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DESGIN AND FABRICATION OF HOVER CRAFT

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Abstract:

A hovercraft, also known as an air-cushion vehicle or ACV, is a craft capable of travelling over land, water, mud or ice and other surfaces both at speed and when stationary. Hovercraft is hybrid vessels operated by a pilot as an aircraft rather than a captain as a marine vessel. They operate by creating a cushion of high-pressure air between the hull of the vessel and the surface below. Typically, this cushion is contained within a flexible "skirt". They typically hover at heights between 200mm and 600mm above any surface and operate above 20 knots and can clear gradients up to 20 degrees. The project aims at designing in a hover craft model which is used for surveillance systems. The hover craft is controlled using wireless RC remote.

Hovercraft use blowers to produce a large volume of air below the hull that is slightly above atmospheric pressure. The pressure difference between the higher-pressure air below the hull and lower pressure ambient air above it produces lift, which causes the hull to float above the running surface. For stability reasons, the air is typically blown through slots or holes around the outside of a disk- or oval-shaped platform, giving most hovercraft a characteristic rounded-rectangle shape. Typically, this cushion is contained within a flexible "skirt", which allows the vehicle to travel over small obstructions without damage. This project finds its major applications while we are monitoring larger areas like political canvassing, cricket stadiums, international conferences, worship places, banking etc. This project assures us with more reliable and confident security system. Modelling and analysis of hover craft done in Pro-E and ANSYS FEA software.

Keywords*:* Hovercraft, Air Cushioned Vehicle, Bag Skirt, Unmanned, Pilotless, Reliability of Operation, Lift, & Propulsion.

I. INTRODUCTION

Background Introduction:

A satellite control testbed is being developed to simulate the zero drag environment of space. The problem is simplified by constraining the motion to a single plane (2 axis translational, 1 axis rotational). To create a frictionless surface, a few options including low friction bearings, magnetic levitation, and air bearings were investigated. The system had to be completely isolated to avoid torques and forces from a tether as well as transportable. The most realistic solution was to create an air bearing.

An air bearing requires air to be pressurized and blown out the bottom of the vehicle to keep a separation between the vehicle and the environment and create a “frictionless” surface. This air bearing can be created using compressed air in a tank or by using a compressor device. Using a pressurized tank would be ideal since there is no angular momentum created but with a low budget, a lightweight, high-pressure tank is not possible. The decision was made to use a motor with a propeller as in a hovercraft. An electric motor was used over a gas engine due to the reduction in vibrations and the hassle of starting and refueling a gas motor. Two electrics motors were used to counteract the torques that each would produce and create a zero-momentum system. By placing the motors vertically, the propeller velocities could be varied and be used as a reaction wheel about the third axis. The resulting vehicle is shown in Figure 1.

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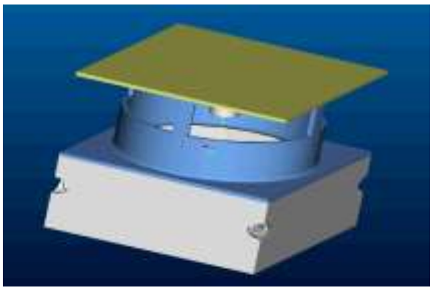
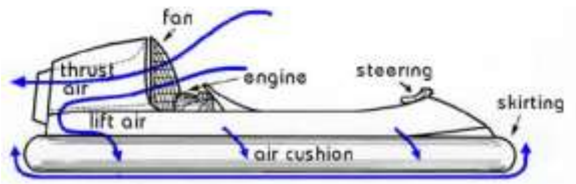
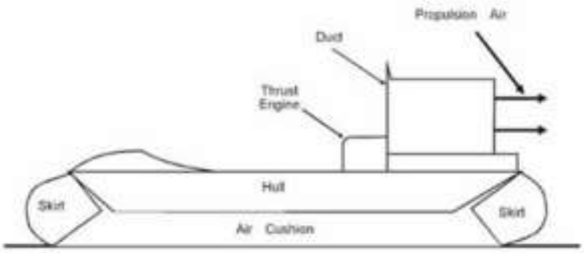


Hovercrafts are vehicles that can traverse over a diverse range of relatively smooth terrain. A cushion of air is generated through a lifting fan underneath the vehicle. A flexible skirt traps this air simultaneously and causes an increase of air pressure. This trapped cushion of air provides a frictionless surface to glide upon and hence gives the hovercraft the ability to traverse water, ice, snow, or mud. Vehicles of this nature can hover over agricultural crops without damaging them. Hovercrafts can achieve relatively high speeds at lower consumption of energy as compared to contemporary transport vehicles like ships, boats, helicopters, and ground vehicles. The concept and term of the modern hovercraft is associated with Sir Christopher Cockerell, who experimented with several models in the 1950's.

The design of hovercrafts in various configurations and types are well established in text. The purpose of this paper is not to present a new or augmented design to the already conventional literature. The purpose is to utilize the established theory to design and fabricate a hovercraft with the resources and equipment available in many countries. This project is unique when compared to the contemporary designs seen in this country for this type of vehicle in the sense that it is pilotless. The absence of a pilot supplements the capability of transporting loads to hazardous locations with a lesser power demand and safety to human life. Design data and performance parameters are presented so that future researchers can take advantage of this literature in augmenting or creating a new design. The hovercraft presented in this paper is a light hovercraft vehicle. A hovercraft that carries less than a 1000Kg load is classified as a light hovercraft vehicle. The vehicle is designed with a balloon skirt. The following sections will discuss the design and assembly process for the lift, thrust, and steering systems. The design and fabrication of the frame and assembly is presented.





Limitations are discussed and future considerations are highlighted. The advantageous to hovercrafts in many countries are numerous. They can aid in providing relief work and supplies to remote areas affected by natural disasters. They can be used in diverse terrains to facilitate transportation of goods and personnel in an efficient and optimal manner. The pilotless hovercraft presented in this paper can be used as a transport vehicle in space stations or in outer space colonies where pressurized cabin air can facilitate the vehicles levitation. The power to weight ratio of hovercrafts can make them beneficial and attractive alternatives to heavier and less efficient vehicles. This is crucial in space missions where weight is a primary factor to success and failure. Hovercrafts can also be used as simulators for planetary vehicles and may even pose to be viable transport solutions if pressurized atmospheric gasses are found in planets' atmospheres.

2.0 Method

The following section defines the terminology and scope of work for the intended system. A brief discussion of the working principles, governing equations, prototype design, modeling, fabrication, and testing are consequently presented.

2.1 Definition & Design of Hover Craft

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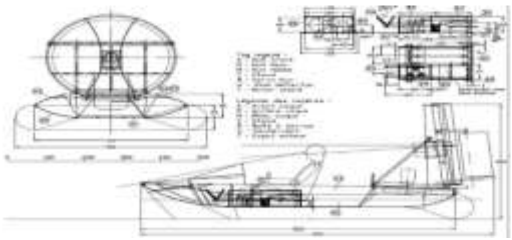
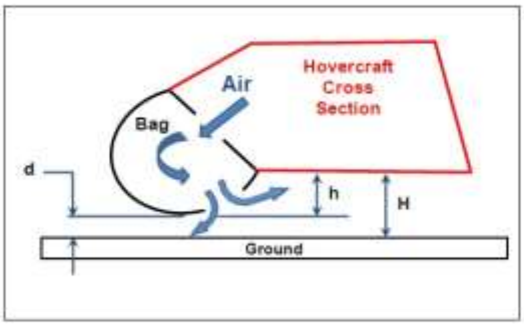
A hovercraft is a vehicle that glides over a smooth surface by hovering upon an air cushion. Hovercrafts are also called an Air-Cushion Vehicles (ACV) because of this hovering phenomenon. Hover means 'to be suspended in the air or afloat in the air'. The hovercraft involves two main principles: principle of lift and principle of propulsion. For propulsion of the hovercraft, a propeller is pivoted within the duct. The rudders attached to the duct are responsible for the turning of the hovercraft.

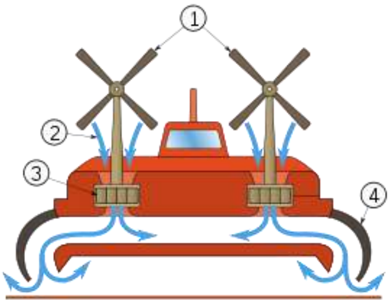


The design of this propeller is important when considering the optimal speed for the hovercraft and the consumption of power. For the lifting the vehicle produces air by the means of fan or blower. This air is forced by an attached motor or engine which traps the air beneath the vehicle via a curtain called a skirt. This air cushion provides the necessary lift to glide over surfaces and hence produces the hovering phenomenon. A flexible material makes up the skirt, which is the region where the air is trapped and is consequently released with the buildup of pressure. Hovercraft designs employ two commonly used skirts. The bag or loop skirt and the finger or segment skirt. The Bag skirt can easily be described as a tube like skirt as it looks like a tube sealed around the boundary surface of hovercraft. The bag skirt inflates into a tube shape around the hovercraft when air is pressurized through the blower or engine. This helps in trapping the air and providing the necessary levitation. The finger skirt is a collection of many 'U' shaped bags. The air is then pumped out and fills into the divided bags. These segments (composed of combination of U-shaped bags) have holes in them, which cause the transfer and distribution of air. When air pressure is built under the hovercraft, the skirt inflates, and a certain amount of air is trapped before it escapes to the outside environment. This volume of trapped air is referred to cushion air [1]. The thin air gap, d, on which the hovercraft seems to float on is called daylight clearance, Figure 1. The distance from the ground to the underside of the hovercraft is "H" and the distance from the bottom of the inflated skirt to the underside of the hovercraft is "h". Day light clearance typically varies from 1.5cm to 2.5 cm. The day light clearance depends upon skirt design and the amount of being forced in by the lift fan. It is recommended to keep day light clearance as small as possible because almost one third of the available power goes into providing the necessary lift. The hovercraft presented in this paper has been designed to lift 200kg, use bag skirts to develop the air cushion, have a minimum operation time of 30 minutes, and be able to operate without a pilot or driver on board the vehicle.



The Bernoulli's equation is simplified to Equations 2 – 3 to find the escape velocity. This velocity is used with mass flow rate and the kinetic energy equations to find the power required for lifting the vehicle. The escape velocity is the velocity of the air which escapes from the skirt and forms the frictionless surface underneath the hovercraft. This calculation is very important as the efficiency of the power consumption depends upon the escape velocity. The greater the escape velocity will create a larger frictionless surface and will therefore require a larger power requirement. The approximated power requirement through these calculations is 2.9 kW. Two motors have been employed to provide the necessary lift and thrust for the vehicle. A blower unit is used for lifting and a 0.76-meter propeller is used for thrust. The mass airflow calculations for both the lift and thrust have not been included in this paper for brevity. Readers are referred to the following text for the design calculations of mass airflow of lift and thrust in this hovercraft. General theory for lift calculations can be accessed by text and a good guideline for thrust calculation in a ducted fan is given. Data reported in the results and discussion section presents the measured parameters for airflow.

The hovercraft has also gone through a modeling and simulation phase to determine the best material and deign possible for operation. A 3D prototype model was developed in PRO-E and a static linear analysis was conducted in ANSYS to determine the best material and thickness for the base of the vehicle. Details of the analysis can be found. The best material that was found suitable for both land and water applications was fiberglass. Fiberglass is fiber-reinforced polymer, which is strong, durable, lightweight, and robust. It is also very expensive. It was therefore decided that a more inexpensive material be used for the first prototype design of the vehicle. The hovercraft designed in this paper is made out of 22-gauge steel sheets. Although his adds much weight, it also gives a good opportunity to experiment and modify the design. The weight of the frame of the vehicle is approximately 80 Kg and can be reduced considerably if a lighter material is used. Table 3 presents the performance parameters of this hovercraft. The next prototype of this hovercraft will hopefully employ fiberglass and it is logical that the lift capacity, lift height, operational time, power requirements, and vehicle durability will be greatly improved. It is also hoped that researchers can use this hovercraft and design parameters as a benchmark for future designs. The results of using steel as a material is presented in this paper and the performance data fora lighter tougher material must give even better results.



1. Propellers
2. Air
3. Fan
4. Flexible skirt

2.3 Manufacturing and Assembly

. Two round stripes were added to the structure of the duct to support the upper skin of duct so that the flexible sheet could be formed into round shape and doesn’t deflect due to air thrust from the propeller. The duct was mounted on the hovercraft with bolts. The rudders were mounted at the far end of the duct to alter the direction of thrust so that the direction of hovercraft can be controlled. These rudders were coupled with a 12V motor.

Two DC motors were mounted in the duct, Figure 7, and to the centrifugal blower unit, Figure 8, for thrust and lift. The Bag skirt design was selected for the vehicle and a rubber skirt, Figure 9, was riveted throughout the base. A 130A/hr., 12V lead acid battery was used to supply the power for the motors and it was mounted just under the passenger seat i.e.
At the center of gravity of the hovercraft.

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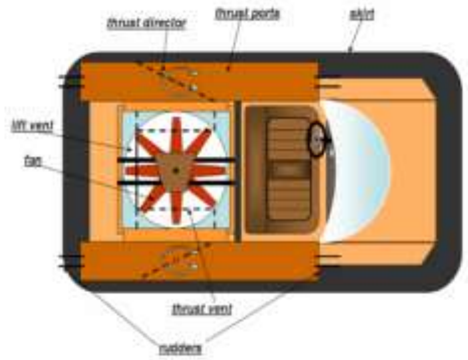
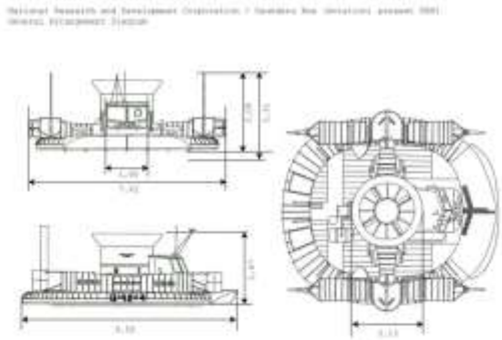
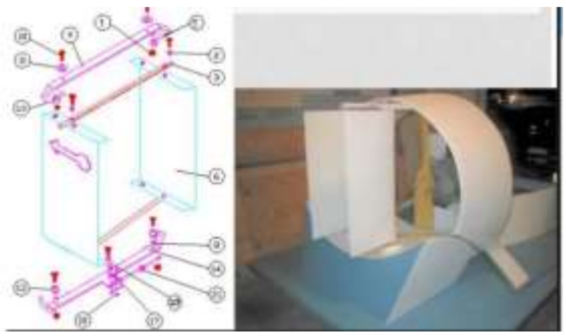




To augment the design of the hover craft it was decided to make it unmanned. This is achieved via remote control. A three channel IR remote controller was used to control the direction of rudders, speed of thrust propeller and hovering of the craft. The rudder motor's speed was reduced by a pulse width modulation (PWM) generated from 555 timer IC. The direction input from remote controller was given to ULN2003 IC which is the driving IC and also used to actuate the relays.



The PWM output from 555 IC was given to relay so that when the specific relay actuates due to the input of the IR remote controller given at ULN2003 IC, the PWM passes from the relay and goes to L298 IC. This IC is a H-bridge IC to control the direction of motor and actuate the gate. The motor hence starts to move CW or CCW with a reduced speed due to PWM applied at it. The speed of propeller for thrust was controlled from the remote controller as well. The PWM generated in the remote was given to a module of field effect transistors, which were connected in parallel to cater for the high amperage of the motor. A heat sink was also used. The hovering was also controlled from the remote controller. Two relays capable of catering high amperage were connected in parallel and these relays were actuated by the input signal given by remote controller via ULN2003 IC.

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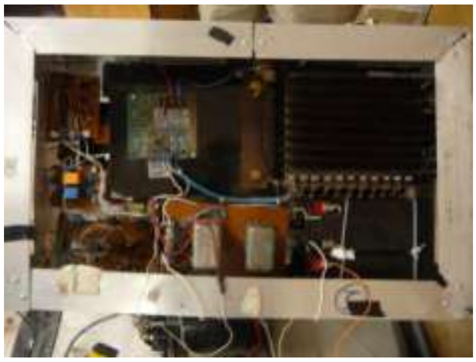

These circuits were placed in an aluminum dashboard covered with an acrylic sheet. A fan was provided to cool the circuits. A separate battery of 12V, 7A/hr. was used to power up the circuits so that back EMFs from the propeller and blower motors did not damage the delicate circuitry. Figures 12 & 13 show the circuitry and assembly.

With the remote-control sensors in this hovercraft, the max distance of 10 meters can be maintained. As mentioned earlier this is the first prototype hovercraft for the intended design. Subsequent designs will employ lighter and more robust materials. This will increase the operational time, life capacity, and power consumption of the vehicle. The vehicle has also been tested successfully on relatively smooth surfaces like cement, tiles, sand, mud, and grass.

The data presented and published in this paper should serve as a benchmark and guideline for future designs of hovercrafts in many countries.

Qualitative benefits

Rescue purposes of hovercraft, Hovercraft has the ability to hover above land, thin ice, and water, even during flood conditions, is a lifesaving asset to both victims and rescuers. Due to their unique capability to safely access areas that no other rescue vehicle can reach, hovercraft is used in a diversity of rescue scenarios. These include, but are not limited to

- Rescue operations on rivers, lakes and oceans in ice, swift water and mud
- Search and rescue missions in floods, shallows, wetlands, bogs, marshes and sand
- Rescue operations in Tsunami
- Dive team recovery missions
- Aircraft crashes

These services provided are priceless benefits.

One of key areas in which the use of hovercrafts will be highly beneficial is the growing industry of tourism. The ability of a hovercraft to travel on both land and water will pave way for a whole new experience for passengers. Riding the hovercraft will not be just another cruise at sea. It will have the unique feel of being part airplane and part speed boat. Tourists will be able to get up close with aquatic wildlife and enjoy the excitement the ride has to offer. These facts shows that hovercrafts play a significant role in tourism hence directly increase the revenues from tourism.

Feasibility of employing hovercrafts for many countries maritime defense

- Its rapid deployment capability with the ability to converge on an enemy target with minimum delay
- Higher energy efficiency compared to conventional buoyant watercrafts (i.e. ships and boats) due to fluidic resistance from contact of water
- Improvement of coastal defense efficiency will eventually decrease the number of security units that needs to be deployed to maintain coastal defense
- Ability to maneuver land-based terrain along with oceanic floors

In combination, we believe that hovercrafts are the most suitable crafts to be used for maritime defense in Sri Lanka and this region. It will not only improve defense and security in the region, but will reduce the costs on maritime defense making an impact on the overall defense budget.

4. Conclusion

An unmanned battery-operated light hovercraft has been presented in this paper. The process of engineering has been outlined. Important design parameters and performance parameters have been highlighted. This project is particularly important for many countries because it has utilized resources and equipment only available here. The final scope of this project is to produce a fully autonomous unmanned hovercraft capable of obstacle avoidance. To achieve this the next prototype will employ lighter and more robot materials such as fiberglass. It will utilize a lighter and more efficient energy source, preferably one that has a long operation time. Sensors, artificial intelligence, and circuitry will be employed for the autonomous vehicle.

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The vehicle will also be tested on water and mud. Such vehicles are very beneficial in providing quick and efficient transport to remote locations without human intervention. They can traverse diverse terrain such as mud, water, ice, and vegetation. These capabilities can also make the hovercraft a viable solution for equipment and personnel transport in outer space structures or colonies. Hovercraft can also serve as simulators of outer space rovers to provide training to astronauts in inter planetary exploration. It is even possible that planets will atmospheric air exist apart from our own. Such places can be explored efficiently in vehicles such as hovercrafts.

The hovercraft discussed in this paper is also available here at the international conference for display and operation. It is hoped that this vehicle will raise awareness among the engineering and technological community of many countries to vehicles of this nature. It is also hoped that this literature will provide an access to future researchers in designing and manufacturing such vehicles. Lastly it is stressed that many countries do have the capability to engineer and manufacture projects that can facilitate her future. Indigenous projects such as this one should find a way into the industry so that many countries can strengthen her economy and stability. Hovercrafts, such as the one presented, can be used by the armed forces and even in commercial or consumer industries.

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