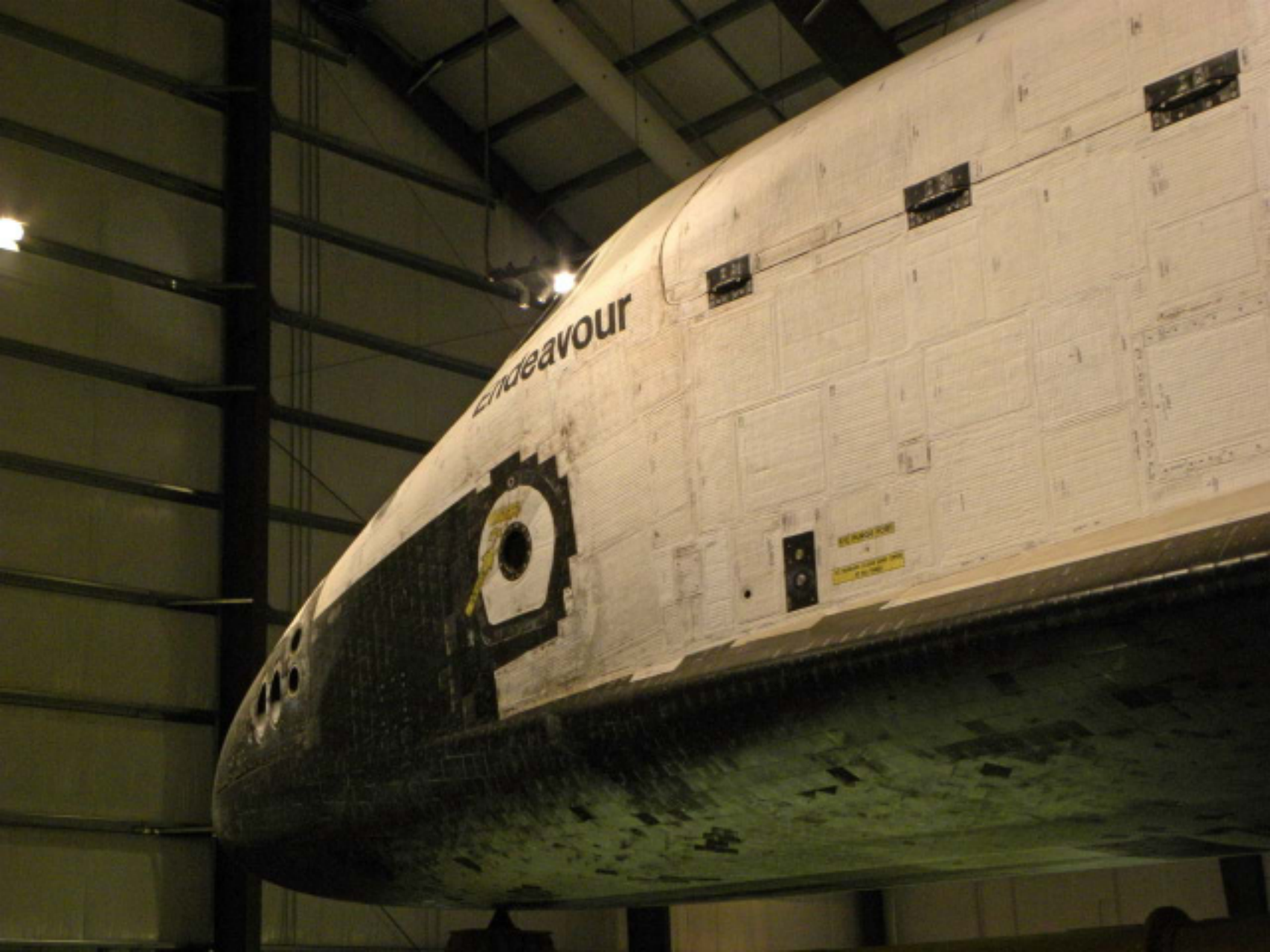
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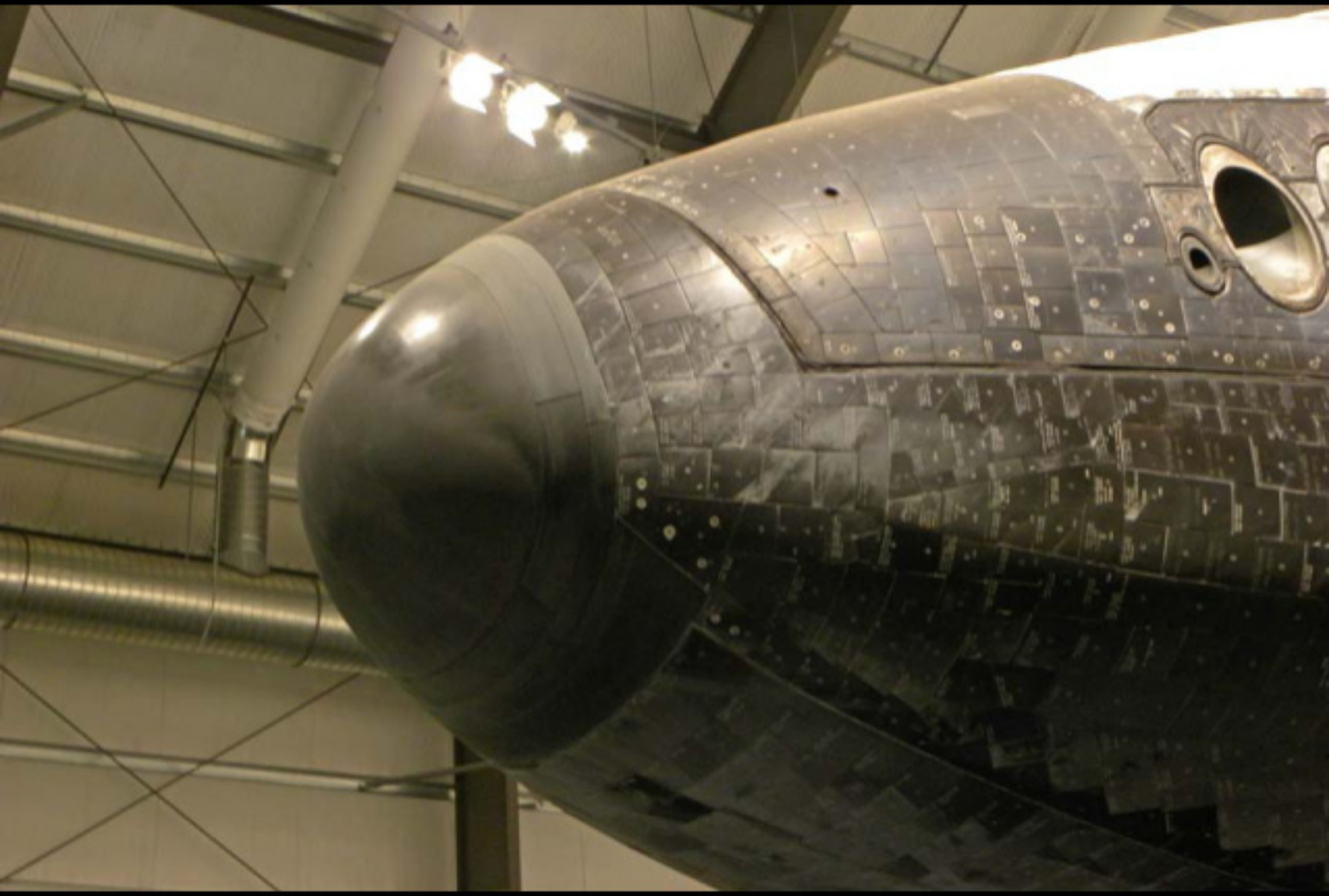


THE SHUTTLE FLEET

The space shuttle program included six orbiters—five that flew into space, and one, the *Enterprise*, used for test flights in Earth's atmosphere. The shuttle punched through the atmosphere and into orbit for the first time on April 12, 1981, when *Columbia* launched. Next came *Challenger*, *Discovery* and *Atlantis*.

Endeavour, the newest of the orbiters and known as the "jewel of the fleet," was built as a replacement for *Challenger*, which was destroyed shortly after launch in January 1986. *Endeavour* first launched on May 7, 1992, and flew a total of 25 missions.

ENTERPRISE (OV-101)

Rollout	September 17, 1976
Test flights	5
Days in space	0
Number of orbits	0
Miles traveled	N/A
Status	On display at the Intrepid Sea, Air + Space Museum

COLUMBIA (OV-102)

First launch date	April 12, 1981
Number of missions	28
Days in space	300
Number of orbits	4,808
Miles traveled	127,000,000
Status	Lost during reentry on February 1, 2003

CHALLENGER (OV-099)

First launch date	April 4, 1983
Number of missions	10
Days in space	62
Number of orbits	995
Miles traveled	25,661,200
Status	Lost during launch on January 28, 1986

DISCOVERY (OV-103)

First launch date	August 30, 1984
Number of missions	39
Days in space	365
Number of orbits	5,830
Miles traveled	148,221,675
Status	On display at the National Air and Space Museum

ATLANTIS (OV-104)

First launch date	October 3, 1985
Number of missions	33
Days in space	307
Number of orbits	4,848
Miles traveled	125,935,799
Status	On display at Kennedy Space Center

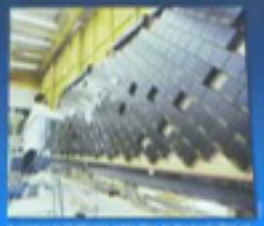
ENDEAVOUR (OV-105)

First launch date	May 7, 1992
Number of missions	25
Days in space	299
Number of orbits	4,671
Miles traveled	122,883,151
Status	On display at the California Science Center

TAKING THE HEAT—AND COLD

While reentering Earth's atmosphere at the end of each mission, parts of the outer surface of the shuttle orbiters heated up to 3,000° Fahrenheit (1,649°C)—hot enough to melt steel. On orbit, temperatures dropped as low as 250° below zero Fahrenheit (-157°C). Special tiles, coatings and even high-tech blankets on the outside of the orbiter protected it and the astronauts inside from extreme temperatures.

Look closely. Each tile on the orbiter is different, engineered to fit the shape and the expected temperatures at a specific spot. Because the orbiter expanded and shrank slightly with temperature changes, tiles were stuck to felt pads bonded to the orbiter. If tiles were bonded directly to the orbiter, the expanding and shrinking could have cracked the tiles.



A worker in California adds tiles to the body flap of Endeavour during construction.

The orbiter's thermal protection system—made up of coatings, tiles and flexible insulation blankets—was designed to handle extreme temperatures.

Fast Facts

- During reentry, the nose and leading edge of the wings got hotter than any other part of the shuttle.
- Approximately 24,000 tiles and 1,000 flexible insulation blankets cover the outside of each orbiter.
- A single tile could cost as much as $2,000 to make.
- The main ingredient in the tiles is silica, which comes from sand.
- The black coating seen on the tiles under the orbiter helped the tiles shed heat. The white tiles and blankets on the orbiter's topside helped reflect solar radiation when the shuttle was on orbit, which helped Endeavour keep cool.
- The tiles are very light and fragile. You could crush one in your hand.

THE ORBITER FROM THE INSIDE

Fast Facts

- The orbiter completed over 134 miles (215 km) of orbit.
- Endeavour weighed 178,000 pounds (81,000 kg) with most cargo bays installed.
- Each window had a polished pane that was 1½ feet (0.5 m) wide and 2½ feet (.75 m) long that could open up to 45,000 pounds (20,000 kg) of cargo.
- When the orbiter sat on its landing gear on the runway, it was 57 feet (17 m) tall. Here, the tail is slightly lower because the nose has been raised.
- The orbiter is 122 feet (37 m) long, and its wingspan is 78 feet (24 m) wide.
- The main body of the orbiter is built with aluminum, over two miles altogether. The tiles and thermal blankets on the surface keep the aluminum from melting during launch and entry back into the atmosphere.

THE FLYING BRICK

Though the space shuttle orbiter was the first spacecraft to land as an aircraft on a runway, its landings were far from typical. No engines controlled the orbiter's trip down through the atmosphere. And when approaching the runway, the orbiter dropped 20 times faster and at an angle seven times steeper than a passenger plane. Astronauts and engineers called the heavy, minimally aerodynamic orbiter "the flying brick."

To begin the landing process, the shuttle turned backwards and fired the engines from the orbital maneuvering system to slow down and drop out of orbit. After leaving orbit, the orbiter turned forward again to reenter the atmosphere.

In space and in the thin outer atmosphere, the thrusters in the aft reaction control system helped maneuver the orbiter. But as the orbiter traveled down through the atmosphere, air pressure increased and the elevons and rudder kicked in, allowing the orbiter to maneuver like an aircraft. The orbiter went through a series of long s-shaped turns to slow down enough to land at about 230 miles an hour.

Fast Facts

- When breaking the sound barrier, the shuttle made two sonic booms less than a second apart—one with the nose and one with the tail.
- As glide toward the Earth's surface took the orbiter 5,000 miles—almost the distance between Tokyo and Los Angeles—in half an hour.
- Of the 133 shuttle landings, 78 were at Kennedy Space Center in Florida and 54 were at Edwards Air Force Base in California. A single shuttle flight, STS-3, landed at Northrup Strip in White Sands, New Mexico.
- Twenty-six landings occurred at night— 23 in Florida and six in California.
- Endeavour landed in California seven times.

LIFTOFF!

About seven million pounds of thrust pushed the shuttle off the launch pad for each flight to orbit. Around 85 percent of that thrust came from the two solid rocket boosters (SRBs), and the three space shuttle main engines (SSMEs) generated the rest.

The SRBs gave the astronauts a rough ride. According to one astronaut, it felt like bouncing over railroad ties in a pickup truck! When the SRBs detached after about two minutes of flight, the ride felt smoother but the shuttle kept speeding up. The external tank, still attached to the orbiter, fed fuel to the SSMEs through the rest of "the ride uphill," as ascent to orbit is called. By the time the SSMEs cut off and the external tank detached eight and a half minutes after liftoff, the shuttle was just short of its orbit and traveling over 17,000 miles per hour. Orbital maneuvering system engines fired to push the orbiter into a circular orbit above the atmosphere.

FastFacts

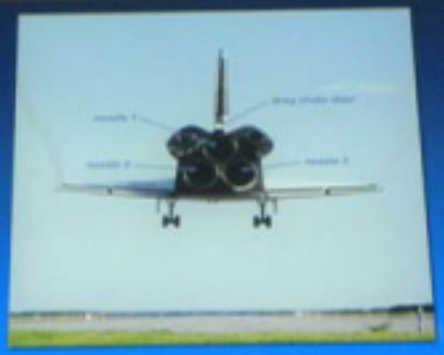
- Each solid rocket booster held over a million pounds of propellant at launch.
- During the last minute that the SSMEs are firing, astronauts experience forces three times the strength of gravity (three Gs). But when the engines cut off, they felt weightless almost instantly.

ENGINE SWITCH

The space shuttle main engines (SSMEs) rocketed the shuttle from the launch pad to orbit. But even though the SSMEs look like part of the orbiter, they were completely removed for maintenance between flights. The engines were even swapped out between orbiters.

The SSMEs are still the most advanced large rocket engines in the world, so NASA removed the engines and plumbing from *Endeavour* for reuse in the new Space Launch System (SLS). The SLS will be designed to push past Earth orbit into the solar system.

Even though the engines inside *Endeavour* are missing, NASA installed a set of real SSME nozzles for display. Nozzle 1 flew four times, including three missions on *Endeavour*. Nozzles 2 and 3 didn't fly, but they were used in engine development tests and went through a total of 54 test firings.



WHAT A DRAG!

Notice the door at the base of *Endeavour*'s tail. That door hid the drag chute—a giant parachute that popped out during landing when the front landing gear hit the runway. The drag chute helped to slow down the orbiter on the ground, taking pressure off the brakes and allowing the shuttle to roll to a stop much sooner. *Endeavour* was the first orbiter to use a drag chute, but later all the shuttles were updated to include them.

During the landing process, the drag chute door often got badly damaged when it blasted off the orbiter to release the chute or when it hit the runway. But the door used on *Endeavour*'s last flight, STS-134, was recovered in good condition and reinstalled for display.

MOVING AROUND IN SPACE

The two large humps on either side of Endeavour's tail are called orbital maneuvering system/reaction control system (OMS/RCS) pods. The pods, which were removed for maintenance and even swapped between orbiters, contained propellant tanks that fed the pods' thrusters and engines.

The orbital maneuvering system (OMS) engines helped bring Endeavour up to orbit, change orbits as needed and break out of orbit at the end of a mission. The reaction control system (RCS) thrusters, which are set into the pods at different angles, helped make small changes in the orbiter's speed in space and gave the crew precise control of Endeavour's movements. Without the RCS, docking to the space station or capturing satellites would have been impossible. The RCS also maneuvered the orbiter during the early stages of reentry into the atmosphere, before the wing flaps and rudder could work in the air.

Each OMS/RCS pod includes a single OMS engine and several RCS thrusters.

FastFacts

The chemicals that fueled the OMS engines were extremely toxic, so the OMS propellant tanks were removed to make Endeavour safe to display. In the photograph, the OMS/RCS pod is ready to be reinstalled on Endeavour after being fully cleaned and prepared. Notice Endeavour's tail in the upper right and the large holes for the space shuttle main engines (SSMEs).

The OMS/RCS pods displayed on Endeavour were built for Atlantis (left) and Discovery (right), both of Endeavour's original OMS/RCS pods were lost with Columbia.

CONTROL IN THE AIR

At first glance, *Endeavour* looks a lot like a plane. The wings and the tail serve as a hint that the space shuttle orbiters were unique among spacecraft—they could land like gliders on a runway. In space where there's no air, the wings and tail had no real purpose. But in the atmosphere, the moving parts on the tail and wings, called the control surfaces, allowed astronauts to fly the orbiter and bring it in for a safe landing.

The orbiter's control surfaces included the elevons, body flap and rudder/speed brake. Moving the elevons tilted the orbiter up and down or rolled it from side to side. The body flap helped with up and down movements of the orbiter and protected the engines from scorching heat during reentry. The rudder steered the orbiter left or right. When the two pieces of the rudder flared apart, they worked as a speed brake to slow down the orbiter during landing.

Endeavour comes in for a landing, with the speed brake open to slow down the orbiter.

This close-up of Endeavour's wing, taken from the International Space Station, shows the elevons in detail. Elevons are a cross between two parts commonly found on planes – the elevators and the ailerons. Elevators are flaps that move a plane up and down, and aileron flaps control a plane's rolling motion. Elevons do both of those jobs.


MERCURY-REDSTONE 3 CAPSULE


GEMINI 11 SPACE CAPSULE

THE APOLLO SOYUZ TEST PROJECT

This Apollo command module was flown by American astronauts to rendezvous with a Russian Soyuz spacecraft parked in orbit around the Earth. Although built to fly to the moon as Apollo 18, its mission was changed when funding was cut for the Apollo program.

Both the Soyuz and Apollo spacecraft were launched on July 15, 1975 with the Russian spacecraft lifting off about 7.5 hours before the Americans. The two spacecraft successfully docked in orbit over Europe on July 17, 1975.

Launch of Russian Soyuz spacecraft

Launch of Apollo command module

APOLLO SOYUZ TEST PROJECT	
Initial docking with Soyuz	July 17, 1975 at altitude of 222 kilometers (138 miles)
Duration of initial docking	44 hours
Final undocking with Soyuz	July 19, 1975
Apollo splashdown	July 24, 1975
Duration of Apollo flight	9 days, 1 hour, 28 minutes, 24 seconds
Number of orbits for Apollo	148
Distance traveled for Apollo	5,950,000 kilometers (3,700,000 miles)
Apollo launch vehicle	Saturn IB booster

All capsules on loan from the Smithsonian Institution National Air and Space Museum