Designing of Unmanned Surface Surveillance Vehicles (USSVs)

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Abstract – *The navy and other department of defense organization are increasing the interested in the used of Unmanned surface surveillance vehicles for variety of missions and applications. The term USSV refers to any vehicle that operates on the surface of the water as well on the ground surface. USSVs have the potential, and in some cases they demonstrate the ability, to reduce risk to man forces, provide the necessary force multiplication to accomplish military mission, performed the task which man vehicles cannot and do so in a way that is affordable to the navy. Technical challenge of developing USSV includes its intelligence level, control, high stability and developmental cost reduction.*

1. INTRODUCTION

Unmanned surface surveillance vehicles (USSVs) have also called autonomous surface craft (ASC). As the name implies they remove the operators from the platform and allow new modes of operations. As global positioning systems have become more compact, effective and affordable unmanned surface vehicles have become more capable. Long range and higher bandwidth wireless data systems have also been key to rapid growth on USSVs for many applications. USSVs are used for military, commercial, and research purposes. The potential of the use of unmanned surface surveillance vehicles (USSVs) for tasks such as shallow-water surveying, weapon delivery, environmental data gathering, and surveillance is quite advantageous.

2. DESIGN

Design consists of application of scientific principles, technical information and imagination for development of new or improvised machine or mechanism to perform a specific function with maximum economy & efficiency.

Hence a careful design approach has to be adopted. The total design work, has been split up into two parts

- System design
- Mechanical Design.

System design mainly concerns the various physical constraints and ergonomics, space requirements,

arrangement of various components on main frame at system, man and machine interactions, No. of controls, position of controls, working environment of machine, chances of failure, safety measures to be provided, servicing aids, ease of maintenance, scope of improvement, weight of machine from ground level, total weight of machine and a lot more.

In mechanical design the components are listed down and stored on the basis of their procurement

PARTS TO BE DESIGNED & MANUFACTURED

1. Hull (2 no's) --- PVC pipe
2. Base Brackets (12 No's) ….Aluminum
3. Propulsion Fan (1 N0's) ----Plastic
4. Propulsion Shaft (1 N0's) ----Mild steel
5. Propulsion Drive (Elbow Mechanism) ---Mild steel
6. Propeller drive gear box----Polyamide gears
7. Steering Mechanism gear box---Polyamide gears
8. Steering linear actuator (Rack & pinion) Polyamide gears
9. Steering mechanism arm…..Aluminum
10. Camera Base bracket ….Aluminum
11. Camera Drive Gear box ….Mild steel/Polyamide gears
12. Wireless microcontroller

Description and Calculation

Rack And Pinion:

Number of teeth's on Pinion = 24

Inner diameter of Pinion = 6mm

Outer diameter of Pinion = 20mm

Type of Gear = Spur Gear

Length of Rack = 145mm

Number of teeth's on Rack = 46

Fig.1. Rack & Pinion

Design of Pinion Shaft

Material Selection: -Ref: - PSG (1.10 & 1.12) + (1.17)

Designation EN 24

ASME Code For Was Used For Design of Shaft

Pulley & Belt

A pulley is simply a collection of one or more wheels over which you loop a rope to make it easier to lift things.

Fig.2. Pulleys & Belt

Power Transmission

Belts are the cheapest utility for power transmission between shafts that may not be axially aligned. Power transmission is achieved by specially designed belts and pulleys.

Design Calculations:

Velocity of belt: V= 0.0733 m/sec

Power: P = 119.59 W

Angle of contact: $\theta_s = \pi$

Limiting tension: $\frac{T_{ft}}{T_{fs}}$

Centrifugal Tension T

c = 2.56x10-5 N

Initial Tension: Ti = 2185.545 N

Length of Belt L= 441.99 $\approx$ 442 mm

Total tension in tight side: Ttt =3001.3 N

Maximum tensile stress in belt σt= 1.081

Scissor Lift Operation

Scissor lifts owe their mechanical capability to the pantograph. A pantograph is a series of linked parallelograms with hinged intersections that allow the operator to elongate the mechanism while still maintaining the integrity of the geometric figure.

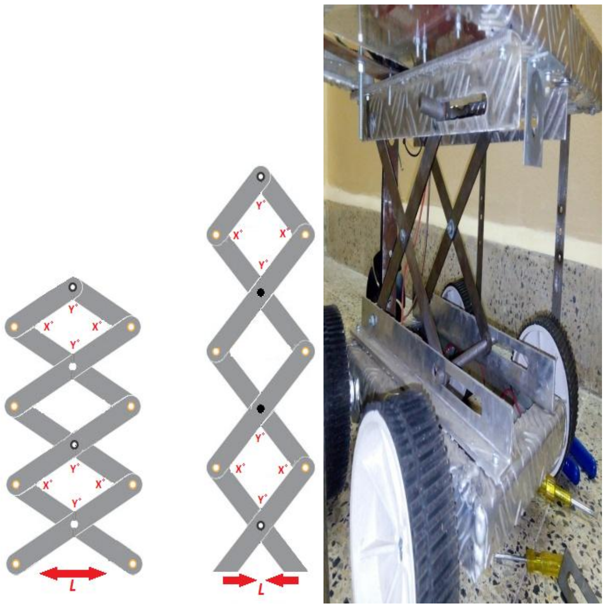


Fig.3. Scissor Mechanism

Torque in a motor

T = ½ x (Ia / A) x Z x φ x {P/ (ΠDł)} x Dł

Motor:- An electric motor is an electrical machine that converts electrical energy into mechanical energy. The reverse of this would be the conversion of mechanical energy into electrical energy and is done by an electric generator.

200 RPM 12V DC motors with Gearbox

- 3000RPM base motor

100 RPM 12V DC motors with Gearbox

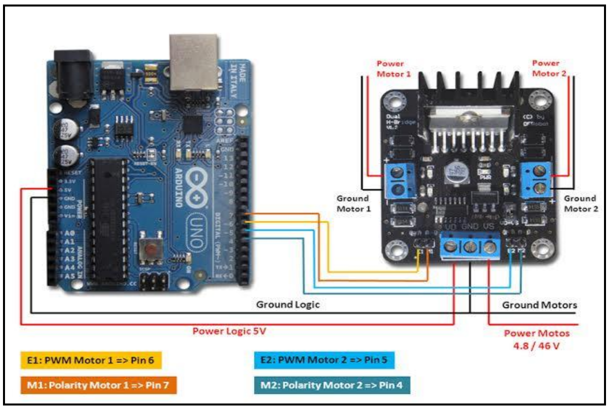
- 3000RPM base motor

30 RPM 12V DC motors with Gearbox

3000RPM base motor

Electronic Components

Microcontroller:



The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button.

Battery

Turnigy batteries are known the world over for performance, reliability and price. It's surprise to us that Turnigy Lipoly packs are the go-to pack for those in the know. Turnigy batteries deliver the full rated capacity at a price everyone can afford.

Remote Controller

The Wireless Six Axis Controller has a range of 30 feet, with analog controls providing 360 degrees of smooth movement and a D-Pad for precise control. The Six Axis Wireless Controller for PS3 employs a high-precision, motion sensitive, six axis system, which detects natural hand movements for intuitive real-time interactive play.

Wireless Camera & Receiver

Wireless CCTV Audio Video Camera is an easy installable device can be used both indoors and outdoors and is perfect to monitor areas that regular security cameras cannot cover

Aluminium Welding

Aluminium is a very reactive metal, and bare aluminium will form an oxide layer in minutes. (Fortunately the oxide layer protects the aluminium from further corrosion and that's why it lasts so well). But the reactivity of aluminum poses a safety concern.

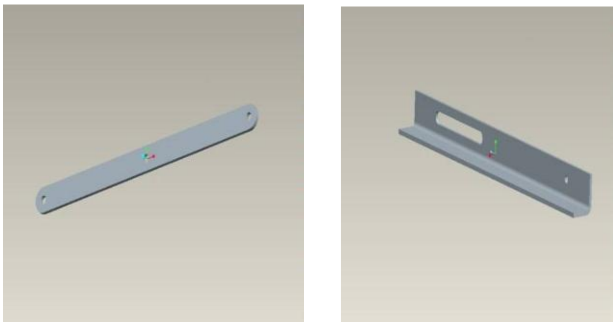


Fig.4.Links and sliding bar

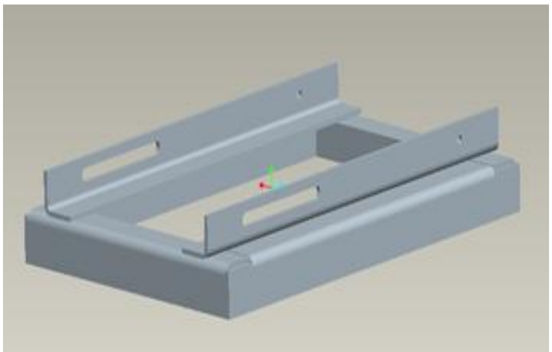


Fig.5. Lower frame

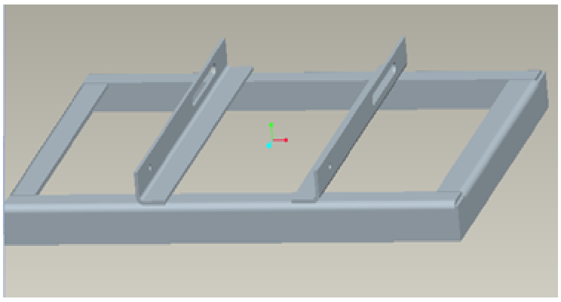


Fig.6. Upper frame

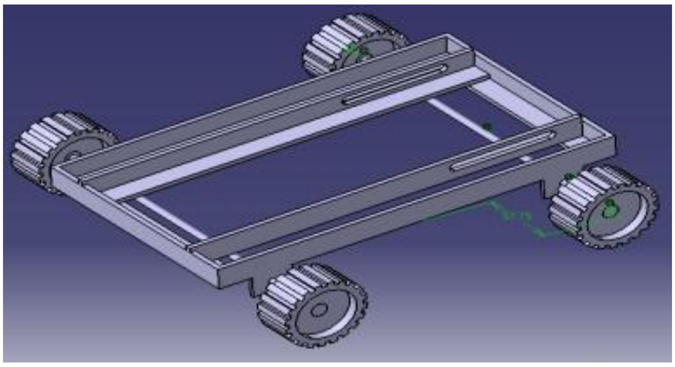


Fig.7. Lower frame with wheels

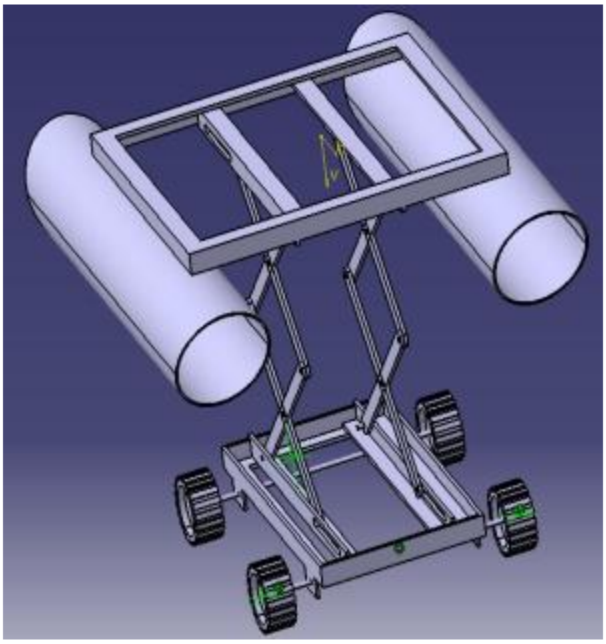


Fig.8.Final Design with scissor mechanism

The final design that was chosen for this project is a catamaran hull surface vessel with a 12V DC trolling motor as the propulsion system.

Hull and Platform

The hulls of the vessel will be constructed from PVC pipes. Rankine oval shaped caps will seal the end of the pipes.

Steering and Propulsion

The power for the vessel will come from a 12 volt DC battery for a deep cycle usage. The propulsion and steering will come from an electric DC outboard motor.

Direction Control

The direction of the outboard motor will be controlled using a remote control receiver. The receiver will control a linear actuator that will drive a torque arm to turn the motor.

3. TESTING

Control Test:-

The first test that was completed was a control test. The linear actuator and trolling motor were tested for functionality. These tests were completed to ensure that the user has complete control over the vessel, which reduces any safety risks.

Turning Test:-

Several Turning tests were completed during the testing sessions. This Included turns from a standstill and also turns while underway. For each of these two categories, port and starboard and also forward and reverse turns were initiated. The Purpose of the turning test is to ensure that the vessel meets the design criterion of having a turning radius of 10 m.

Speed Test:-

Two speed tests were conducted during the testing sessions. These tests were conducted to ensure that the vessel met the design criterion of an operating speed. The vessel was placed at one end of the pool and was driven to the other end while the elapsed time was recorded for each 2.5 m segment that the vessel covered.

Payload Test:-

A Payload test was conducted during the testing sessions at the pool. A Weight of 2.5kg was added to simulate the instruments that will be utilized on the vessel.

Stability Test:-

A stability test was conducted by using the weight of team members on a pontoon while the vessel was stationary. The angle of inclination of the vessel was recorded so that the Meta centric height Of the vessel can be determined.

4. CONCLUSION

Unmanned surface surveillance vehicles (USSVs) aim to extend the demonstrated capability against subsurface contacts to surface contacts. Such work will involve multiple vehicles in cooperation to accomplish the mission. Additional measures must be taken to avoid collisions with other vessels (cooperative or otherwise) and fixed objects which will be found in an operationally relevant environment. The basis for such accomplishments builds directly from earlier work described in the preceding section. Important tools already in use are the MOOS and IvP Helm.

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