

6 Designing for Flight

Forces of Flight

Four forces push and pull an airplane in flight. The force of **gravity** pulls the airplane downward. The airplane's wings produce an upward force called **lift** that counteracts gravity. A force called **drag**, caused by air resistance, slows the airplane down. To fight drag, the airplane uses a propeller or jet engine to produce a forward force called **thrust**.

Everything that flies, from birds to paper airplanes to jets to spacecraft, is pushed and pulled by the forces of flight: gravity, lift, drag, and thrust. An aircraft must harness these forces to fly effectively. That's the challenge faced by aircraft designers.

Today's aircraft share some common parts that help to keep them in the air and allow the pilot to control flight. Designers vary the design of these parts to improve performance. They may lengthen the wings, change the shape of the fuselage (body), or use different sources of thrust, depending on whether their goal is to fly faster, fly farther, or carry more weight.

Using what you have learned about the four forces of flight, you can begin to think about aircraft design and draw some scientific conclusions of your own. If you'd like to learn more, your teachers or local library can provide you with suggestions for further reading and study, or you can visit www.boeing.com/education on the Web.



Length: 242 feet 4 inches

Vertical stabilizer
Elevators
Rudder
Horizontal stabilizer

Movable surfaces on an airplane's wing and tail enable the pilot to control the airplane. Movable surfaces, also called control surfaces, include ailerons, elevators, and rudders.

Commercial Jetliner
Commercial jetliners like the Boeing 777 need to move heavy payloads (passengers and cargo) over long distances. What design features enable the 777 to do this? What do you think would happen if the wings were shorter? Longer? A fully loaded 777 weighs from 500,000 to 760,000 pounds and has a wingspan of more than 200 feet. What enables such a large vehicle to stay aloft?

Fighter Jet

Fighter jets like the F/A-18F Super Hornet need to fly fast, turn quickly, and carry only one or two people. What design features enable the F/A-18 to do this? How would it affect this jet's performance if the nose were rounder, like a commercial airplane's nose? If the wings were longer? Why do you think this jet has two vertical stabilizers?

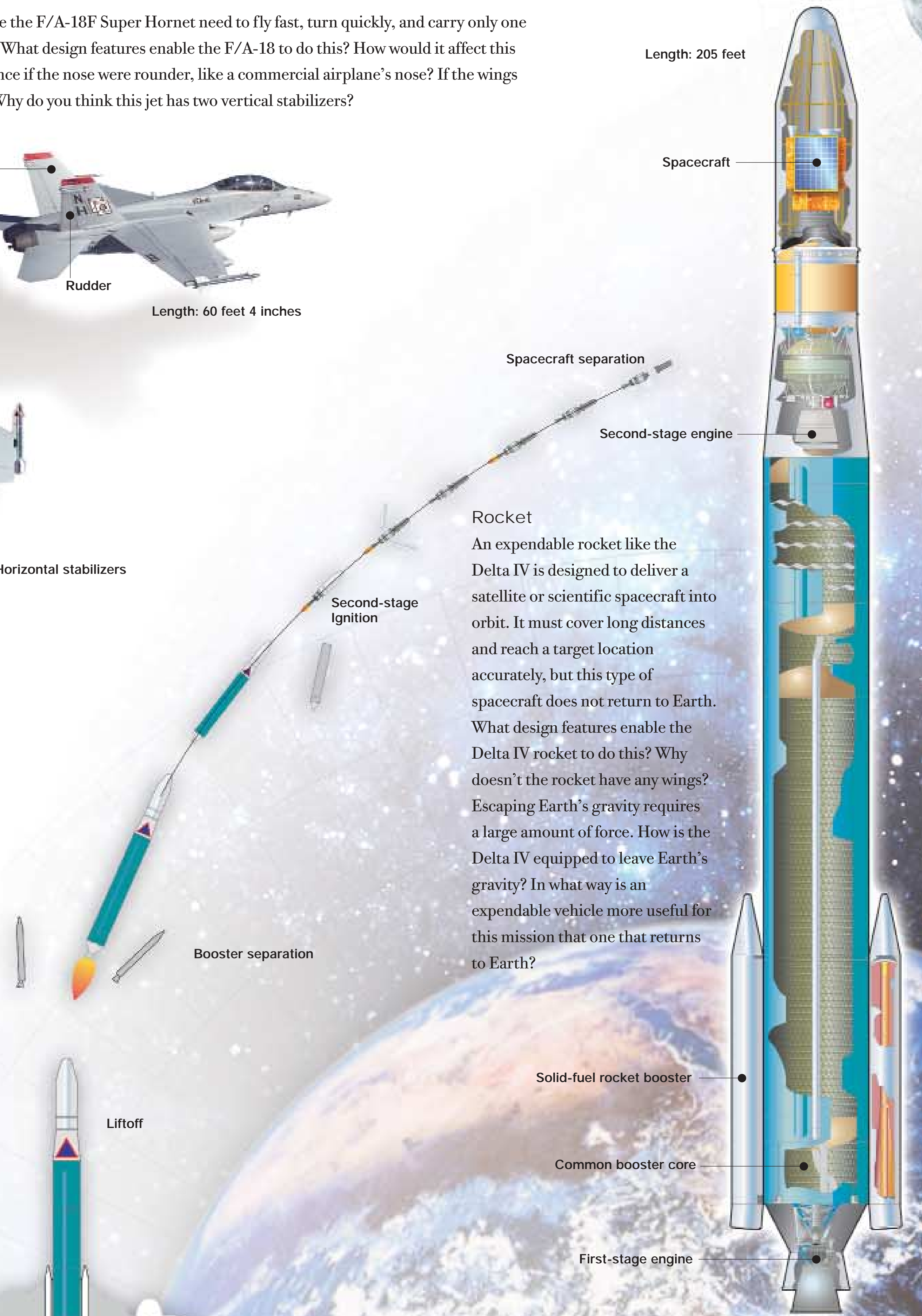


Length: 60 feet 4 inches

Vertical stabilizers
Fuselage
Rudder
Engines
Flaps
Horizontal stabilizers

Rocket

An expendable rocket like the Delta IV is designed to deliver a satellite or scientific spacecraft into orbit. It must cover long distances and reach a target location accurately, but this type of spacecraft does not return to Earth. What design features enable the Delta IV rocket to do this? Why doesn't the rocket have any wings? Escaping Earth's gravity requires a large amount of force. How is the Delta IV equipped to leave Earth's gravity? In what way is an expendable vehicle more useful for this mission than one that returns to Earth?



Length: 205 feet

Liftoff

Booster separation

Spacecraft separation

Solid-fuel rocket booster
Common booster core
First-stage engine
Second-stage engine

Spacecraft

Second-stage engine

Second-stage ignition