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Arighan The Cluster Missile Multiple Target Destroyer

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Abstract: A cluster missile, **Arighan** a self-guided missile have power to eliminate multiple targets in same time whether in air or at ground. It can be launch from both ground and in air. The cluster missile consist a main missile (parent missile) and four missile called mini missile (children missile) attached to main missile. The cluster missile will be a group of four missile. Main missile and cluster missile both have different ranges, Main missile will have 300 km of range and mini missiles has 100-120 km. it can be used as both offensive and defensive. It can be launched by ships also. We will discuss the numerous factors affect cluster missile during the flight like aerodynamic effects like lift and drag and drag of missile is the most concern parameter here because after separation of mini missile there will a cavity formed on main missile.

Key words: Arighan, cluster missile, children missile, drag, separation, nose

1. INTRODUCTION

Cluster missile named, **Arighan** in Sanskrit which meaning of destroyer of enemy. It can be like single arrow hit five different targets. We can launch it by all platform, from ground, in air and from water. It will also act both defensive and offensive. When we launch cluster missile from ground, it will act as an anti-aircraft defense system. When the aircraft or missile of the enemy comes to us, we will launch the cluster missile. The separation of mini missile from the main missile will take place when the distance between the cluster missiles and target reaches less than 160-180km, then the cluster missile will separate all the four mini missile form itself. If the target is single, then all the 5 missile will locked on the same target and if the target is multiple than all mini missile and main missile will choose their individual targets. If the targets is lesser in number than the all mini missile and main missile than not more than 2 missile will locked on single target. The speed of missile will be in supersonic region. We will discuss and try to solve all the problem we will face during missile flight, like the aerodynamic properties lift and drag, air flow, flow separation.

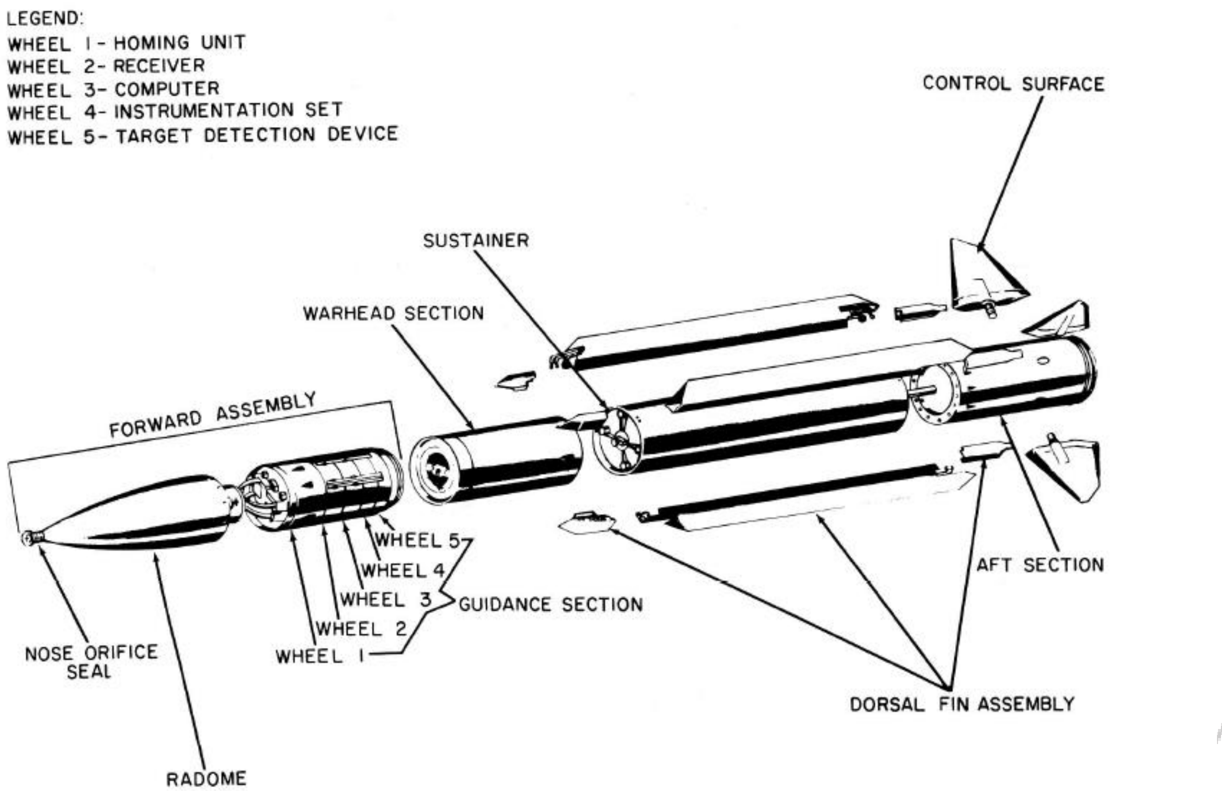
Why we need cluster missile?

Well we should not need any weapon at all but if our enemy try to attack than we should also need weapon to protect ourselves. And we need cluster missile because we don't need to launch 4 different missile for 4 different targets but if we have cluster missile than we have to only launch a single cluster missile that would be enough for 4 different targets. So we don't need to launch 4 missile one by one for every target.

We have two different variant of this missile one is when it hits any object it will explodes and other one is having characteristics that when it approaches target and the distance between the target and any of the children missile or the parent missile becomes less than 30 centimeter than all children and parent missile will trigger themselves and explodes. This variant is reliable when the target have high maneuverability power if we release our variant of missile then there is impossible for target to escape. And we can launch from both air and surface.

2. CONTROL COMPONENTS OF MISSILE AND THEIR AERODYNAMICS

Below figure is a missile having tail control and the complete unit of missile having named of its every parts



Missiles do not have conventional control surfaces like rudder, aileron and elevators like an airplanes have. But missiles also do have similar aerodynamic control surfaces in order to maneuver it during flight. The body of missile is like the fuselage of airplane. Missile body contain the war head, guidance and control system and propulsion unit. Three major surfaces of missile are canards, wings and fins. The places of these surfaces are determined with respect of the position of center of gravity of missile. Wings are located closest to the CG of missile, canards are near to nose and tail fins are aft wards the missile body. Wings are larger in area than tail fin and canards.

a. **Centre of gravity and center of pressure:** center of gravity (CG) of missile is the point where all the mass of missile concentrate at single point and center of pressure (CP) is point on missile where aerodynamics forces acts (lift and drag). In stable missile the CG is ahead of CP but to make missile high maneuverable near the target the missile should be less stable so we need to compromise with stability but if the missile is less stable than it is unacceptable in initial phase of missile. We need to adjust the position of CG and CP carefully. The stability of missile is measured by the distance between CG and CP and that distance is called 'static margin'. Having small static margin (SM) will lead missile to a more unstable flight.

   Static margin = Xcg - Xcp

   .Static stability of a missile is measured by it tendency to return to its equilibrium point after once it get unstable in air during flight.

b. **Tail controls:** tail controls is most commonly used missile control surface among other control surfaces. As tail control provides high maneuverability to missile. New generation aircraft are made with high maneuverability capability, so to intercept high maneuverability aircraft, missile need tail control because it provides high maneuverability. As many missile are only have tail control so the tail control have to make enough lift for missile. The center of gravity lies usually approximately 50% length of missile, and the forward surfaces like canards or strakes both makes missile destabilize the missile and to make missile stabilize we need a tail which must having size which provide require stability. Tail will provide the pitching moments also to balance the moments contributed by wings/canards and nose.[2] The equation for finding required area given below,

$$S_T / S_{Ref} = \{(CN\alpha)_B[X_{CG}-(X_{CP})_B]/d + (CN\alpha)_W\{[X_{CG} - (X_{CP})_W]/d\}(S_W/S_{Ref})\} / \{[(X_{CP})_T - (X_{CG})]/d\}(CN\alpha)_T$$

c. **Canard:** Canard can be used for many reasons like to produce lift, stability and un- stability both, trim and to make change air flow over wings of missile. Canard are also often used in missile, mostly in short range missile. At low angle of attack canard provide high maneuverability to missile but when it hit with high angle of attack it stalls due to flow separation. Canards are located ahead of CG, this makes canard a destabilizing control and that make require large fixed tail to balance and keep missile stable. Canard has two type of set one is single canard set and other is split canard set. In split canard set, there are two canard, one behind other. Now new generation short range missile mostly have split canard set.

d. **Wings:** wings on missile was the first control surface that mounted on missile body but now it become rare. Some long range missile has wing like Indian Nirbhay missile. Location of wing on missile body should not affect the flow over tail because we know the downstream interaction on tail surfaces are very important. And these interaction depends upon the size and location of wings.

A finite wings form vortices flow due to tip effect and it generates the downwash. The reaction force of this downwash is lift. We can also find the angle off downwash from both elliptical wings and non-elliptical wings.

a. For elliptical wings:-

$$\varepsilon = 57.3 C_L/\mu AR \text{ (in deg)}$$

b. For non-elliptical wings:-

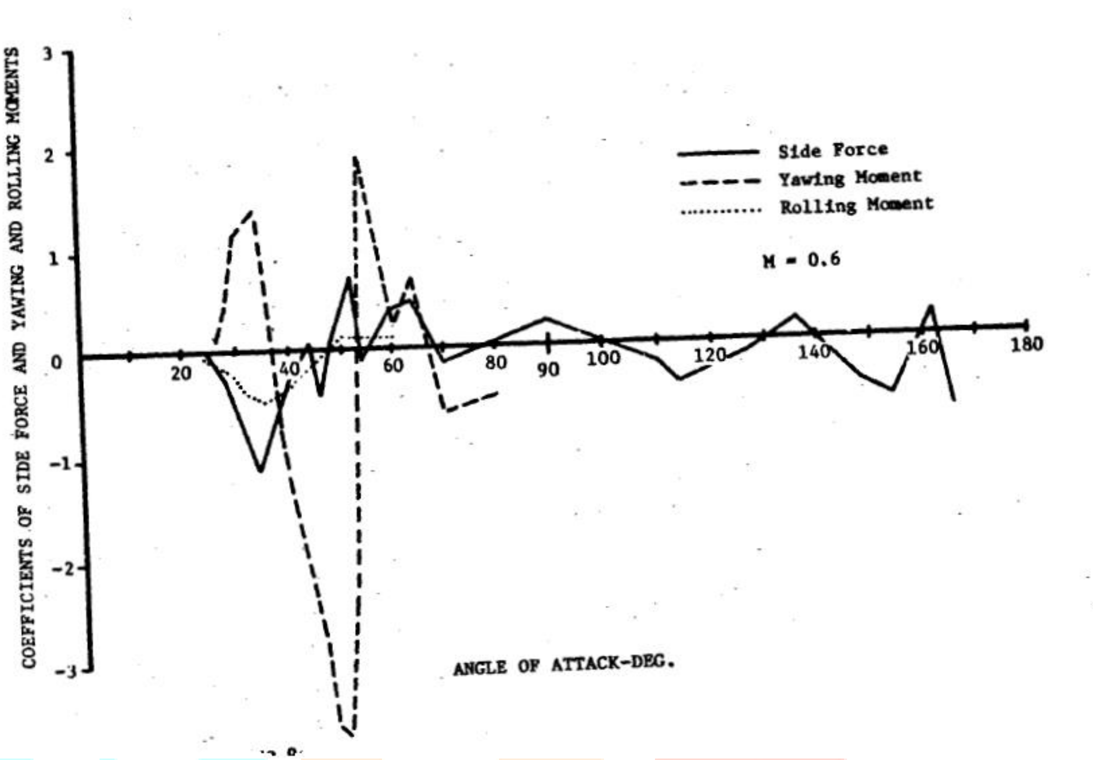
Average downwash angle, $\varepsilon = 57.3 C_L/e\mu AR$ (in deg)

Where,

e= Oswald efficiency
μ =friction coefficient

AR = aspect ratio of wing

When a missile having cylindrical shape places in a uniform flow the flow separation will take pace either of side of missile and form lee-side wake [3]. Usually this takes place when angle of attack of missile reaches near 6 degrees. These wakes later on will make itself as an asymmetric and counter rotating vortices and as angle of attack increases the size and strength of vortices increases. Nature of these asymmetric wakes will make asymmetric pressure distribution over the surface of missile. This will result in the unwanted forces and moments created. Control problems caused by vortices are in different ways. Very common and classic problem is asymmetric separation of vortices on body surface due to high angle of attacks. Cross flow is also the reason by which asymmetric vortices separation happens.



3. DRAG

In fluid dynamics drag force acts against to relative motion of any object moving in the surrounding fluid and drag is important property to be studied because it is the weight and drag which determine the top speed of missile. Drag force is more concern factor of any object moving in fluid, as it more responsible for increased fuel consumption and lower the object's top speed.

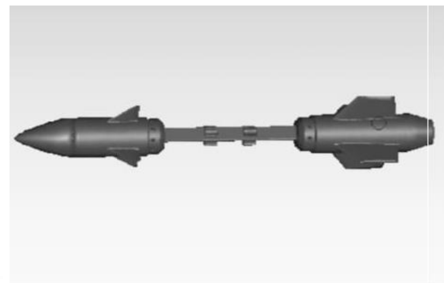
$$D = \frac{1}{2} C_d \rho A V^2$$

Where,
C_d = Coefficient of Drag
A = Frontal area
V = Relative velocity of the object w.r.t. fluid medium
ρ = Density of air

To study drag will help us to shape the missile and it component's shape for best performance. Study Drag force can be put us to get the favorable aerodynamic force for the fins of missile and shape of missile itself, called 'lift. After finding drag we estimate the speed of the missile.

From the above formula of drag we can see that there is squared of velocity (v^2), means v×v, so the influence of the velocity on drag is very strong. So, as we increase the flight speed of missile than it has to face more drag and drag will decrease as we increase altitude. But if we increase the nose fineness ratio and keep small diameter, missile will face less drag. We can't eliminate drag completely but we can reduce it, reduce it by giving favorable shape, by its compact shape of components. Drag force is very complex phenomena which occurs from various sources and every component of missile produce drag. Overall drag of missile will be equal to the sum up of drags of each part of missile.

Here, our more concern is about drag, because when the mini missile will separate from the main missile, the shape and size of missile will change during flight. After the separation of mini missiles there will be an empty space shown in below figure and this empty space or cavity may be the part of missile that produce the more drag. We examine the drag produce by missile before the separation and after separation. There are many types of drags and each type of drag have its own reason, below is the brief discussion about types of drag and how it occurs.

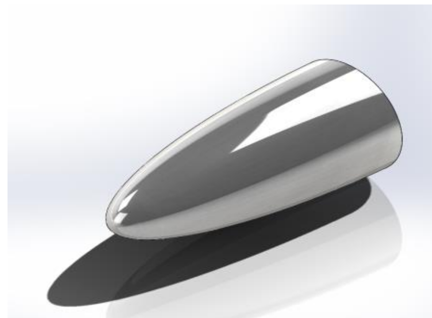
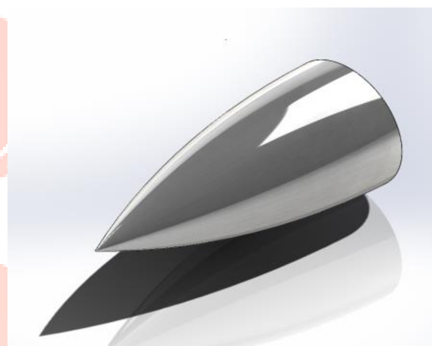
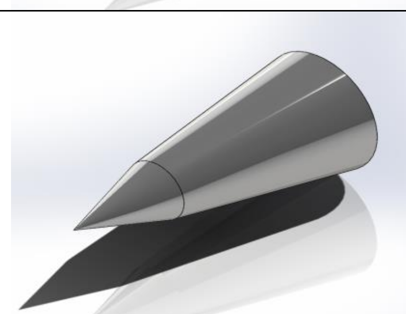


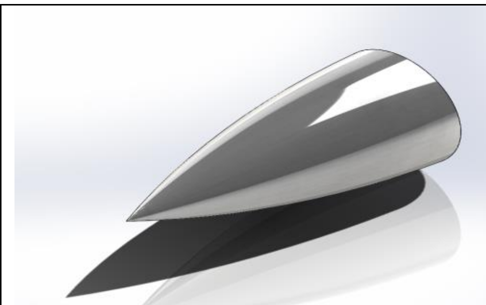
3.1 CAUSES AND SOURCES OF DRAGS:

3.1.1. NOSE OF MISSILE

Drag depends on the viscosity of fluid in which missile is flying. It is most important factor also very hard to measure it very accurately.

There are variety of nose geometry we have, below are types of nose design with their geometry

S.NO	NAME OF NOSE TYPE	GEOMETRY
1.	ELLIPTICAL NOSE	
2.	TANGENT OGIVE NOSE	
3.	CONIC NOSE	
4.	BI- CONIC NOSE	

5.	SECANT OGIVE NOSE	

There are few assumptions by which we can make reduce the drag on our missile. A theory of developments of early missile was based on assumption that flow is inviscid that was given a small perturbation of missile. If a missile is a finitely long and thin slender body. A linear partial differential equation (In Differential analysis means a description of flow from point to point) and potential equation describes the behavior of flow. This solution gives us that dimensionless quantity like lift confident C_l and drag due to lift (CDL) are independent of Mach number and shape of body but within slenderness restriction of the theory. And static pitching moment (C_m) that depends on volume of missile

$$C_{DL} = C_L\, \alpha/2 = \alpha^2$$

$$C_m = -2\alpha\left(l - \frac{volume}{l\, S_{base}}\right),$$

Where

a is angle of attack

L is the length of missile

General Nature of drag forces: component of drag

The total combination drag has four components

$D_c = D_B + D_W + D_{W(B)} + D_{B(W)}$

D_B = drag of body alone

D_W = drag of wing alone

$D_{W(B)}$ = drag of wing due to presence of body

$D_{B(W)}$ = drag of body due to presence of wing

The components $D_{W(B)}$ and $D_{B(W)}$ are due to pressure field of the interference of potential.

there are several significant methods to separate the total drag of missile in component parts and drag of each. One of the simplest method that have an consideration that whether drag is caused by force acting perpendicular to the body of missile or tangential to the body.

The drag formed from the pressure force acting normal to the missile body is called pressure drag.

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The drag formed from the pressure force acting normal to the missile body is called pressure drag. A small discerption of pressure drag below;

❖ PRESSURE AND PRESSURE DRAG

Pressure drag created by the pressure forces acts perpendicular to the surface. And drag cause by the tangential forces (skin friction) by viscosity called skin friction drag.

Pressure drag on surface of missile is given by

$$D_P = -\iiint_{SM} PCOS(\mathbf{n}, \mathbf{Vo})dSm$$

In this equation cos (n, v_o) is the cosine angle between V_o and outward normal to the missile surface. S_m is the total surface area of missile including base area

'τ' is the local skin friction per unit area due to viscosity than the viscous drag or skin friction drag is given by

$$D_v = -\iiint_{SM} \tau \cos(t, Vo)\, dSm$$

Here $\cos(t, V_o)$ is the cosine of angle between V_o and the tangent to the missile surface in the τ direction.

if we assume that the flow having constant density and unaffected by viscosity and in all distant direction having velocity of q_o and in nearby field velocity is q. now, if at everywhere the distant pressure is p_o and in distributed flow $p_o + p$ is the pressure at a point, than the super stream pressure p is given by Bernoulli theorem

$$P/P_n = 1 - q/ q_o^2$$

Where $p_n = \rho q_o^2/2$ called stagnation pressure or nose pressure.

S_{basse} is the surface are of missile (reference area)

The drag can be separated into the components of fore drag and base drag both. The fore drag is the part of the total drag acting on the missile body exclusive the base area. Fore drag consist pressure drag and viscous drag and the base drag have almost pressure drag. And now the total drag of missile can be divided into the pressure fore drag, base drag and viscous drag. There is another type of drag generally we know it by the name parasite drag and a brief discussion of parasite drag is below

PARASITE DRAG

Parasite drag is classified as form drag or pressure drag, skin friction drag and interference drag.

- Parasite drag is occurs when body moves in fluid.
- Drag is simply produces by shape of body itself.
- Drag due to skin friction.
- Form drag is caused due to shape of body moving through fluid. It is depend on cross section of the object. An object having small cross section and sharper shape will experience less drag.

- Interference of two or more waves having different speed is the reason of interference drag. Interference drag produces by mixture of airflow streamlines over different aircraft components.

Parasite drag consist mostly skin friction drag. Skin friction drag caused by friction between fluid and object, the smoother surface of body less the drag will be. Skin friction depends on wetted area, means it is directly proportional to area in contact with fluid. Skin friction drag is produces by the viscosity of air. Turbulent flow creates more drag than laminar flow.

Now first component of missile drag pressure fore drag is amendable to analysis through potential theory in those case wherein the boundary layer does not separate and cause large alteration in pressure distribution, even with boundary layer separation, potential flow frequently plays a role in determining the pressure distribution.

Second component of missile drag can be considered as base drag is determined by consideration of potential flow and viscosity. The so-called dead water region behind the base of a missile has a static pressure which depends on how the outer flow closes in behind the missile and how the boundary layer from the base mixes with the dead water and outer flow.

The final and third component of the missile drag the viscous drag or skin friction drag. It is very hard to predict or measure accurately. It is difficult because from incomplete understanding of where the boundary layer turns from laminar to turbulent in flight.

VISCCOUS CROSSFLOW

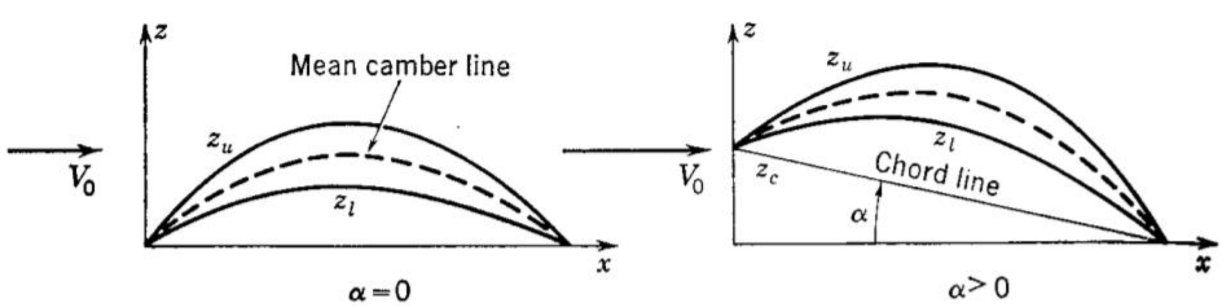
This drag acts through pressure forces accompanying boundary layer separation and vortex formations and is not due to skin friction forces. The pressure forces rising as a result of crossflow are the basis of the definition of the cross flow drag coefficient C_{de}. The drag due to viscous crossflow is taken as the forces normal to the body axis due to crossflow time the angle of attack. Thus if the S_c is the planform area of the body subjected to viscous crossflow and C_{de} is the viscous crossflow drag coefficient than the drag due to viscous crossflow D_e is

$$D_e = C_{de}\, q_o\, \alpha^3\, S_c$$

Pressure drag on wing alone;

We can accumulate the pressure drag on wing at supersonic speed by the supersonic wing theory. The pressure drag on wing alone at supersonic speed can be considered to be the result of thickness drag and camber drag that occurs at zero lift and of drag due to lift.

To examine the pressure drag on the wing, we need to go through the two dimensional pressure drag of airfoil. So let considered an airfoil with camber and thickness distribution at zero angle of attack in below figures;-



The thickness distribution is given by

$$t(x) = Z_u - Z_l$$

and the camber distribution is

$$\bar{Z}(x) = \frac{Zu+Zl}{2} \qquad \alpha = 0$$

At angle of attack the camber distribution is

$$\bar{Z}(x) = \frac{Zu+Zl}{2} - Z_c$$

For upper and lower airfoil surfaces, the combined effect of angle of attack, camber and thickness coordinates are given by the

$$Z_u = Z_c + \bar{z} + t/2$$

$$Z_l = Z_c + \bar{z} - t/2$$

BOTTAIL:-

Bottail means the cylindrical section of the body where the diameter is continuously decreases towards the rear. Bottail can be conical or ogive planform shape. The decreasing diameter of bottail helps to reduce because of large negative bas e pressure. The pressure at the rear (base) of missile is called as base pressure, which having a large negative value as compare to the free stream pressure on missile. So it can create more drag if base is large. But as we discussed before, bot tail can reduce the base drag of missile

2. **After the de attachment** of children missile from parental missile the cavity will be created and it can be a great force overall drag force. So, we need to minimize the drag created by that space otherwise missile will lose its flight velocity. Drag will increase dramatically because of cavity created when the children missile separate from parent missile. The flight speed will also decrease and overall lift also. Not also drag but the stability of missile is also effected when the children missiles separated from the parental missile.

Everything of this missile behave like normal missile but we need to examine how Arighan missile will behave and how it aerodynamic properties changes when children missile separates from the main parent missile. To studies the behavior of missile after separation we need to analysis the flow over the missile so we need to CFD it. Because the importance in the analysis of flow conditions around bodies of revolution with surfaces at angles of attack is the increase in flow velocity normal to centerline of the body. Because the as the continuity equation (governing equation) air must divided and pass the body, the velocity of air closed to the surface of body must be increased due to increase path length which it have to cover. And it has been found that the velocity at the surface is almost twice the velocity of free stream velocity (normal to the body centerline.

Cavity created after the missile separations compromises the stability of the missile due to downwash. Because when a missile having wings (forward or aft locations) when climbs at a certain angle of attack, the airflow will be changed as the air passes on the forward lifting surfaces. This interference between the tail and wing called downwash and certainly this downwash effect the lift of aft surfaces. Here, Arighan will experience both downwash and flow separation.

CFD analysis of Arighan missile;-

Here are some pic from the ansys workbench of cluster missile, velocity of air is 540 m/sec

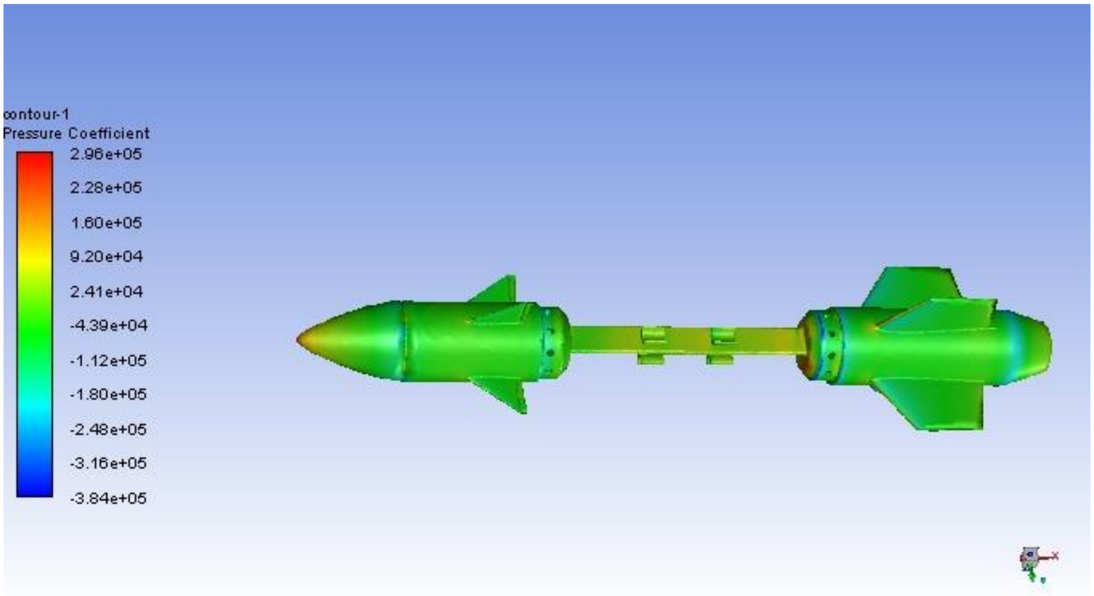


Fig: - pressure coefficient pressure at 510 m/sec

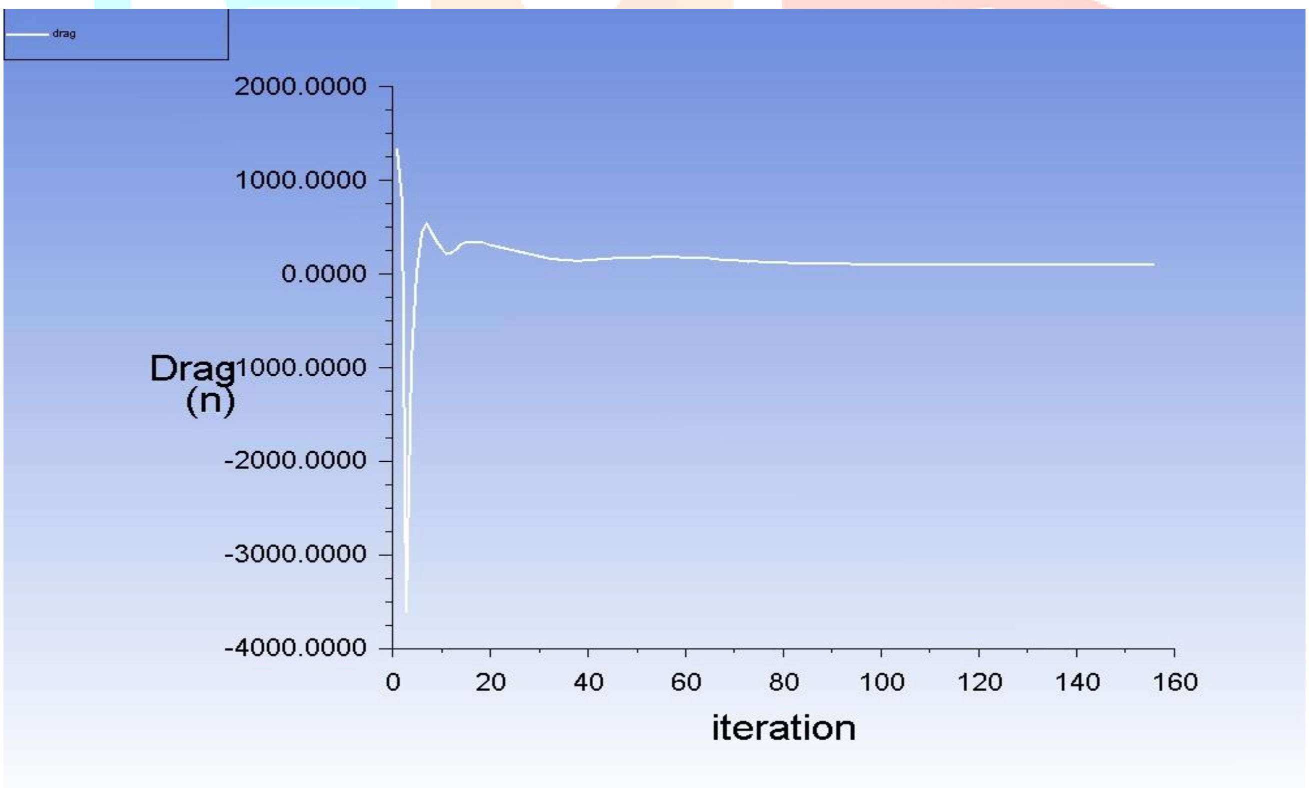
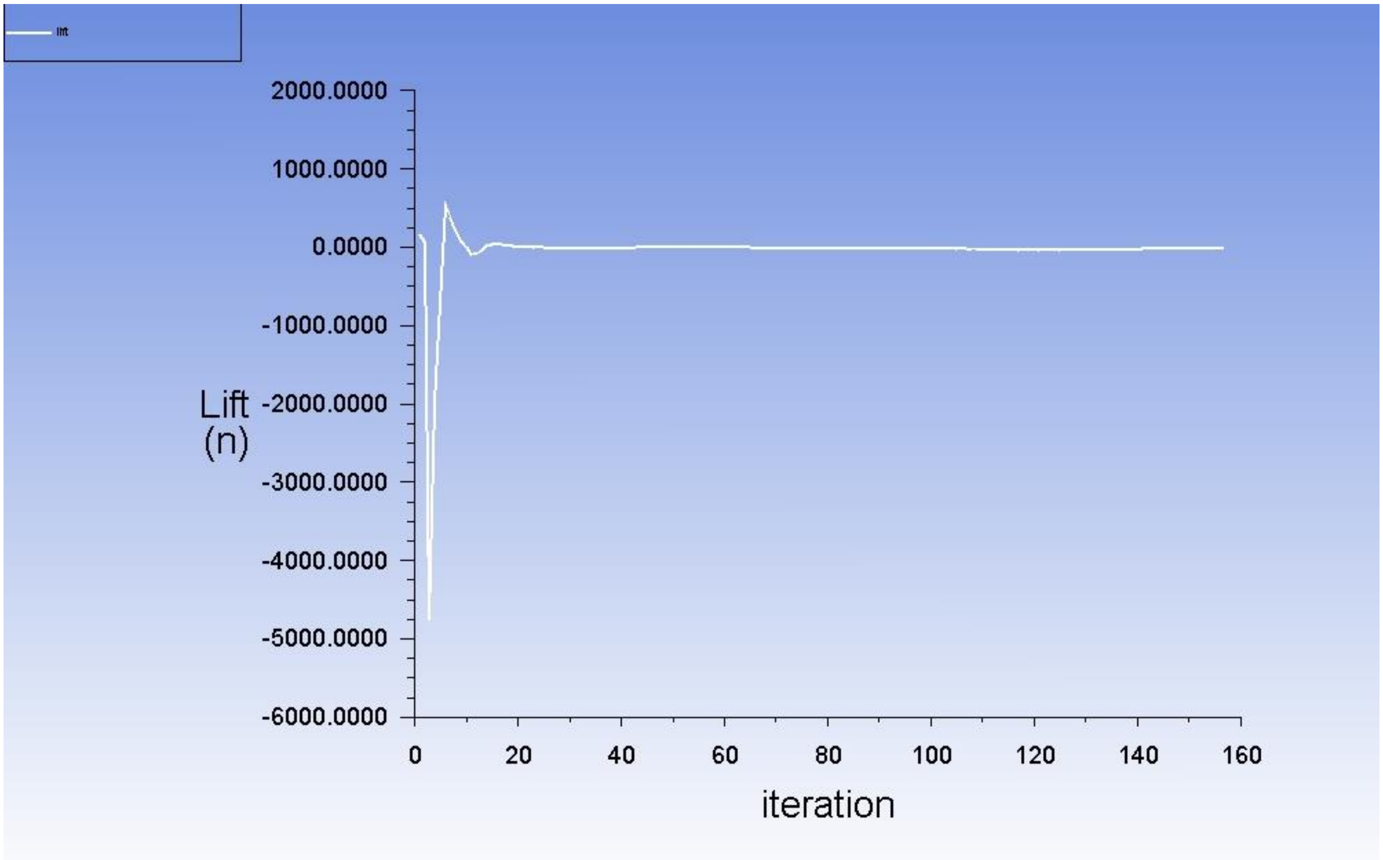


Fig: - Drag plot at 510 m/sec



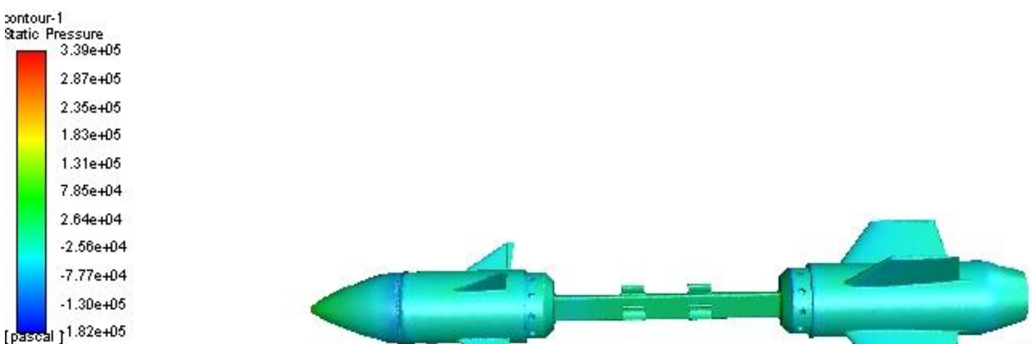
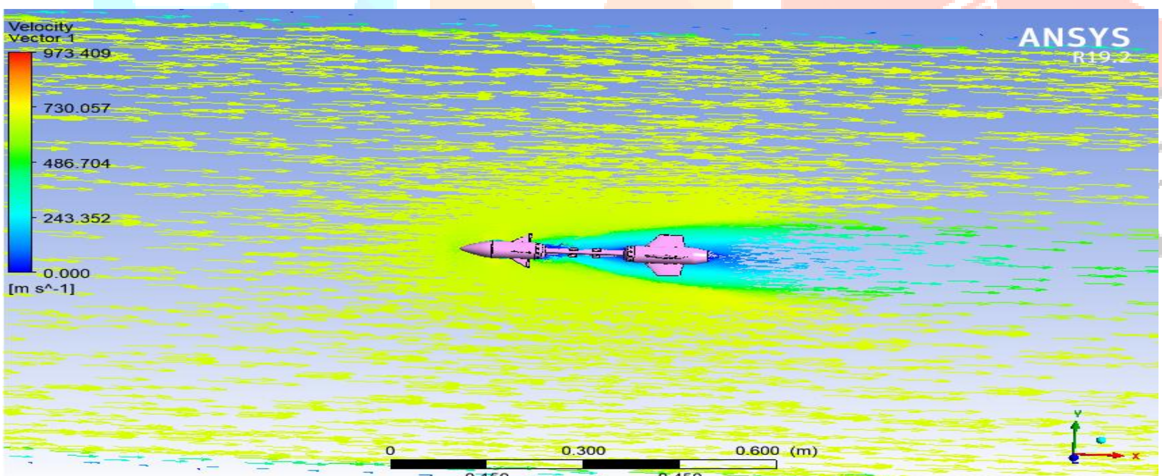
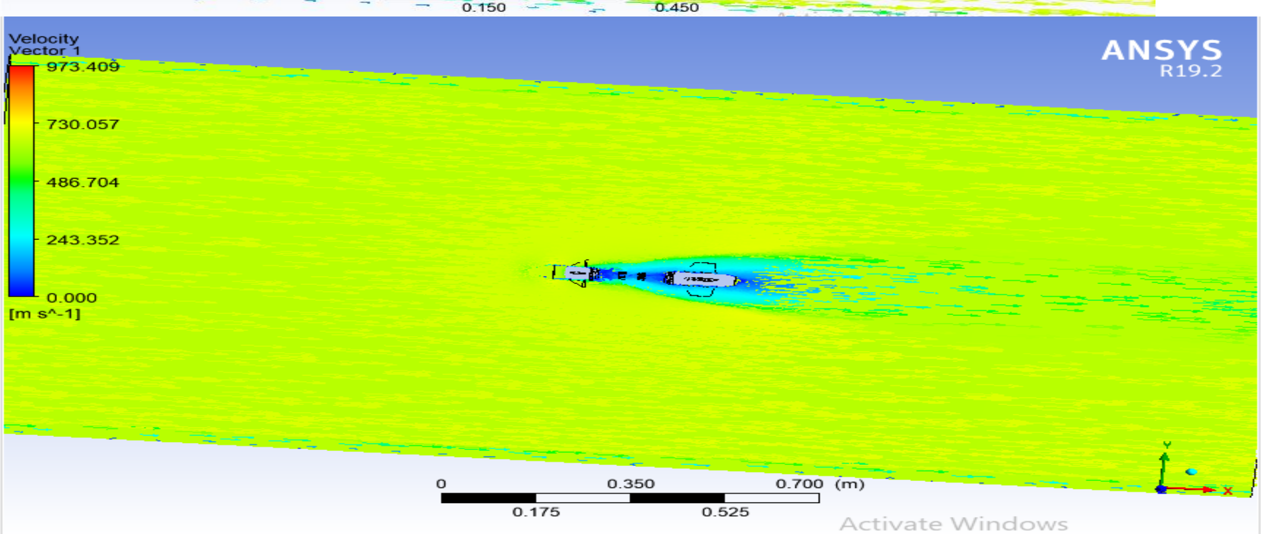


Fig: - static pressure at velocity of 510 m/sec

Fig: streamlines at 680 m/sec





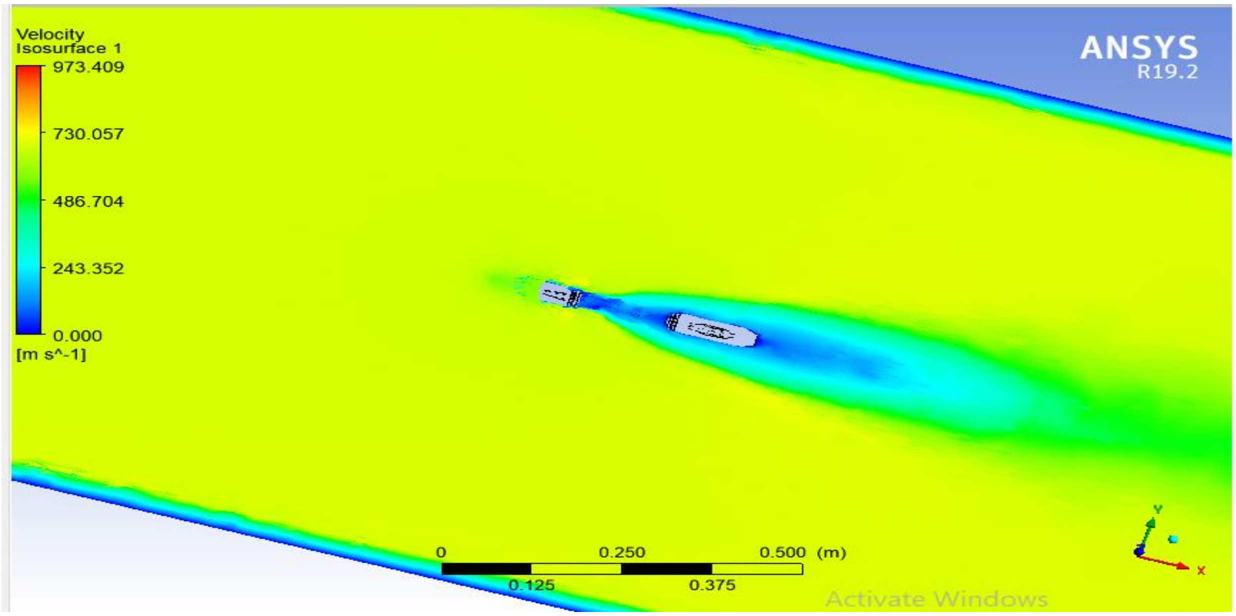


Fig: velocity vector at 680 m/sec

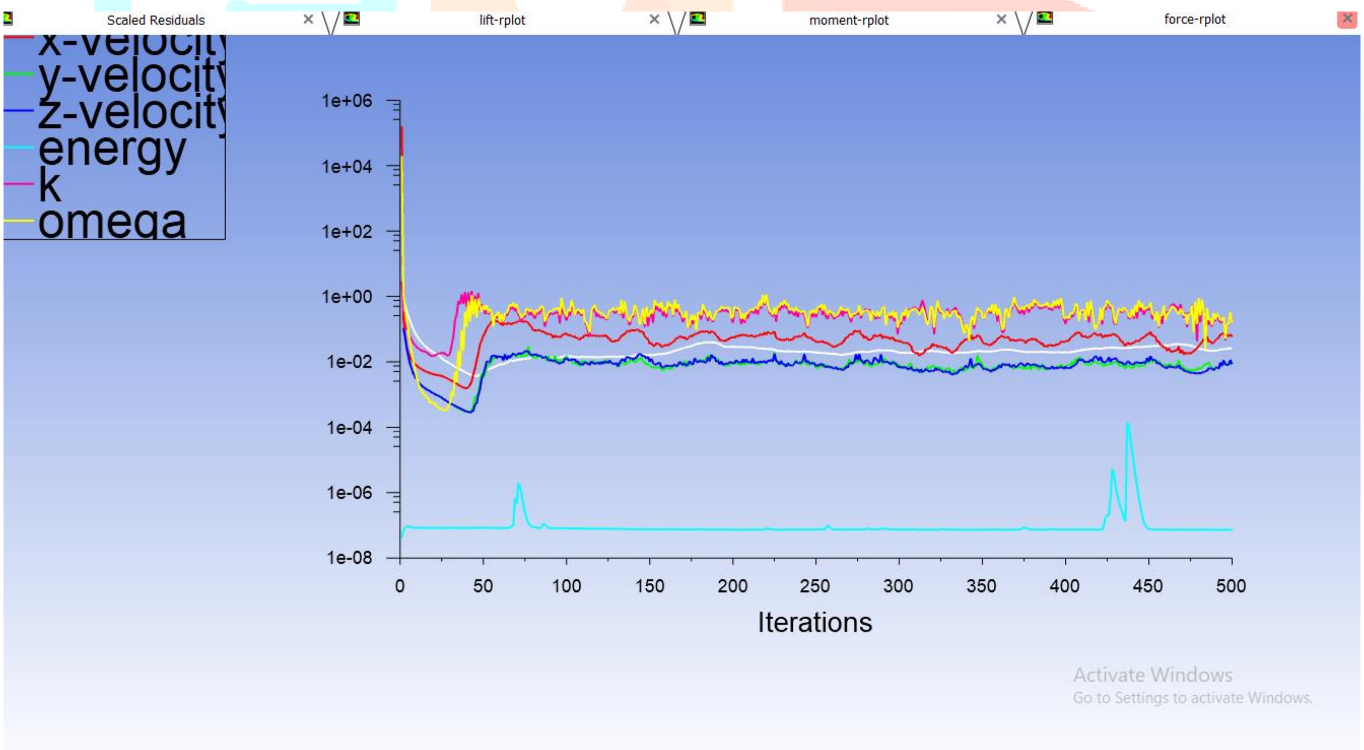


Fig: Residuals at velocity 510 m/sec

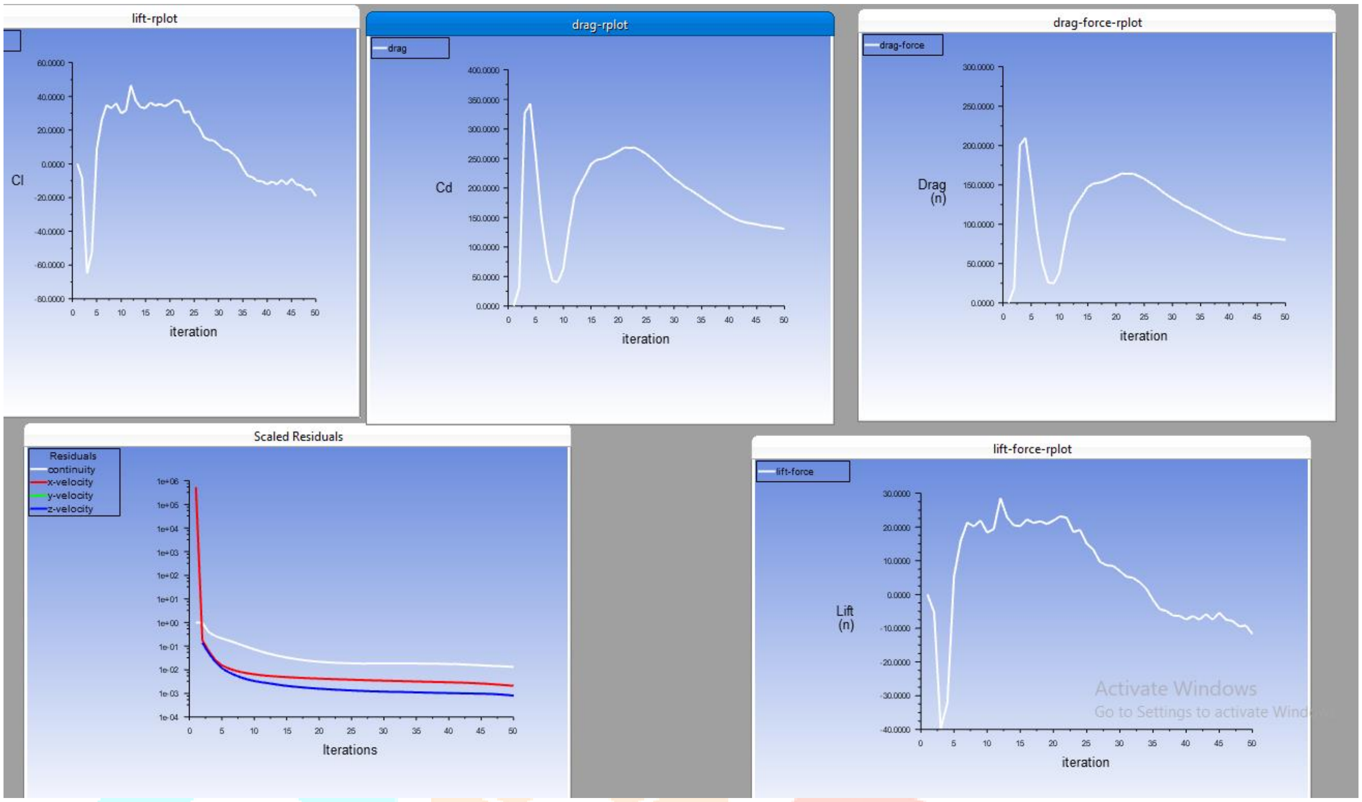


Fig: lift and drag coefficient, lift and drag force and residuals at 680 m/sec

We have these result for Arighan in ansys workbench and everything works fine with missile.

Arighan will work fine before and after the separation of its children missile

CONCLUSION

We can make Arighan the cluster missile happens in practical. Arighan missile can be solution for multiple problems. It can be used as anti-aircraft missile defense system, can be used to destroy target both on ground and in air. It has two version of it one of them is especially for high maneuverability aircraft can trigger itself so there is no chance for target to get escape. CFD analysis shows the flight path of the missile is fine and it can be practically possible.

This missile is has unique design with more accuracy and more probability to destroy target as it can explodes both the way, explodes after hit the target and if the target having maneuverability than we can make all the missile explodes themselves when the missile come closer to < 30 centimeter. It can be proved best when it used as anti-aircraft system and to take down the enemy aircraft in air. Because when we release Arighan missile than the target hitting probability becomes 5 time more than the single missile released to hit target. I'm not in favor to make weapons at all but if your enemy has weapons and try to threat or attack you then you should go with stronger weapons and this is stronger. We can make it ballistic missile with more range and with more destroying power.

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