BASIC HOVERCRAFT THEORY

3RD DIMENSION
AEROMODELLING CLUB - NIT TRICHY

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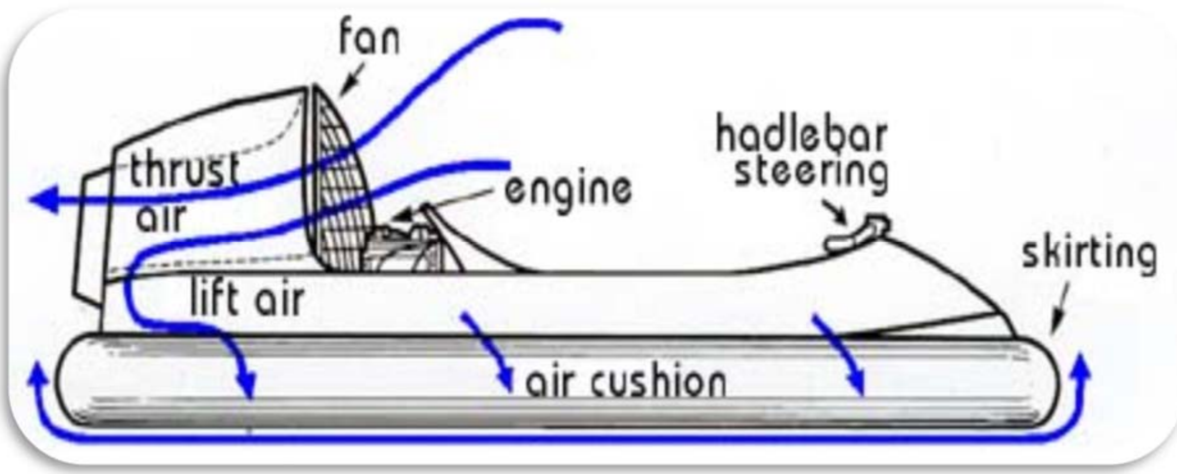
AN ISO 9001 AND 20121 CERTIFIED ORGANISATION

A hovercraft is an amphibious vehicle that is supported by a cushion of pressurized air. To understand how hovercrafts work, it is necessary to realize that the dynamics are more closely related to aircraft than to boats or automobiles.



A conventional hovercraft has three main components: A platform, a motorized fan, and a skirt. The fan blows air underneath the platform, where it is trapped between the platform and the ground by the skirt. This region of trapped air underneath the hovercraft is called a **plenum chamber**, and the air flowing into the chamber forms a ring of circulating air around the base of the skirt that helps to keep the air underneath the platform from escaping.

Since more air is being forced into the plenum chamber all the time, the air underneath the hovercraft is at a higher pressure than the air outside the chamber. This high pressure air pushes up on the hovercraft. To get a better understanding of air pressure, try to squeeze a blown up balloon - the reason why the balloon pushes back when you squeeze it is because the air in the balloon is at a higher pressure than the air outside the balloon. When air pressure pushing upward on the hovercraft perfectly balances the weight, the hovercraft floats on a cushion of high-pressure air.

To make the craft function more efficiently, it is essential to limit the cushion air from escaping, so the air is contained by the use of what is called a skirt. Fashioned from fabric, which allows a deep cushion or clearance of obstacles, hovercraft skirts vary in style.

SKIRT TYPES

A) Bag Skirt

The bag skirt offers very good hovercraft stability; however, when operating on water, the frontal area will cause buffeting in chopping water, waves and turbulent river rapids.

B) Segmented Skirt

The segmented skirt offers a much smoother ride into chopping water, waves and turbulent river rapids; however, craft stability is poor. Also, to the rear of the hovercraft the segments are prone to catch, snag and detach from the hull in shallow stony rivers or undulating terrain.

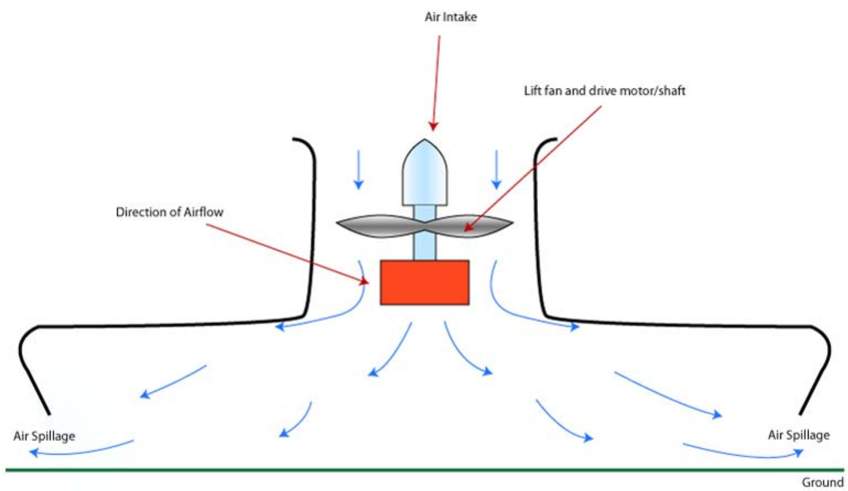
C) Hybrid Skirt

Hybrid skirt features the stability of the loop skirt and the frontal non buffeting smooth ride of the segment skirt. Also, this type of skirt system is not prone to snagging in shallow stony rivers or undulating terrain.

MOMENTUM CURTAIN

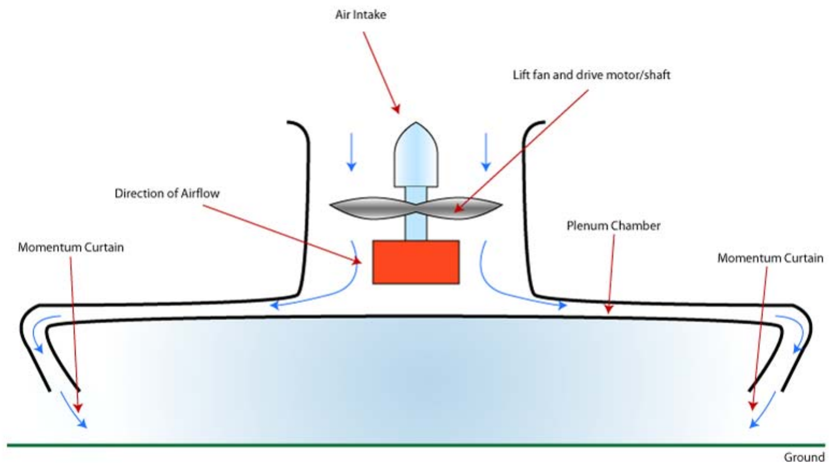
Discovered by British engineer Christopher Cockerell, the momentum curtain is a unique and efficient way to reduce friction between a vehicle and its surface of travel, be it water or land, by levitating the vehicle above this surface via a cushion of air. It is this principle of levitation upon which a hovercraft is based, and Christopher Cockerell set about applying his momentum curtain theory to hovercraft to increase their abilities in overcoming friction in travel.

Cockerell used the idea of pumped air under a hull and improved upon it further. Simply pumping air between a hull and the ground wasted a lot of energy in terms of leakage of air around the edges of the hull.

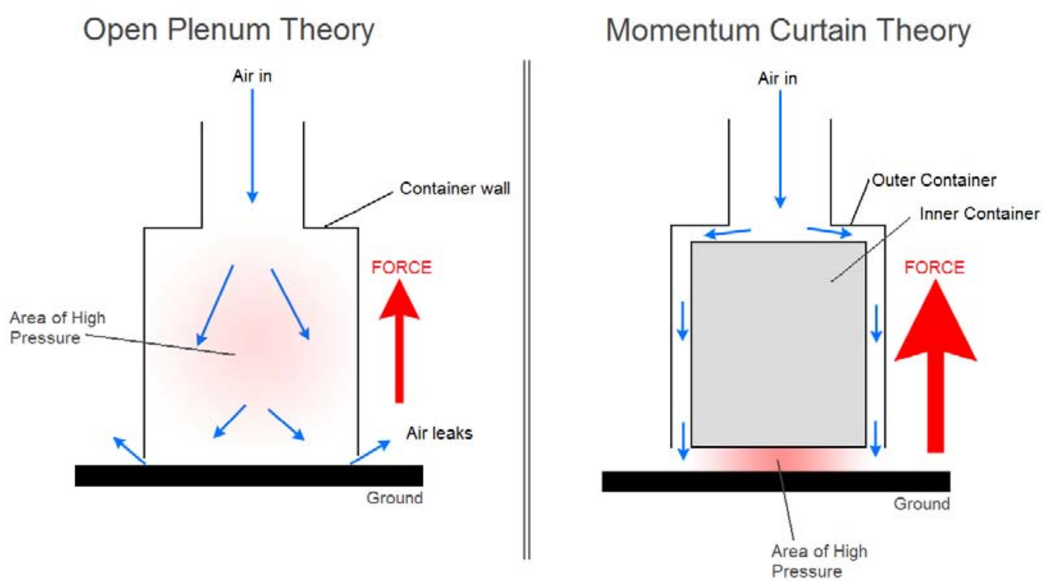


Basic Principles of the Hovercraft:
Open plenum, no Momentum Curtain effect

Cockerell discovered that by means of generating a wall (curtain) of high-speed downward-directed air around the edges of a hull, that less air leaked out from the sides (due to the momentum of the high-speed air molecules), and thus a greater pressure could be attained beneath the hull. So, with the same input power, a greater amount of lift could be developed, and the hull could be lifted higher above the surface, reducing friction and increasing clearance



Basic Principles of the Hovercraft:
The Momentum Curtain effect

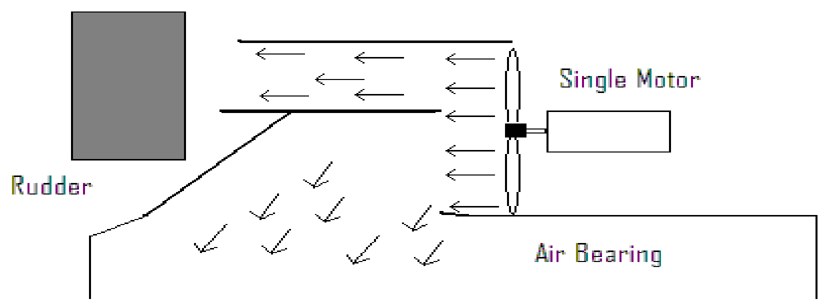


HOVERCRAFT DESIGN AND OPERATION

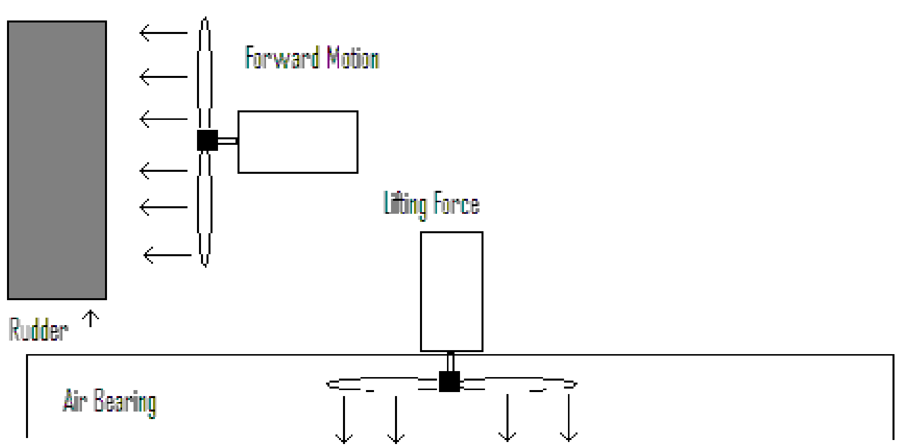
Four basic parts of a Hovercraft:

1) The hull, below which is attached the skirt system,
2) The carriage or cabin part which needs to hold the passenger(s), crew or freight,
3) A propulsion system to move the craft, and
4) The lift system to feed air into the plenum chamber below the craft in order to create the air cushion.

Some hovercrafts use a single engine system to provide both the air for the plenum chamber and propulsion. The difficulty in using one engine is to provide optimal efficiency for both systems, dividing the power for propulsion as well as for the fan to produce enough air for the lift.



Many modern air cushion vehicles use separate systems for air and propulsion. But advances in engines have made it possible to choose between one and two engine systems, especially for smaller, recreational hovercraft. Bigger, industrial, commercial or military hovercraft can have anywhere up to eight engines for propulsion and lift.



Design considerations

- Carrying capacity/payload
- Aerodynamic drag
- Thrust
- Skirt
- Stability

A hovercraft skirt is required to fulfill the following functions:

- Contain the cushion of air beneath the craft at the required hover-height.
- Have the ability to conform or contour efficiently over obstacles so as to keep the loss of cushion air to a minimum.
- Return to its original shape after having been deformed.
- Give adequate stability.
- Offer little resistance to the passage of obstacles beneath it.
- Have the ability to absorb a large proportion of the energy which is produced on impacts or collisions with obstacles greater than hover-height or cushion depth

The **power-to-weight** ratio determines the amount of ground clearance between the skirt and the ground surface. The greater this ground clearance the more efficiently the propulsion system operates. That is not to say that the higher the hovercraft lifts into the air the better. Lifting it too high will cause instability.

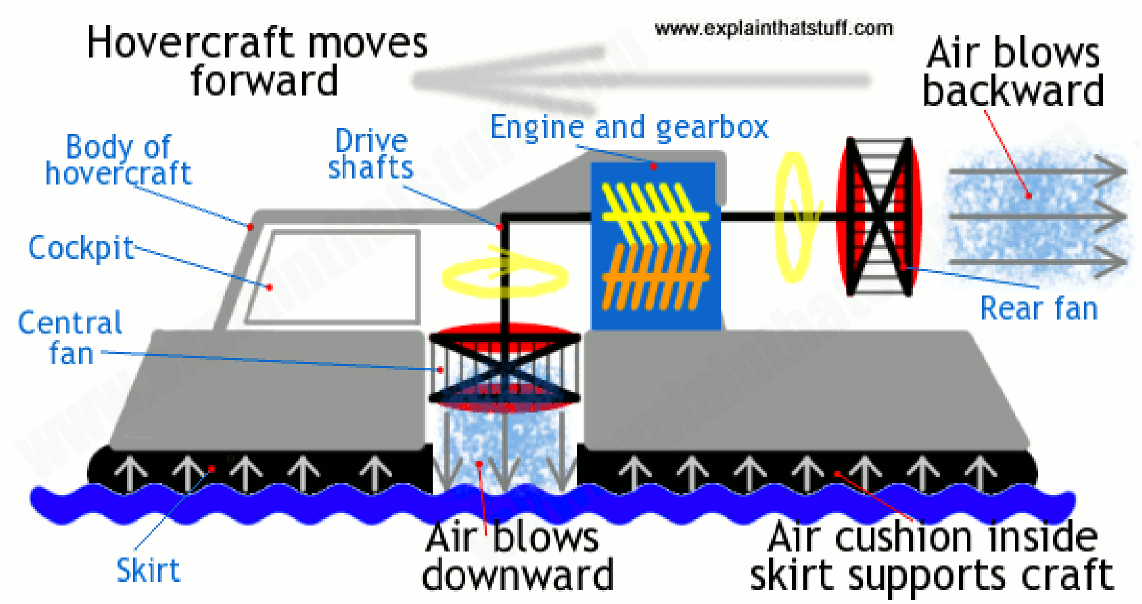
The **power-to-weight-to-strength** ratio deals with the structural strength of the craft to be light enough to be lifted by the air cushion created underneath, yet strong enough to carry the weight of the engine, its passengers or payload. Air cushion vehicle hull construction is more closely based on aviation rather than marine constructions for the simple reason that aviation hulls are a combination of strength and lightness as opposed to strength as a priority.

Although wood and plywood are often used, many hovercraft hull structures are made of aluminum skin, welded or riveted onto an aluminum web or frame. Enclosed spaces are sealed to provide airtight compartments for natural buoyancy.

A hole in the center of the raft can be made to feed air to the plenum chamber beneath the craft. However, the use of new skirt techniques makes peripheral jets, led in from the edge of the raft through ducts.

Other crafts use aluminum honeycombed paneling to provide the buoyancy, and fiberglass and composite materials, such as PVC, are becoming more popular as they combine strength, lightness and buoyancy in a single material.

Operation



Hovercrafts have a propeller attached to the back of the vehicle that blows air backwards, which pushes the vehicle forward providing thrust.

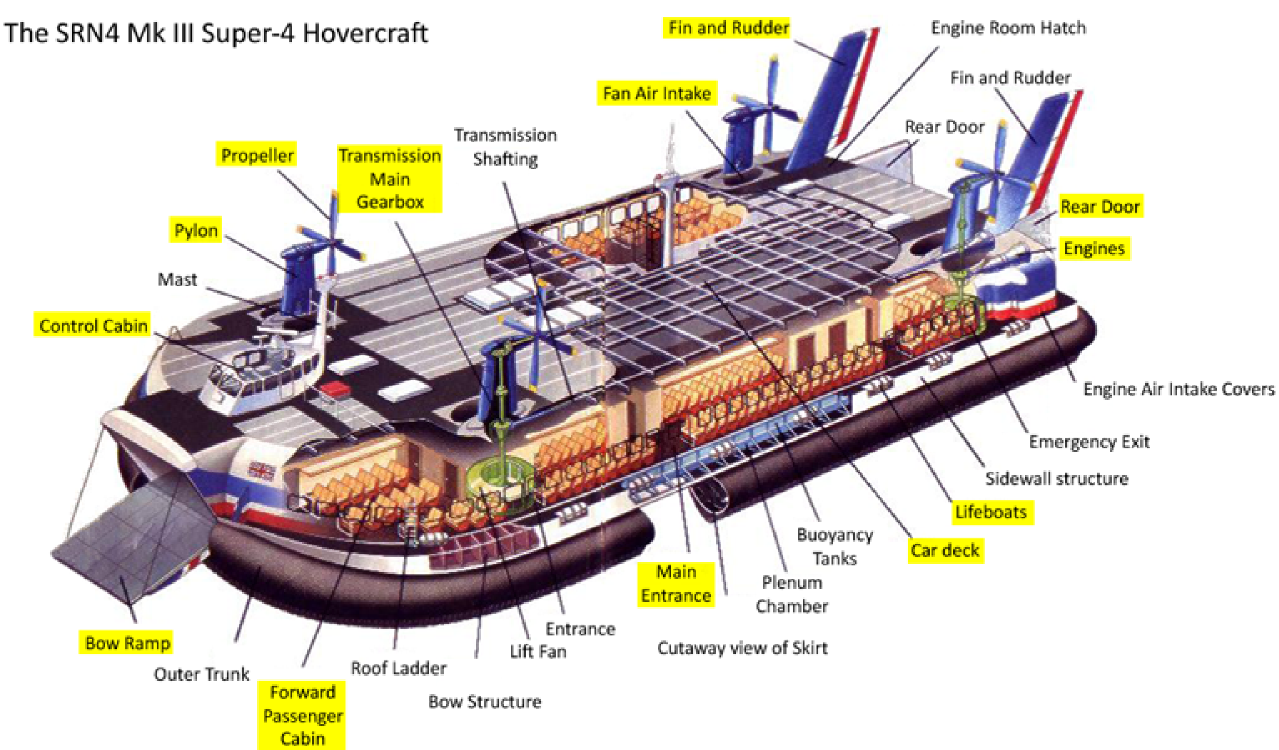
Steering can be achieved in three ways on a hovercraft:

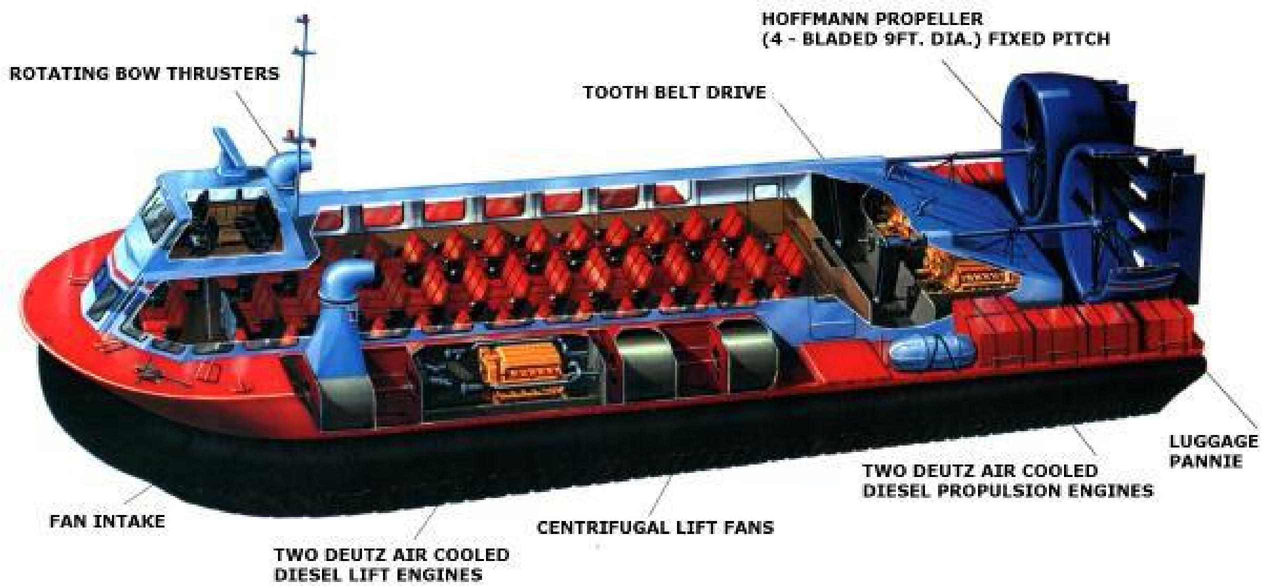
- By means of rudders behind the propeller or at the back of the craft,
- By means of moving the propellers themselves to change the direction of the thrust generated, or
- By means of moveable air ducts such as the bow thrusters on the AP1-88.

Rudders act much like the steerable wheels on a car. The direction in which a rudder points affects the direction the craft goes, by deflecting the air hitting it in the opposite direction. Rudders normally have about 30 - 45° maximum range of movement either side of their normal direction (aligned with the craft's forward direction). They are usually located directly behind the propellers of a craft (such as in Tiger 12 and AP1-88) or at the rear of the craft, like in the SRN4 or later version of the VA-3

API - 88

Bow thrusters are used along with rudders on the AP1-88. These use air bled from the lift system to push the craft in any direction. On this craft the bow thrusters can swivel up to 180° from their normal direction, allowing fine-tuned steering and even reverse thrust.





Rotating the propellers can be a useful form of steering also, most popularly as utilized on the SRN4 hovercraft. This craft had four propellers mounted on swivelling pylons, each capable of moving 30° either side of their normal heading. The swivelling pylons meant that the craft could turn or even counteract drift caused by a crosswind. Directional control was provided by the direction of the thrust emitted by the propellers.