This project paper demonstrates the construction of RC airplanes, the theories behind the flight of these miniature structures and the specifications of the components assembled in the designed RC plane.

Author Name: Naresh.K
Web Site: www.rcbuildfly.weebly.com
About our Book:

This project book demonstrates the construction of RC airplanes, the theories behind the flight of these miniature structures and the specifications of the components assembled in the designed RC plane. This book is created to enable all those enthusiastic students, who are interested to create RC planes, to get an overview of the construction of miniature flying machines. This book also demonstrates the construction of water rocketry, paper planes and also real-time construction of flights or similar aerodynamic structures.

Naresh.K

B.E Aeronautical Engineer

Rc Build Fly

www.rcbuildfly.weebly.com

09003033595
ACKNOWLEDGEMENT

It’s my important duty to thank and submit my work to the divine feet of Pondy Mother and Aravindar, under whose blessings, love, protection and divine grace.

Our heart full thanks to the almighty for all his blessings and love. The success chronicle of Rc Build Fly that we celebrating now would have been an improbable destiny without the constant guidance and support of a large number of people. We are extremely delighted to have this opportunity to express our sincere gratitude and salutations to all of them.

I dedicate our sincere thanks to my beloved Dad R.Kumarasamy for his constant support and encouragement.

I highly indebted to my Mom K.Kala who has been constantly inculcating us on various counts.

I extend my special thanks to My Brother Muthukrishnan Kumarasamy (MSc Advanced Engineering Design) for his guidance and support throughout the project.

I owe my deepest gratitude to my mentor Lect. V.Vinoth., whose inspirational speech, vision, guidance, support and training had transformed my life personally and enabled me to achieve huge success in this project. I’m indebted sir.

This paper is dedicated to my lovely grandparents for their infinite love, constant support, and this wonderful opportunity.

Finally I would like to take this opportunity to thank our friends N.Muthu Kumar, U.Naveen Kumar, K.Prakash for their endurance, patience and support in achieving my ambition.
# Table of contents

1. Abstract ................................................................................................................. 6
2. Gist of theory .............................................................................................................. 6
3. General introduction ................................................................................................. 6
   a. Aeronautics Definition ....................................................................................... 6
   b. Rc airplane ........................................................................................................ 6
   c. Rc airplanes propulsion/ power plants ............................................................... 7
   d. Rc electric motors ........................................................................................... 7
4. Parts of RC airplane ................................................................................................. 7
   a. Fuselage .......................................................................................................... 7
   b. Wings ............................................................................................................... 7
   c. Engine ............................................................................................................. 8
   d. Engine cowl ...................................................................................................... 8
   e. Propeller .......................................................................................................... 8
   f. Horizontal tail .................................................................................................. 8
   g. Empennage ...................................................................................................... 9
   h. Vertical tail ...................................................................................................... 9
   i. Spinner ............................................................................................................. 9
   j. Ailerons ........................................................................................................... 9
   k. Flaps ............................................................................................................... 9
   l. Elevators ......................................................................................................... 9
   m. Rudder .......................................................................................................... 9
   n. Nose gear ....................................................................................................... 10
   o. Main gear or landing gear ............................................................................... 10
5. Basics of Aerodynamics .......................................................................................... 10
6. Construction of RC airplane .................................................................................... 13
   a. Airframes ....................................................................................................... 13
   b. Plan – Layout of the model ............................................................................. 13
   c. Blocking wind ribs ......................................................................................... 16
   d. Fuselage ....................................................................................................... 17
   e. Wings ............................................................................................................ 18
   f. Hatches .......................................................................................................... 19
   g. Installations ................................................................................................... 20
   h. Hinges .......................................................................................................... 20
   i. Special linkages ............................................................................................. 21
   j. The Propeller Installation ............................................................................ 23
   k. Battery Elimination Circuit (BEC) ................................................................. 23
7. Adjustment Check List ................................................................. 25
8. Glide ............................................................................................. 26
   a. Aspect ratio affect on the stall angle of attack of RC airplane
   b. Aspect ratio affect on the wing lift coefficient of RC airplane
   c. Cg of RC airplane - how to check the center of gravity point of RC airplane
   d. How to check the RC airplane for structural strength before flying
9. Wing design Explanation .......................................................... 28
10. Wing Design .................................................................................. 28
11. References

Appendix

Specifications of the components ..................................................... 29

A. Fly sky fs-th9x 9ch transmitter .................................................. 29
B. Setup ......................................................................................... 30
C. Flight testing .............................................................................. 30
D. Corrugated plastic / Coro polypropylene sheet ............................... 30
E. Scorpion sii-2208-1100 v2 brushless motor .................................. 31
F. Propeller ................................................................................... 33
G. RC lithium polymer battery ...................................................... 34
H. Grayson hobby 30amp brushless speed controller (esc) .................. 34
I. Hitec hs-55 micro servo ............................................................ 35
J. Specification of UAV ................................................................... 36
K. Photos of our UAV ................................................................... 37
L. External view of an UAV ............................................................. 38

Water Rocketry ................................................................................. 39

A. Operation ................................................................................... 39
B. Multi bottle rockets ................................................................. 41
C. Two multi bottle rockets ........................................................... 41
D. Sources of gas ........................................................................... 42
E. Nozzles ...................................................................................... 42
F. Fins ............................................................................................ 43
G. Water rocketry competition ...................................................... 44
H. Conclusion ................................................................................ 47
Design, Development and Demonstration an of RC Airplane

Naresh.K

ABSTRACT
The essence of the intense theory models of the aeronautical study could be apprehended with the hands-on experience on the real-time construction of flights or similar aerodynamic structures. So a new project was launched to design, develop and operate an RC airplane. This project book demonstrates the construction of RC airplanes, the theories behind the flight of these miniature structures and the specifications of the components assembled in the designed RC plane. This paper is created to enable all those enthusiastic students, who are interested to create RC planes, to get an overview of the construction of miniature flying machines. The electronic components are readily available in the market as a ready-to-install sets. So this book assumes that explaining the intricate details of electric circuits as absurd. But all possible efforts have been made to explain the detailed mechanical and aerodynamic properties of the RC airplane. The model was constructed and was exhibited and demonstrated in an international technical festival held at IIT, Bombay. This model won the best design award for the year and made a successful flight at the event.

Gist of theory
General introduction

Aeronautics Definition
Aeronautics is the study of the science of flight. Aeronautics is the method of designing an airplane or other flying machine. There are four basic areas that aeronautical engineers must understand in order to be able to design planes. To design a plane, engineers must understand all of these elements.

RC Airplane
RC planes are small model radio-controlled airplanes that fly using electric motor, gas powered IC engines or small model jet engines. The RC Airplanes are flown remotely with the help of a transmitter with joysticks that can be used to fly the aircraft and perform different maneuvers. The transmitter comes also with a receiver which is installed inside the Model RC Airplanes which receives the commands send by the transmitter and controls servos. The servos are small motors which are mechanically linked to the control surfaces e.g., ailerons for roll control, elevator for pitch control and rudder for yaw control. The servos moves the control rods (which are small rods that connect the servo to different flight control e.g. to elevator etc) which in turn moves the control surface be it elevator, flaps, aileron or rudder. An RC Airplane can be
controlled in flight by using the transmitter from where you can control pitch, yaw and roll of your RC Airplane and you can also control the throttle settings. The receiver which accepts the transmitter signal and the servos attached to it are run on rechargeable batteries. Most popular rechargeable batteries for RC Airplanes use include Ni-Cad (Nickel Cadmium) and Li-Po (Lithium Polymer). Lithium Polymer lasts longer and more powerful than there Ni-Cad counterparts but a bit more expensive.

**RC Airplanes Propulsion/ Power plants**

RC Airplanes fly using either electric motor as propulsion device or IC (internal combustion) gas powered engines or small model jet Engines.

**RC Electric Motors**

Electric motors are most used in many model RC Airplanes because of the ease in use. Electric Motors give the advantage of low-cost, easy to use. The throttle of electric motors is controlled using a speed controller which comes with the motor. The speed controller lead is connected to the receiver. The transmitter than can control the throttle of electric motor just as other controls.

**Parts of RC Airplane**

The parts of the RC Airplane include,

**Fuselage**

Fuselage is the main structural element of the RC Airplane or the body of the RC Airplane. The Wing, Horizontal and Vertical Tail are connected to the fuselage. The Engine is also mounted to the fuselage. The fuselage is made up of bulk-heads. The bulk-heads are structural members which give strength and rigidity to the fuselage, support load and weight of the RC Airplane. The Engine bulk-head is made relatively stronger as compared to other bulk-heads of RC Airplane fuselage because it carries the load of the engine as well as encounters vibrations during engine operation so it must be strong to resist all the loads. The nose gear and main landing gear are also connected to the fuselage. The fuselage also houses all the electronic components necessary for RC Airplane flight including ESC (electronic speed controller) in case of electric RC Airplane, Receiver, Servos, Batteries and fuel tank in case of gas powered RC Airplane. External or internal payloads are also carried inside the fuselage. The fuselage can be used to connect an external camera for example or to carry some payload inside the RC Airplane.

**Wings**

Wings are the main lifting body of the RC Airplane providing the lift necessary for RC Airplane flight. The wing provides lift because of its aerodynamic shape which creates a pressure differential causing lift. If a cross-section of the wing is cut, a shape or profile is visible which is called an airfoil. Airfoil shape is the key to the wings ability to provide lift and is airfoil selection and design is an important criterion in the design of RC Airplanes. The front most edge of the wing is known as leading edge and the aft most edge of the wing is known as the trailing edge. There are typically three kinds of airfoils which are used on RC Airplanes namely, symmetrical
airfoils, semi-symmetrical airfoils and heavily cambered airfoils. On the wing are mounted the flaps and ailerons.

**Engine**

Engine is the main power-plant of RC Airplane. The power-plant of RC Airplanes can be electric motor, internal combustion gas engines and jet engines. The engine is mounted on the RC Airplanes and provides thrust to the RC Airplanes. Thrust is the forward force necessary for flight. The engines run a propeller.

**Engine Cowl**

Engine Cowl is the external covering made of fiberglass or plastic material to protect the engine from debris from the ground during takeoff and landing. The engine also makes the RC Airplane more aerodynamically clean.

**Propeller**

The propeller is basically a wing section made of airfoil sections just like a wing but it is twisted along the span. The propeller is mounted to the engine in propeller driven RC airplanes. Jet engine RC Airplanes don’t have a propeller and generates thrust by means of the jet engine.

**Horizontal Tail**

The horizontal tail or the horizontal stabilizer provides pitch control to the RC Airplane. Elevator is mounted on the horizontal stabilizer or horizontal tail of RC Airplanes. Normally, the Horizontal tail is set at a -1 degree angle of attack (AOA) relative to the wing.
Empennage

Horizontal and Vertical tail are collectively known as the empennage of RC Airplanes

Vertical Tail

The Vertical tail or the vertical stabilizer provides the yaw control to the RC Airplanes. Rudder is mounted to the vertical tail or vertical stabilizer of the RC Airplanes.

Spinner

A spinner is used to house the central hub of the propeller and makes the RC Airplane more aerodynamically efficient.

Ailerons

Ailerons are roll-control control surfaces of the RC Airplanes. Ailerons provide roll by moving in opposite direction to each other. When one aileron moves down the other moves up thus providing more lift on one side as oppose to the other causing the RC Airplane to roll. Ailerons are at the trailing edge of RC Airplane wing and towards the wing tips.

Flaps

Flaps provide additional lift to the RC Airplane by increasing the maximum lift coefficient of RC Airplanes. The flaps can be used to increase the lift during landing and take-off to better take advantage of the ground effect. The flaps move simultaneously. When both flaps move down it is known as flaps-down and increases lift of the wing. When flaps move up it is known as flaps-up. Sometimes, flaps are designed so that they only move down or come to the neutral position and not move up.

Elevators

Elevators are the pitch-control control surfaces of the RC Airplanes. Elevators provide pitch control by moving either up or down simultaneously causing the airplane to pitch about the center of gravity of RC Airplane. When elevator is moved up the nose of the airplane rises and is known as pitch up. When the elevator is moved down the nose of the RC Airplane moves down and is known as pitch down.

Rudder

Rudder is the yaw-control control surface of the RC Airplanes. Rudder provides yaw control by moving to either side be it left or right. The rudder yaws the RC Airplane about the center of gravity cg of RC Airplane causing the RC Airplane nose to move right or to move left. A right rudder maneuver causes the RC Airplane to move to the right. A left rudder maneuver causes the RC Airplane to the left.
Nose Gear

Nose gear is a member of the landing gear set on a typical conventional RC Airplane configuration. The nose gear is used to steer the RC Airplane nose to move RC Airplane right or left when on the ground. The servo which connects the nose gear is also connected to the rudder. So, the direction in which the rudder moves the nose gear also follows that direction. During takeoff the nose gear is used to steer the RC Airplane so that RC Airplane is centered to the runway. Without a steerable nose gear it is not possible to maneuver/ move on the ground without manually moving it. With a steerable nose gear the RC Airplane can be moved on the ground.

Main Gear or Landing Gear

The main gear or landing gear is the main landing wheels of the RC Airplanes which takes the entire RC Airplane. Main gear have to be strong and yet flexible enough to provide safe takeoff and landing to RC Airplane. A rigid inflexible landing gear can damage the RC Airplane structure as the entire weight / reaction force would be carried by the fuselage. So, in order to avoid this landing gears are designed to be strong yet flexible enough so they bend slightly during landing or takeoff to disperse the load and provides safe and smooth landing. Landing gear or Main gears consist of a pair of wheels which are generally larger in diameter as compared to the nose gear wheel. The landing gear wheels are not steerable.

BASIC AERODYNAMICS

The understanding of the principles of flights is important in understanding also what happens to the model during the various stages of its flight. We are unfortunate enough to crash a model through a flying error it is important to know why it is crashed, so that we can avoid making the same mistake again. It is not intended to pursue the detailed aerodynamics for design models, etc., but sufficient flies and what effect controls surfaces have.

Let us first consider how an airplane stays up in the air. Although it seems to be the general view that the airplane is held in the air by the action of the propeller, it is of course, the wings that create the lift to suspend the aircraft. Now if we look at the side elevation of the model in figure, we can see that the wing is set at slight angle, with the leading edge slightly higher than the trailing. When the model is being propelled forward in straight and level flight in the air, when it reaches the leading edge of the wing, has to divide, some passing over the top of the wing and some underneath. The air passing beneath the wing is forced downwards, owing to the angle of incidence and because it is now in an area of relative pressure, tends to push the wing upwards. Over the top of the wing there is, because of the angle of incidence and the camber of the upper wing surface, an increase in the speed of the airflow, causing an area of relatively low pressure, thus sucking the wing upwards. The combination of the area of high pressure pushing upwards and the low pressure over the wing sucking it upwards are together known as lift. About two-thirds of the wings total lift is created by the top surface of the wing and one-third from the airflow over the airflow over the lower surface.
The lift created on the top surface can easily be demonstrated by holding a piece of note paper by one edge and blowing along the surface. Notice how the paper rises.

Lift is directly related to the speed of the model, and therefore follows that if a model slows down too much there will be insufficient lift created to allow the model to fly – a most important point to remember during the launching or take-off and landing. Figure shows the airflow over the aerofoil section in normal conditions and in A, B and C the airflow through straight and level flight, through a climbing angle and reduction in speed, until there is a break-up of the airflow over the wing. When the break-up of the airflow is reached, the model is said to be stalled, and control cannot be attained until the model is dived and flying speed built up.

Having seen how the model stays up, we can now consider the disposition of other forces acting in flight, as shown in figure. Thrust is provided by the engine ‘pulling’ the model forwards. The speed of the model is governed by the power of the engine, the altitude to the ground, i.e. climbing or diving, and the drag from the model, the model will cease to accelerate. Various types of drag are involved when the model is flying but, at this time, we will just consider it as resistance to air. The lift must, as stated before, counteract the weight of the model and because lift has to be increased by an increase of speed, it is important to keep our model as light as possible. A heavy model has fly faster to stay in the air, therefore landing and launching speeds are higher – even the slow landing and launch speeds can seem too fast for a beginner! Notice that the thrust line and the line of drag are not in line with one another, thus causing a climbing effect unless counteracted. Although the line of weight (acting through the center of gravity) is offset compared to the Line of Lift, to counteract this climbing effect it is often also necessary to change the line by introducing engine down thrust.

Having considered the forces acting upon the model, we will now take a look at the axes through which a model can turn.
The diagrams are reasonably self-explanatory and it is sufficient to say that the control surfaces move the aircraft by creating more lift, as shown in figure. For the purpose of our training model we shall be considering the rudder as a method of turning. This does not mean, however, that all our turns, using rudder, will be flat yawing turns; as the yaw occurs the wing on the outside of the turn increases its speed and creates more lift (and vice-versa for the inboard wing), thus causing the outside wing to rise, and the model banks in the direction of the turn. Note that when the model is in a steeply banked turn, the elevator in effect becomes the rudder or turning action and, to a lesser degree, the rudder becomes the elevator. This knowledge is important when we are trying to recover from a spiral drive. In these special circumstances, the application of up elevator will aggravate the condition and not improve it.

Ailerons give, when combined with elevator, smoother turns than achieved with rudder; less tendency for the nose to drop during the turn and better axial rolls.
Ailerons may not be so effective when the model is at lower speeds, such as on the landing approach, when rudder may be used for correction of the direction of the model. For correction in direction during the take-off run of a model, the ailerons are of no value as we need to yaw the model, (the model still being ground based) and not bank the model as required in flight.

**CONSTRUCTION OF RC AIRPLANE**

The basic understanding of the aerodynamic concepts and the correct scaling down methods can enable a designer to build a successful RC flight. This construction has an advantage of understanding the properties of the materials used, mechanisms design, concept creation and grading the components. The quality of the materials has to be given consideration for long life of the flight and better functionality.

**Airframes**

To build a successful airframe, one that will allow the radio control equipment to operate the model accurately, it is important to pay attention to the three A’s.

Accuracy-Cut all parts as accurately as possible so that they fit without gaps or having to force fit joints.

Alignment-Square and true construction at all times and correct alignment of wings and tail surfaces on the completed model.

Avoirdupois-Weight is a key property. Keep the weight as low as possible.

**Plan – Layout of the model.**

The plans are usually laid out using the values from the real models and scaling it down to a higher scaling factor. This at the end gives us a layout with different dimensions but regulated by a common factor of orientation. For example, may be the length of the wing may be considered as a common factor and all other dimensions are given as a multiplier of the length of the wing. This enables easy construction and improved adaptability to changes.
We choose a Russian Biplane model and an already available scale down model plan is adapted for guidance and the flight is built over it. The flight plan is shown in the figure. The weight of the flight is given importance and the whole flight is built using choro sheet, the properties of which are discussed latter in the report. The main frame is constructed in the balsa wood and then the choro sheet is used to surface the body and the wings. The high resistivity and toughness of the sheet helps in withstanding the air forces encountered on the flight course.

The materials are to be cut with precision and the uncut edges, corner chips and sanding problems are to be eliminated by filing smooth, laser cut and the adhesive bonding. To keep sanding minimum try to cut all parts as accurate as possible including spars, longerons, wing leading edge sheeting etc. This will save time of replacing broken parts. It is advised not to cut the plan over as it will lead to formation of ribbons and hence reducing the aero – properties of the structure.
LAYOUT OF THE RC PLANE

a) Side view of the fuselage

b) Top view of the plane

c) Front view of the plane
Blocking wind ribs

Cutting out the identical wind ribs can be something of a chore even when a metal template is used for cutting around. An easy, and accurate, method of producing large number of wind ribs is by using two templates, plywood, metal or plastic laminate and sandwiching between them the required number and thickness of balsa sheet for the ribs. The balsa sheet for the rib blanks needs to be cut only to rough dimensions as the full circumference is cut and sanded.

Although the balsa and choro sheets are fixed together and held firm by this arrangement, a better error reducing method is to drill a hole through the woods and template and fastening it before cutting through. Slot for the spars can be cut with a small hacksaw and finished with a square edged fine file. Wings with a tapered profile can also have ribs cut by the ‘blocking’ method providing that the rib spacings are all equal and that the taper is not too pronounced. The rib blanks must be included for both the port and starboard wings and that the templates should be for the root and tips ribs.
**Fuselage**

Most fuselages, whether built from the longerons, uprights etc. or sheeted, are box-like in structure, although they may have blocks and stringers added to ‘round-off’ the appearance. Usually the main length of the top or bottom of the fuselage, or at least the wings seating area, are flat and these areas can be laid out flat on the building board to check that the fuselage formers and sides are square. Te most common faults in building the fuselage are to get unequal tapers on the sides and to build the fuselage on the vertical true, i.e. with a twist in it. Avoid these faults by marking a vertical centerline on the formers and lining them up on the longitudinal centerline during construction.

When cutting the uprights and the cross pieces for built up fuselages cut them together in pairs; this reduces the time taken and also ensures consistency. The ideal method is to use a construction jig but many models require a completely new jig for its parts.
Wings

Building wings without warps is simple enough with flat bottom wings provided the balsa wood is reasonably evenly graded. With symmetrically wing sections it is often necessary to block up the leading and trailing edges and this must be done accurately and at close intervals to prevent any bowing between supports. The correct balance of the wings is also important; both panels should be of identical weight so that the wing balances around the center line. Try sanding down the heavier wing, particularly around the tip area where the reduction in weight will have most effect, but, if needs be, add some ballast to the tip of the light wing.

The wing with few exceptions should be built in one piece. For a F/F original scale model it is better to choose simple dihedral, polyhedral or tip dihedral; just be sure to tip the wing 1/15 of the span above the center section. The outline can be rectangle or wit curved tips, tapered, or elliptical, in order of difficulty. The figure shows several dihedral schemes and outlines. We choose the simple dihedral model to design in our model and machine it accordingly. Choosing the aerofoil shape is critical to choose and is very important factor to decide to achieve the desired aero – stunts, which is case sensitive. Few models of the aerofoils are shown in figure. The most commonly used and most easy to build is the Clark Y model and hence we adapt the same for construction.

The simple dihedral shaped wing is first designed without the development of aerofoil around it, to fit into design and the C.G is checked. Then the aerofoil is built over it by simply adding the balsa blanks in along the wing bone and the choro sheet is wrapped around it to achieve the shape desired.
The components of the wing are to be checked for accuracy before wrapping it around with the choro sheet. It needs to be ensured that all parts fits together precisely without deviation from each position and the symmetry must be maintained at all costs. To do this we need a center line or datum line for reference along the side of the fuselage.

We choose the centerline of the tail plane as the datum line as this is normally set as $0^0$ incidences. Incidentally if we are using the incidence measurements in terms of degrees remember that the incidence angle of the flay bottom wing is measured from the center of the leading edge to the center of the trailing edge and not to the bottom of the wing. With the datum line marked on the plan it is possible to measure off the distances to the wing leading and trailing edges, and by marking the fuselage in a similar way the incidences can be checked.

**Hatches**

Weight compensation for hinged doors, hatches, gates, or the like, which swing up and down on an upper horizontal hinge axis, comprises a torsion rod extending parallel to the hinge axis and having hollow shafts or bushings at its respective ends, one of the bushings is connected through a lever and a continuously length adjustable rod to the frame and on one side of said door, hatch, or gate, the other bushing is mounted to a lever, and a continuously adjustable tensioning screws fastens that lever to the door, hatch, or gate, and at the other side thereof.

Hatches are frequently required in models to give access to the engine, fuel tank or some radio equipment. The hatch should be securely fixed and incapable of coming loose I flight. A number of hatch fixings are illustrated here.
Installations

The installations will be divided into four parts as follows:

1. Hinges
2. Linkages
3. Special Linkages
4. Radio equipment

Hinges

The whole effort to improve the resolution of the equipment can be nullified by poor job of hinging of the control surfaces and installations of the pushrods and control horns. The aims to achieve a good control surface hinge are:

1. Freedom of movement.
2. Close coupling of the control surface to the wing, fin or tail plane.
3. Strength of the hinge.

A wrong attachment of installations like hinges could result in the following drawbacks:

1. Added loads at higher altitudes on the servos.
2. Air loads on the control structures and surfaces during flying.
3. Expense of greater battery drain and generally of accuracy too.
4. Increased drag and hence the possibility of failure.

Close coupling of the control and primary surfaces is important for two reasons. It will allow passage of air between the surfaces, reducing the efficiency and creating turbulence. Many of the older, full sized, light aircrafts had strips of linen doped loosely between the surfaces to prevent
this spillage of air. Other reason is that it will give improved movement for the structure than being offered by mechanism.

### Linkages and special linkages

The linkage between the servo and the control surface, or control function is the area where most loss of control efficiency occurs. The inefficiency is caused by the wasted movements which ultimately may happen due to flexing control rods, over-large holes in horns and servo output arms and discs and a number of other reasons. To avoid it and obtain a greater accuracy of control, we take care to keep connection and connecting rod, as precise as possible. There are so
many possible combinations of linkages, horns, cranks, etc. That it is impossible to discuss them all. But the one used in the plane alone is discussed in here. The following figure is self-explanative of the details used in the design.
The Propeller Installation
The propeller is fixed to the motor on the shaft, which rests on the fuselage at the crevice provided at the front of the fuselage. This actually is being mounted using the x-mount supplied by the motor manufacturer along purchase. The x-mount holds the motor body firmly along with the fuselage by means of four screws. The Picture shows in detail how the motor and propeller is fixed. The propeller is held firmly by means of the knob-cap in the shape of a bullet.

Battery Elimination Circuit (BEC)

This Electronic Speed Controller (ESC) contains a Battery Elimination Circuit (BEC) which may be used to power your receiver and servos under certain conditions. This will allow you to eliminate the separate onboard radio battery pack, and reduce the weight of your aircraft. The BEC may not be used simultaneously with and onboard radio battery pack. You must use one or the other, but not both. Up to 4 servos can be used when the voltage is 7.4V or less. With 11.1V or above, only 3 servos can be used.
If you are not using the BEC function, you must clip the red (+) wire on the ESC receiver lead.
Cutoff Voltage:
- Cutoff voltages are auto-set
- 6V/2Lipo
- 9V/3lipo
- 0.8V per unit for NiMh selection

To Enter Programming Mode:
1. Connect the motor and receiver to the ESC.
2. Remove battery power from the ESC.
3. Set the throttle stick to full power and then turn on the transmitter.
4. Reconnect battery power to the ESC.
5. If you are using a separate receiver battery pack instead of using the BEC, connect the receiver battery pack and turn it on.
6. Secure the airplane and stay clear of the propeller
7. A sequence of one to three beeps will be followed.
8. The table below summarizes the simple options for the choices:

<table>
<thead>
<tr>
<th></th>
<th>1 Beep</th>
<th>2 Beep</th>
<th>3 Beep</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Lipo self protection</td>
<td>Ni-Mh/NiCd self protection</td>
</tr>
</tbody>
</table>

9. Move the throttle stock to the full down position if you confirm the option.
10. You should have only one choice between the lipo self-protection of NiMh/NiCd self-protection.
11. Once you confirm your choice, you will hear a sharper tone indicating this choice has been saved.
12. If you want to change the brake setting, repeat steps 2-10.

CAUTION: At this point the throttle is armed. If you advance the throttle stick the motor will run. If you are not ready to fly, unplug the motor battery and then turn the transmitter off. Always turn the transmitter on (and the receiver if you are using a separate receiver battery) and be sure it is set at idle position before connecting the motor battery. All of your selected programming will be saved in the ESC. There is no need to program again unless you wish to change a setting.

Note: If the motor rotates in the wrong direction, simply sway any two of the three wires from the speed controller to the motor.

Additional Features:
1. Soft start
2. Start prohibition if the throttle position is wrong.
3. Auto learning on the throttle response
4. Auto shut down of the power if the signal is wrong
5. Auto calibration of the motors
6. If there is no response on the receiver, the input will be automatically shut off. The ESC can be used with 4-10NiCd/MiMh or 2-4 cell Lipo batteries and will automatically detect them. The BEC is functional with up to 3 Lipo cells. With 4 lipo cells you will need to disable the BEC.
The only programmable feature on this ESC is the brake. The brake defaults to OFF. If you don’t need to program the brake function, your ESC is plug and play and ready for use up to 3 cell Lipo or 10 cell NiCd/NiMh.

Connecting the Motor:

Note the wiring diagram below:

1. Solder an appropriate connector on the battery + (red) and battery? (Black) leads.

We recommend Deans Ultra If using a polarized connector, make sure the polarity matches your batteries,

2. Connect the three motor wires to your brushless motor (ignore the wire colors).

If the motor spins in the wrong direction, swap any two of the motor wires to reverse the direction. We recommend using gold plated spring connectors (also known as bullet connectors) between the motor and the speed control to facilitate swapping the wires. Make sure to cover the bullet connectors with heat shrink tubing.

3. Plug the servo connector into the appropriate channel on your receiver. Most receivers use channel 3 for the throttle, but some use channel 1. Consult the manual for your receiver for details. The red wire on the servo connector is positive (+), the brown or black wire is negative (-), and the orange or white wire is the signal.

4. Make sure your transmitter throttle channel is not reversed. Most Futaba transmitters have the throttle channel reversed by default.

5. Before flight, you can program the battery type, number of cells, and cut-off voltage. See the next page for programming instructions.

6. Install your ESC in a location in your airplane that receives good cooling airflow. Keep the motor and battery wires away from your receiver and antenna.

Adjustment Check List

Once the construction part is over, it’s time to work with the adjustments of the flight since the probability of making a perfect flight is very low and it requires some fine tuning to achieve the perfect center of gravity, stability and other defects probably needs to be overcome at this point of design. The following points would help anyone to analyze the flight and trouble shoot for its performance.
• **Glide:**
  - Model dives –
    - Increase positive incidence in wing
    - Increase negative incidence in tail
    - Add weight to tail
    - Lighten nose
  - Model stalls –
    - Decrease positive incidence in wing
    - Decrease negative incidence in tail
    - Add weight to nose
    - Lighten tail
    - Increase turn
  - Model wavers and falls off on one wing –
    - Check for warps in wing or elevator
    - Increase rudder area
  - Model turns too sharply –
    - Offset rudder in opposite direction
    - Warp up trailing edge of wing on side to which turns
    - Offset wing – tip opposite turn to rear
    - Tilt elevator – Raise side opposite turn
  - Model yaws or flips over –
    - Lower center of gravity
    - Increase rudder area
    - Increase dihedral

• **Power:**
  - Model drives –
    - Raise thrust angle
    - Increase positive incidence in wing and add weight to nose
  - Model stalls –
    - Increase down-thrust
    - Increase engine offset for more turn
  - Model spiral dives –
    - Reduce engine offset
    - Use lower pitch prop
    - Add rudder area below fuselage
  - Model turns too sharply –
    - Reduce engine offset and increase down thrust if necessary
    - Use lower-pitch prop
CG of RC Airplane - How to Check the Center of Gravity Point of RC Airplane

Normally, the RC Airplane center of gravity or cg of the aircraft is to be located at 25% or 0.25c (of the mean aerodynamic chord). For the RC airplane, a vertical line is marked on the mean aerodynamic chord. At 25% or 0.25c of the mean aerodynamic chord, a horizontal line is marked on the wing. At the center point of the joint of two wings a straight vertical line is marked. The two lines will intersect each other at a point. That point is the reference cg point. An RC Airplane can be either nose heavy or tail heavy. If the airplane is chosen to be statically stable you will most probably chosen 25% of the Mean Aerodynamic Chord as the reference. Now the reference cg point is obtained. Then the airplane is checked if the cg of airplane is at the reference cg point or is it nose heavy or tail heavy. To do this, two people are required. One person stands on each side of the wing. Wing is lifted with a single finger (don't lift up/touch any other part of the aircraft during this check) along the reference vertical line which passes through the reference cg point. If the airplane is nose heavy or tail heavy it will automatically move in either direction. If airplane not at the cg point add ballast either to the nose or tail until the cg point is reached.

How to check the RC Airplane for Structural Strength before Flying

Before starting to fly the RC Airplane, it is important to check the RC Airplane for strength.

For most trainer model RC Airplane, wing should be designed and structured to carry at least 2g of loads in maneuvers. What it means is that your wings should be able to carry twice the weight of the aircraft. If the RC airplane weight is 4 lb. 2g will mean that the airplane wing should be able to carry at least 8 lb of loads.

For aerobatic models, the requirements may be high e.g. 4g or 6g loads. But adding more wood in the RC Airplane does not make it stronger. In mass consideration, the more structure added to the RC Airplane, the more weight gets added the RC Airplane. So it’s better to use improved design techniques to make the RC Airplane structure with lesser weight. Most of the time, new modelers don't care about the grain direction of the balsa wood and ply wood when making these RC Airplanes. If the strip of balsa wood and ply wood is examined closely, it could be seen to have a grain structure on it. With proper direction of the grain structure of balsa wood and plywood on your RC airplane, the weight can be saved and also make a stronger structured aircraft. The factors like the kind of loads the structure is taking, the direction in which the load is acting, and the nature of the load like compression or expansion.

Wing design Explanation

- We used Dihedral wing, which helps to increase the gliding time with less battery charge.
- Our wing is designed as High wing, because it's easy to fly for trainer.
- We used electric motor, which has the capability to carry 1.5 kg.
- Our UAV is used for military purposes

Wing Design:

Wing design specification:

- Wing Span - 110 cm
- Wing Area - $110 \times 20 = 2200$
- Wing Weight - 206 gram with servos
- Center of gravity - 55 cm
- Type of wing - Chrosheet material (light weight)
Specifications of the components used

Fly Sky FS-TH9X 9Ch Transmitter

The 2.4 GHz 9Channel transmitter model FS-TH9X from the manufacture of Corona and Assan is used in the system for transmission of control signals. This transmitter offers 9 channels of which only 5 channels are used. This was carried out to enable upgrading the current system to higher controlled features in the future research. The Fly Sky FS-TH9X is offered under various brand names but it is basically the same transmitter. One major thing to note is that the amount of channels will vary depending on whether you use PPM or PCM. Switching to PPM reduces the number of available channels to only 8. The actual layout of the transmitter is best for operating convenience; there is a vast array of switches for selecting rates, gear, trainer-mode, flight modes, etc. These are complimented by three knobs which serve for flaps, hover, pitch, etc.

Specifications

The Fly Sky FS-TH9X is modular system, so specifications may vary depending on the module selected. The transmitter is loaded with features, which will usually be found only on some high end transmitters.

- Number of Channels: 8ch PPM/9ch PCM
- Display: 128*64 LCD
- Support Type: Heli/Acro/Glid
- User Models: 8
- Stick Modes: 4
- Encoder Type: PPM/PCM
- Sub Trim: Yes
- Simulator Interface: Yes
- Buzzer: Yes
- Low Voltage Display: Yes

The menus are clearly and easy to navigate using the 128×64 pixel LCD display. The only issue was that the +/- buttons are back to front with the positive on the left.
Setup

The package included the transmitter and transmitter module but no receivers. The setup is extremely easy. Simply bind the receiver to the transmitter by putting the bind plug in the receiver and powering on the transmitter while holding in the bind button. All the receivers bought were bound without any problems. Once bound the receiver to the radio, it’s time to program the radio to suit the model. Careful attention is paid to servo reversing and also the transmitter’s mode selection.

Flight Testing

The transmitter exhibited excellent performance. Our model was able to fly the very limits of human vision without any glitches. On an initial test, the transmitter was checked for controllability and then the secondary test was conducted to test the range of transmitter. The transmitter could take it out about 300 meters on the second round test and it reached almost 400 meters before it became difficult to tell the orientation of the model at such heights.

Positives

- Affordable
- Easy to Program
- Module Flexibility

Negatives

- No Failsafe
- Only 8 Model Memories
- Quality Control Issues

As said earlier, the Fly Sky FS-TH9X is available under various brands, Imax, Turnigy, Eurgle etc. Hobby King’s Turnigy 9X is now in its 3rd revision.

Corrugated Plastic / Coro Polypropylene Sheet

Referred to, in the industry, as "Corex" or "Coro", this material is predominately used for temporary and promotional signage. Ideal for lawn signs (election, job site, sales, promotion directional, etc.) & real estate signs, site signs for new building projects. Coroplast CI meets the exacting corrosion protection standards of users ranging from the Guggenhein Museum of Art to Delco Electronics. Originally developed to protect electronics, these materials have applications in many industries. Permanently neutralizes corrosive gases, using no oils. Protects silver, copper, brass, bronze and ferrous metals.
Scorpion SII-2208-1100 V2 Brushless Motor

Scorpion Competition Series Brushless Motors are built from the best materials available, and are designed to provide both quality and performance at an affordable price. The new SII-22 series motors are an updated and improved version of the popular S22 motors that have been so successful. This V2 motor replaces the V1 S-2208-34. Max Continuous Power 130 Watts. Max Continuous Current 12 Amps, 1100 Kv.

Scorpion 2208-1100 V2 Brushless Outrunner Motor

The new SII-22mm motors have been designed to replace the original S-22mm motors that were introduced in January of 2007. These new motors include several design improvements that make them more powerful and more efficient than the original S-22mm series. The design improvements include:

1. New cooling fan design that works equally well in either direction of rotation.
2. New stator design to concentrate the magnetic fields at the pole faces.
3. New stator plate alloy to increase efficiency and reduce heat losses.
4. New flux ring alloy to contain more of the magnetic field within the motor.
5. The higher efficiency of the motor naturally lowers the Kv of the motor, so to get the Kv back up, fewer turns of heavier gauge wire are used. This lowers the internal resistance (Rm) of the motor and increases the current handling ability.

The Scorpion SII-2205 motors come with 3.5mm male bullet connectors already soldered on to the motor leads, and also include 3 matching female bullet connectors for your speed controller, along with a cross style motor mount with 4 mounting screws, a threaded shaft style prop adapter and also a prop saver class type prop adapter with the internal O-Rings attached provisionally. All Scorpion motors are built to exacting tolerances on state of the art CNC machines for the highest level of fit and finish. The stators are all hand-wound to insure the highest copper fill rate and high voltage tested to insure that no shorts are present. All the metal motor parts are electro-coated in a beautiful black and gold finish so the motors look as good as they perform. To top off the high quality fit and finish of these motors, Scorpion backs them with a 2-year warranty against defects in materials and workmanship. (Due to the nature of ball bearings, and the fact that they can be easily damaged by prop strikes or by getting dirt in them, the ball bearings are not covered under the two-year warranty.)

![Specifications Table]

### Included in the Box

1 x Scorpion SII-2208-1100KV Motor  
1 x Scorpion 22mm Cross Mount  
1 x Scorpion 3mm Threaded Prop Adapter  
3 x Female Connectors  
3 x Heat Shrink  
4 x M3 Screws
APC Model 10 x 10 RC steel

Propeller

Specifications
Model: LP 10010
Dimensions: 10 cm x 10 cm
Material: Steel

Features
- Steel Propeller
- Suitable GP & EP
RC Lithium Polymer battery

Specifications

RC Lithium polymer battery 11.1v 2650mah 30c ,

Nominal Voltage : 11.1v
Capacity : 2650mAh
Cont. discharge rate : 20c
Cont. Discharge Current : 53A
Peak Discharge Current : 66A
Max Charge Current : 4A
Size (LxW x T) mm : 138 x45 x20
Approx Weight (g) : 230g
Charging temperature : 0 C ~ +45 C
Operating temperature range : -10 C ~ +80 C

GraysonHobby 30Amp Brushless Speed Controller (ESC) [GH30A-ESC]

Technical data

- Weight: 21.9 grams / 0.77 oz.
- Use with ni-cd,ni-mh, li-ion, and li-poly batteries
- Size: 32 x 24 x 9 mm
- Auto throttle calibration
- Auto cell detect !!!
- Bec: 3 amp (suggested use --> 2 li-poly=4
  servos, 3 li-poly =3 servos)
- Timing: auto
- High rate switching: 8khz
- Auto voltage cutoff set at 3.0v a cell li-poly 0.8 nicd/nimh
- Brake: programmable on/off
Hitec HS-55 Micro Servo

- Max rpm: 40,000 rpm with 14 pole motor
- Auto shut down when signal is lost

The HS-55 set the standard for affordable performance, offering precision components that have been engineered to provide long lasting trouble free service! Featured in a hundred model aircraft reviews worldwide, the HS-55 is the best choice when it comes to controlling “smaller” electric’s and Park Flyers.

<table>
<thead>
<tr>
<th>Motor Type:</th>
<th>Coreless</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bearing Type:</td>
<td>None</td>
</tr>
<tr>
<td>Speed:</td>
<td>0.17 / 0.14 sec @ 60deg.</td>
</tr>
<tr>
<td>Torque:</td>
<td>15.27 / 18.05 oz.in (4.8v/6v)</td>
</tr>
<tr>
<td>Size:</td>
<td>0.89” x 0.45” x 0.94”</td>
</tr>
<tr>
<td>Weight:</td>
<td>0.28oz</td>
</tr>
</tbody>
</table>
**COMPLETE SPECIFICATION OF OUR UAV:**

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>WING SPAN</td>
<td>110 cm</td>
</tr>
<tr>
<td>WING AREA</td>
<td>$110 \times 20 = 2200$</td>
</tr>
<tr>
<td>LENGTH</td>
<td>87 cm</td>
</tr>
<tr>
<td>CENTER OF GRAVITY</td>
<td>55 cm</td>
</tr>
<tr>
<td>BATTERY WEIGHT</td>
<td>220 grams</td>
</tr>
<tr>
<td>WING WEIGHT</td>
<td>206 gram with servo</td>
</tr>
<tr>
<td>MOTOR</td>
<td>Brushless-1100 kb</td>
</tr>
<tr>
<td>THRUST</td>
<td>950 grams</td>
</tr>
<tr>
<td>ELECTRONIC SPEED CONTROLLER</td>
<td>30 amp</td>
</tr>
<tr>
<td>LITHIUM POLYMER BATTERY</td>
<td>11.1 volts</td>
</tr>
<tr>
<td>ACTUATOR</td>
<td>servo control</td>
</tr>
</tbody>
</table>
PHOTOS OF OUR UAV:

Right side view

Left side view

Top view
External and Internal view of our model:
Water Rocketry

A water rocket is a type of model rocket using water as its reaction mass. The pressure vessel—the engine of the rocket—is usually a used plastic soft drink bottle. The water is forced out by a pressurized gas, typically compressed air. It is an example of Newton's third law of motion.

The term "aquajet" has been used in parts of Europe in place of the more common "water rocket" and in some places they are also referred to as "bottle rockets"

Operation

Simplified animation of how a water rocket works. 1) Compressed air is added which creates a bubble that floats up through the water and then pressurizes the air volume in the top of the bottle. 2) The bottle is released from the pump. 3) The water is pushed out the nozzle by the compressed air. 4) The bottle moves away from the water because it follows Newton's Third Law.

The bottle is partly filled with water and sealed. The bottle is then pressurized with a gas, usually air compressed from a bicycle pump, air compressor, or cylinder up to 125 psi, but sometimes CO₂ or nitrogen from a cylinder.

Water and gas are used in combination, with the gas providing a means to store potential energy, as it is compressible, and the water increasing the mass fraction and providing greater force when ejected from the rocket's nozzle. Sometimes additives are combined with the water to enhance performance in different ways. For example: salt can be added to increase the density of the reaction mass resulting in a higher specific impulse. Soap is also sometimes used to create a dense foam in the rocket which lowers the density of the expelled reaction mass but increases the duration of thrust. It is speculated that foam acts as a compressible liquid and enhances the thrust when used with De Laval nozzles.

The seal on the nozzle of the rocket is then released and rapid expulsion of water occurs at high speeds until the propellant has been used up and the air pressure inside the rocket drops to atmospheric pressure. There is a net force created on the rocket in accordance with Newton's third law. The expulsion of the water thus can cause the rocket to leap a considerable distance into the air.
In addition to aerodynamic considerations, altitude and flight duration are dependent upon the volume of water, the initial pressure, the rocket nozzle's size, and the unloaded weight of the rocket. The relationship between these factors is complex and several simulators have been written to explore these and other factors.

Often the pressure vessel is built from one or more used plastic soft drink bottles, but polycarbonate fluorescent tube covers, plastic pipes, and other light-weight pressure-resistant cylindrical vessels have also been used.

Typically launch pressures vary from 75 to 150 psi (500 to 1000 kPa). The higher the pressure, the larger the stored energy.
Multi-bottle rockets and multi-stage rockets

Two multi-bottle rockets with a cat for scale.

Multi-bottle rockets are created by joining two or more bottles in any of several different ways; bottles can be connected via their nozzles, by cutting them apart and sliding the sections over each other, or by connecting them opening to bottom, making a chain to increase volume. Increased volume leads to increased weight, but this should be offset by a commensurate increase in the duration of the thrust of the rocket. Multi-bottle rockets can be unreliable, as any failure in sealing the rocket can cause the different sections to separate. To make sure the launch
goes well, pressure tests are performed beforehand, as safety is a concern. These are very good if you want to make the rocket go high however they are not very accurate and may veer off course.

Multi-stage rockets are much more complicated. They involve two or more rockets stacked on top of each other, designed to launch while in the air, much like the multi-stage rockets that are used to send payloads into space. Methods to time the launches in correct order and at the right time vary, but the crushing-sleeve method is quite popular.

Sources of gas

Several methods for pressurizing a rocket are used including:

- A standard bicycle/car tire pump, capable of reaching at least 75 psi (520 kPa).
- Water pressure forcing all the air in an empty water hose into the rocket. Pressure is the same as the water main.
- An air compressor, like those used in workshops to power pneumatic equipment and tools. Modifying a high pressure (greater than 15 bar / 1500 kPa / 200 psi) compressor to work as a water rocket power source can be dangerous, as can using high-pressure gases in from cylinders.
- Compressed gases in bottles, like carbon dioxide (CO₂), air, and nitrogen gas (N₂). Examples include CO₂ in paintball cylinders and air in industrial and SCUBA cylinders. Care must be taken with bottled gases: as the compressed gas expands, it cools (see gas laws) and rocket components cool as well. Some materials, such as PVC and ABS, can become brittle and weak when severely cooled. Long air hoses are used to maintain a safe distance, and pressure gauges (known as manometers) and safety valves are typically utilized on launcher installations to avoid over-pressurizing rockets and having them explode before they can be launched. Highly pressurized gases such as those in diving cylinders or vessels from industrial gas suppliers should only be used by trained operators, and the gas should be delivered to the rocket via a regulator device (e.g. a SCUBA first-stage). All compressed gas containers are subject to local, state and national laws in most countries and must be safety tested periodically by a certified test centre.
- Ignition of a mixture of explosive gases above the water in the bottle; the explosion creates the pressure to launch the rocket into the air.[4]

Nozzles

Water rocket nozzles differ from conventional combustion rocket nozzles in that they do not have a divergent section such as in a De Laval nozzle. Because water is essentially incompressible the divergent section does not contribute to efficiency and actually can make performance worse.

There are two main classes of water rocket nozzles:

- **Open** also sometimes referred to as "standard" or "full-bore" having an inside diameter of ~22mm which is the standard soda bottle neck opening.
- **Restricted** which is anything smaller than the "standard". A popular restricted nozzle has an inside diameter of 9mm and is known as a "Gardena nozzle" named after a common garden hose quick connector used to make them.

The size of the nozzle affects the thrust produced by the rocket. Larger diameter nozzles provide faster acceleration with a shorter thrust phase, while smaller nozzles provide lower acceleration with a longer thrust phase.

It can be shown that the equation for the instantaneous thrust of a nozzle is simply:[5]

\[ F = 2PA_t \]

where \( F \) is the thrust, \( P \) is the pressure and \( A_t \) is area of the nozzle.

**Fins**

As the propellant level in the rocket goes down, it can be shown that the centre of mass initially moves downwards before finally moving upwards again as the propellant is depleted. This initial movement reduces stability and can cause water rockets to start tumbling end over end, greatly decreasing the maximum speed and thus the length of glide (time that the rocket is flying under its own momentum). To lower the centre of pressure and add stability, fins can be added which bring the centre of drag further back, well behind the centre of mass at all times, ensuring stability.

In the case of custom-made rockets, where the rocket nozzle is not perfectly positioned, the bent nozzle can cause the rocket to veer off the vertical axis. The rocket can be made to spin by angling the fins, which reduces off course veering.

Another simple and effective stabilizer is a straight cylindrical section from another plastic bottle. This section is placed behind the rocket nozzle with some wooden dowels or plastic tubing. The water exiting the nozzle will still be able to pass through the section, but the rocket will be stabilized.

**Landing systems**

Stabilizing fins cause the rocket to fly nose-first which will give significantly higher speed, but they will also cause it fall with a significantly higher velocity than it would if it tumbled to the ground, and this may damage the rocket or whoever or whatever it strikes upon landing.

Some water rockets have parachute or other recovery system to help prevent problems. However these systems can suffer from malfunctions. This is often taken into account when designing rockets. Rubber bumpers, Crumple zones, and safe launch practices can be utilized to minimize damage or injury caused by a falling rocket.

Another possible recovery system involves simply using the rocket's fins to slow its descent and is sometimes called *backward sliding*. By increasing fin size, more drag is generated. If the centre of mass is placed forward of the fins, the rocket will nose dive. In the case of super-roc or back-gliding rockets, the rocket is designed such that the relationship between centre of gravity and the centre of pressure of the empty rocket causes the fin-induced tendency of the rocket to tip nose down to be counteracted by the air resistance of the long body which would cause it to fall tail down, and resulting in the rocket falling sideways, slowly.
Launch tubes

Some water rocket launchers use launch tubes. A launch tube fits inside the nozzle of the rocket and extends upward toward the nose. The launch tube is anchored to the ground. As the rocket begins accelerating upward, the launch tube blocks the nozzle, and very little water is ejected until the rocket leaves the launch tube. This allows almost perfectly efficient conversion of the potential energy in the compressed air to kinetic energy and gravitational potential energy of the rocket and water. The high efficiency during the initial phase of the launch is important, because rocket engines are least efficient at low speeds. A launch tube therefore significantly increases the speed and height attained by the rocket. Launch tubes are most effective when used with long rockets, which can accommodate long launch tubes.

Safety

Water rockets employ considerable amounts of energy and can be dangerous if handled improperly or in cases of faulty construction or material failure. Certain safety procedures are observed by experienced water rocket enthusiasts:

- When a rocket is built, it is pressure tested. This is done by filling the rocket completely with water, and then pressurizing it to at least 50% higher than anticipated pressures. If the bottle ruptures, the amount of compressed air inside it (and thus the potential energy) will be very small, and the bottle will not explode.
- Using metal parts on the pressurized portion of the rocket is strongly discouraged because in the event of a rupture, they can become harmful projectiles. Metal parts can also short out power lines.
- While pressurizing and launching the rocket, bystanders are kept at a safe distance. Typically, mechanisms for releasing the rocket at a distance (with a piece of string, for example) are used. This ensures that if the rocket veers off in an unexpected direction, it is less likely to hit the operator or bystanders.
- Water rockets should only be launched in large open areas, away from structures or other people, in order to prevent damage to property and people.
- As water rockets are capable of breaking bones upon impact, they should never be fired at people, property, or animals.
- Safety goggles or a face shield are typically used.
- A typical two-litre soda bottle can generally reach the pressure of 100 psi (690 kPa) safely, but preparations must be made for the eventuality that the bottle unexpectedly ruptures.
- Glue used to put together parts of water rockets must be suitable to use on plastics, or else the glue will chemically "eat" away the bottle, which may then fail catastrophically and can harm bystanders when the rocket is launched.

Water rocket competitions

The Oscar Swigelhoffer Trophy is an Aquajet (Water Rocket) competition held at the Annual International Rocket Week in Largs, Scotland and organized by STAAR Research through John Bonsor. The competition goes back to the mid-1980s, organized by the Paisley Rocketeers who have been active in amateur rocketry since the 1930s. The trophy is named after the late founder
of ASTRA, Oscar Swiglehoffer, who was also a personal friend and student of Hermann Oberth, one of the founding fathers of rocke

The competition involves team distance flying of water rockets under an agreed pressure and angle of flight. Each team consists of six rockets, which are flown in two flights. The greater distance for each rocket over the two flights is recorded, and the final team distances are collated, with the winning team having the greatest distance. The winner in 2007 was ASTRA. The competition has been regularly dominated over the last 20 years by the Paisley Rocketeers.

The United Kingdom's largest water rocket competition is currently the National Physical Laboratory's annual Water Rocket Challenge.[9] The competition was first opened to the public in 2001 and is limited to around 60 teams. It has schools and open categories, and is attended by a variety of "works" and private teams, some travelling from abroad. The rules and goals of the competition vary from year to year.

The Water Rocket Achievement World Record Association.[10] A worldwide association which administers competitions for altitude records involving single stage and multiple stage water rockets, a flight duration competition, and speed or distance competitions for water rocket–powered cars.

The oldest and most popular water rocket competition in Germany is the Freestyle-Physics Water Rocket Competition.[11] The competition is one part of a larger part of a student physics competition, where students are tasked to construct various machines and enter them in competitive contests.

Apogee photograph taken by the onboard video camera from U.S. Water Rockets' record breaking X-12 Water Rocket at an altitude of 2,068 feet (630 m).

Most water rockets launched simultaneously, by Gotta Launch
The Guinness World Record of launching most water rockets simultaneously is in hands of Gotta Launch, when on 19 June 2009, they launched 213 of them at the same time, together with students of the Delft University of Technology.

The current record for greatest altitude achieved by a water and air propelled rocket is 2044 feet (623 metres), held by U.S. Water Rockets on 14 June 2007. This altitude was calculated by averaging two flights. The first flight achieved 2068 feet (630 meters) and the second 2020 feet (615.7 meters). The rocket also carried a video camera as payload on both flights as part of the verification required by the competition rules.

CONCLUSION

The RC plane and water rocketry is constructed and operated successfully. The theories behind the successful RC flight are compiled in order and the steps of construction are explained in general and complete machining steps are explained. Pictures supporting the mechanisms, parts and procedures are also included for illustration.