Hovercraft

by Chris Woodford. *Last updated: December 2, 2018.*

s it a boat or a plane? Maybe it's a flying saucer? Back in 1959, when the world's first **hovercraft**, SR.N1, floated out across the windy English Channel, people must have

I wondered exactly what they were seeing. Like a boat, a hovercraft moves across water, but like a plane, it also pushes through the air with the help of propellers . The "big idea" is that a hovercraft can glide just as easily over water, land, or, ice. That makes it a perfect vehicle for getting round some of the world's most inaccessible areas—places where ordinary boats can't beach and planes can't land. How exactly does this unique and rather remarkable craft actually work? Let's take a closer look!

Photo: A US Navy hovercraft (LCAC) photographed in 2008. Picture by Chad R. Erdmann courtesy of US Navy. Much of the deck is empty space, suitable for carrying huge amounts of drive-on, drive-off military cargo.

What is a hovercraft?

One part boat, one part airplane, and one part helicopter a hovercraft is a vehicle that traps a cushion of air underneath itself and then floats along on top of it. The air cushion holds it high above waves and land obstructions, making the craft superbly amphibious (equally capable

hovercraft, designed for swift beach landings, are often called LCACs (Landing Craft Air Cushion).

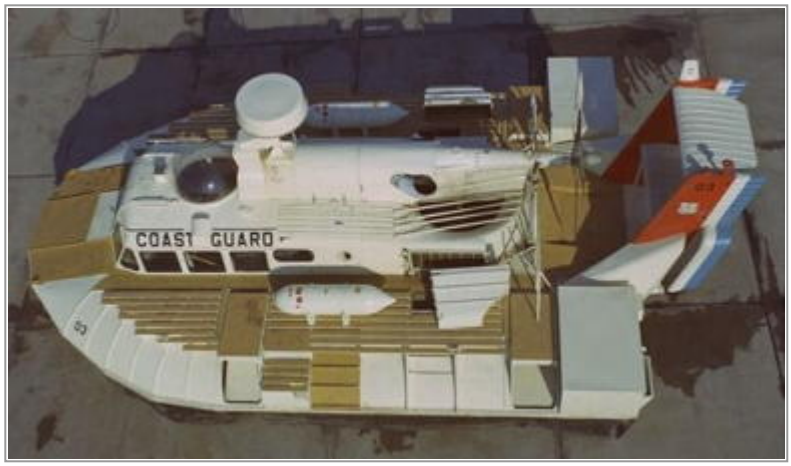


Photo: A coastguard hovercraft photographed in 1971. Photo courtesy of NASA Ames Research Center (NASA-ARC)

Hovercraft come in all shapes and sizes, from one-person fun machines and small beach rescue craft to giant passenger ferries capable of carrying over 400 passengers and 50 cars. Where boats are slowed by hulls that drag deep in the water, hovercraft ride fully clear, which means they use less fuel and can reach blistering speeds of up to 145kph (90mph). From ice and water to mud and sand, from floodplains and river deltas to mangrove swamps and frozen glaciers, the great advantage of a hovercraft is that it can glide with ease to places ordinary boats struggle to reach, and land people safely even where there are no harbors or landing stages.

In practice, hovercraft have four broad applications: large commercial hovercraft are mostly used as high-speed people and car ferries; slightly smaller military LCACs are used as tried-and-tested beach landing craft; smaller niche craft are used for things like oil and gas prospecting, inshore search and rescue, and scientific surveys; and small, one-person recreational craft are often raced round courses like flying go-karts!

How does a hovercraft work?

At first sight, you might think a hovercraft works in much the same way as a helicopter: it throws air down underneath itself and then simply rides along on top. But where a helicopter balances its own weight (the force of gravity pulling it down) with a massive down-draft of air (pushing it back up again), a hovercraft works in a much more subtle way that allows it to use far less air, far more efficiently, so getting by with a much smaller engine and considerably less fuel.

The basic mechanism of a hovercraft is very simple: there's an engine (diesel or gasoline) that powers both a large central fan, pointing downward, and one or more other fans pointing backward. The central fan creates the lift that holds the craft above the waves; the other fans propel the craft backward, forward, or to the side. A rubber skirt (with or without fingers) traps a cushion of air under the craft. Side-wall hovercraft have only partial skirts: with solid sides and a skirt only at the front and back, they can be powered by quieter propellers or water-jet engines, making them quieter.

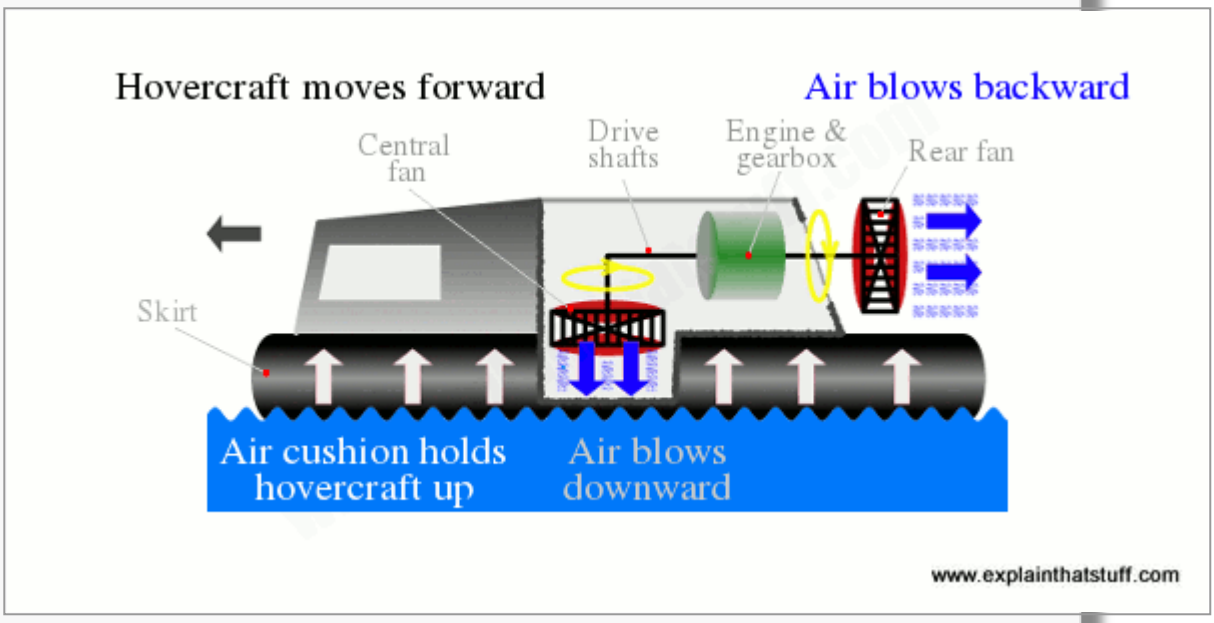


Photo: A typical hovercraft has two or more fans. The main fan in the center blows air downward to push the craft upward, above the water. Two or more other fans at the back blow air backward to make the craft go forward. This is an example of action-and-reaction (Newton's third law of motion) at work.

How much can a hovercraft carry?

A fan of a given power will create a certain amount of pressure under the craft. Now since:

$$\text{pressure} = \text{force} / \text{area}$$

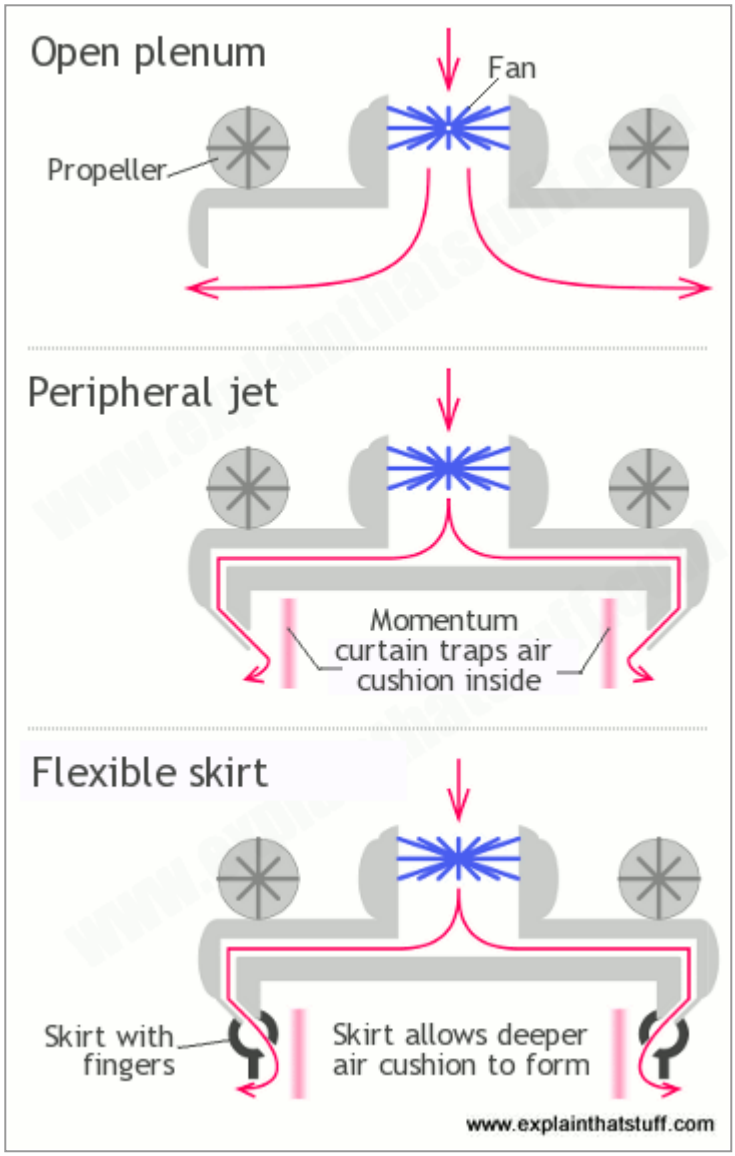
it follows that a bigger hovercraft (one with a bigger overall area) can carry more weight than a smaller hovercraft with a fan the same size. Moreover, as Christopher Cockerell, the inventor of the hovercraft, quickly discovered, bigger hovercraft are more efficient than smaller ones:

> "In such vehicles, the lift or load carrying capacity is proportional to the plan area of the gas cushion or cushions. The energy required to contain the cushion or cushions is proportional to the peripheral dimension of the cushion or cushions. Thus for an increase in size of a vehicle, the lift increases proportionally to the area of the cushion or cushions whilst the energy requirements increase linearly with the periphery of the cushion or cushions. The efficiency of a vehicle therefore increases with the plan area of the cushion or cushions, and hence with the plan area of the vehicle."—Christopher Cockerell, US Patent 3,177,960, 1965.

Types of hovercraft

Artwork: Hovercraft work in three main ways. Top: In an open-plenum design, the air effectively just pumps straight down under the craft. This requires a massive airflow and a very powerful engine. Middle: In Christopher Cockerell's peripheral jet design, a ring of fast-moving air, created by outer (peripheral) jets makes a "momentum curtain" that traps high pressure air inside it. The fan needs to move much less air to create the same lifting force, so it's a more efficient design than the open plenum. Right: Adding a skirt makes the air cushion higher, so the craft can safely clear bigger ocean waves and land obstacles. Skirts are either simple, flexible bags or more complex arrangements of individually moving segments called fingers.

Now it's certainly possible to build a simple hovercraft with a giant fan that blows air down into a container of some kind (you'll find plenty on YouTube—a couple of them are linked in the references at the bottom of this article); that design is called an **open plenum** ("plenum" being another word for the hollow region underneath the craft where the air gathers). However, most hovercraft work in one of two other ways.



The original hovercraft design used a vertically mounted fan to blow air between its outer shell and a slightly smaller inner container, creating what's called a "momentum curtain": a ring of fast-moving, inward-pointing air that trapped a bigger cushion of air inside it. This type of design is called a **peripheral jet** and its big advantage over an open plenum is that the fan needs to move much less air (or, to put it another way, it can create more lift with less power). Unfortunately, it still only produces a relatively modest hover height unless the fan is extremely powerful.

Later, engineers discovered it was more effective (and efficient) to trap a much bigger air cushion with a rubber skirt that could flex around waves and other obstructions, giving a greater hover height and a better seal. Hovercraft with skirts could clear bigger waves and land obstacles with no loss of stability or the all-important air cushion underneath them, so the ride was generally quite smooth. Eventually, the **flexible skirt** evolved into a more intricate design, with hundreds of independently moving "fingers" attached to the bottom that could maintain the airflow even more effectively. A modern hovercraft combines elements of the peripheral jet and flexible skirt designs by directing many jets of air inward through the skirt.

Other important parts

What else do you need to make a hovercraft? A downward-pointing fan can only blow air underneath, so hovercraft typically have one or more propeller fans on top of the hull, pointing backward to propel them forward. Usually, there's a rudder positioned just behind each fan to swivel the air it produces and steer the hovercraft in the appropriate direction. An alternative method of steering is to divert some of the down-draft from the fan through air nozzles that point horizontally—and the very first hovercraft prototype, SR.N1, effectively worked this way. Although hovercraft usually have separate fans (to create the cushion) and

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