DESIGN AND CFD ANALYSIS OF BLENDED WING BODY AIRCRAFT

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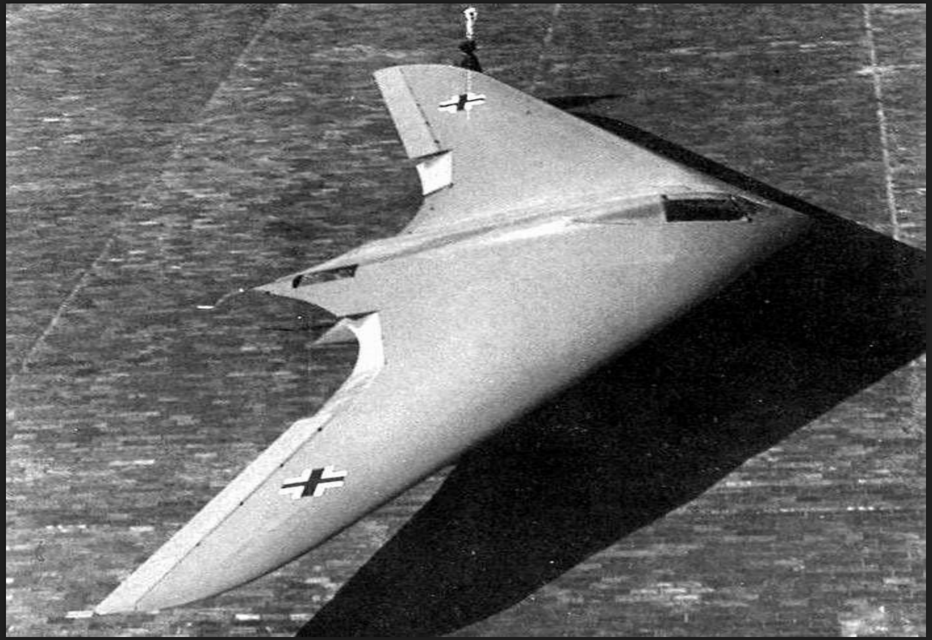
INTRODUCTION

- A Blended wing body (BWB) aircraft is also called as hybrid wing body aircraft
- Blended wing body aircraft have a flattened and airfoil shaped body
- Blended wing body aircraft is a configuration where the fuselage is merged with the wing and tail to form a single entity
- In blended wing body aircraft wing and fuselage lift together. Thus, it increases the effective lifting surface area

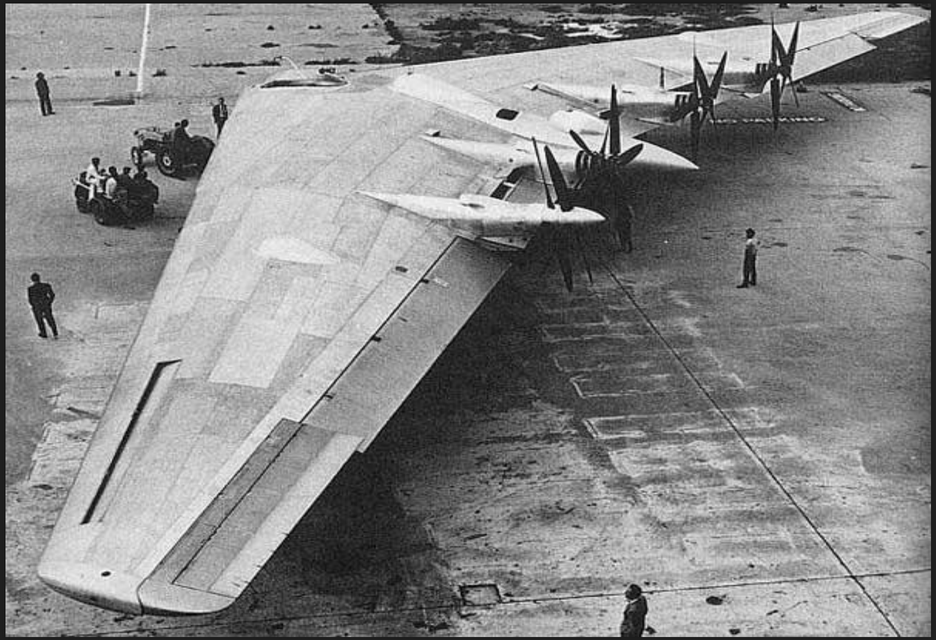
HISTORY OF BWB

- In early 1920s, Nicolas Woyevodsky developed a theory of BWB
- The idea was proposed again in the early 1940s for miles M-26 airliner project
- NASA returned to the concept in 1990s with an artificially stabilized 17- foot called bwb-17 built by Stanford university, which was flown in 1997, and showed good handling qualities.

HISTORY OF BWB



Horton Ho 229 by Horten brothers



The Northrop XB-35 aircraft

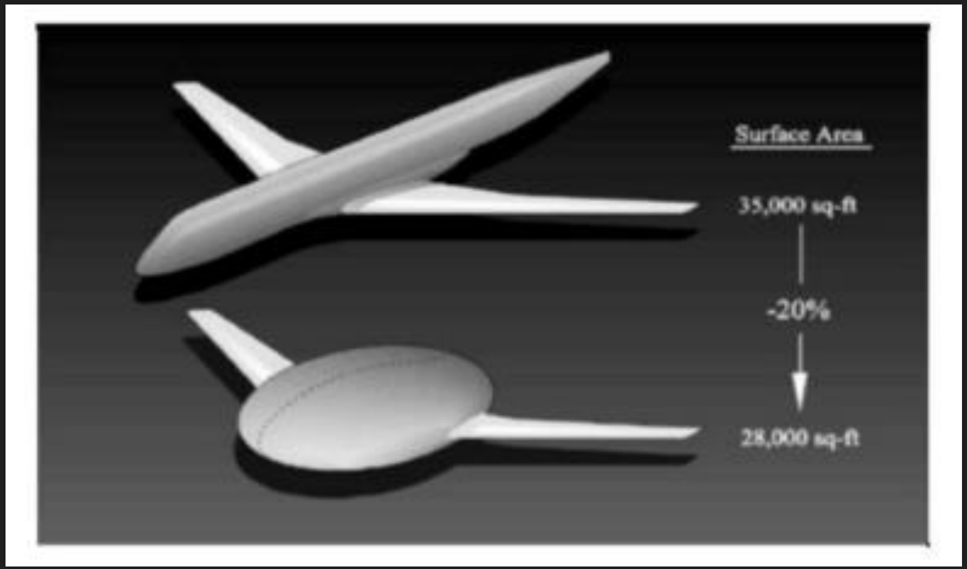
HISTORY OF BWB

Turbojet powered Ho-229 flying wing aircraft the worlds first turbojet powered Blended Wing Body aircraft

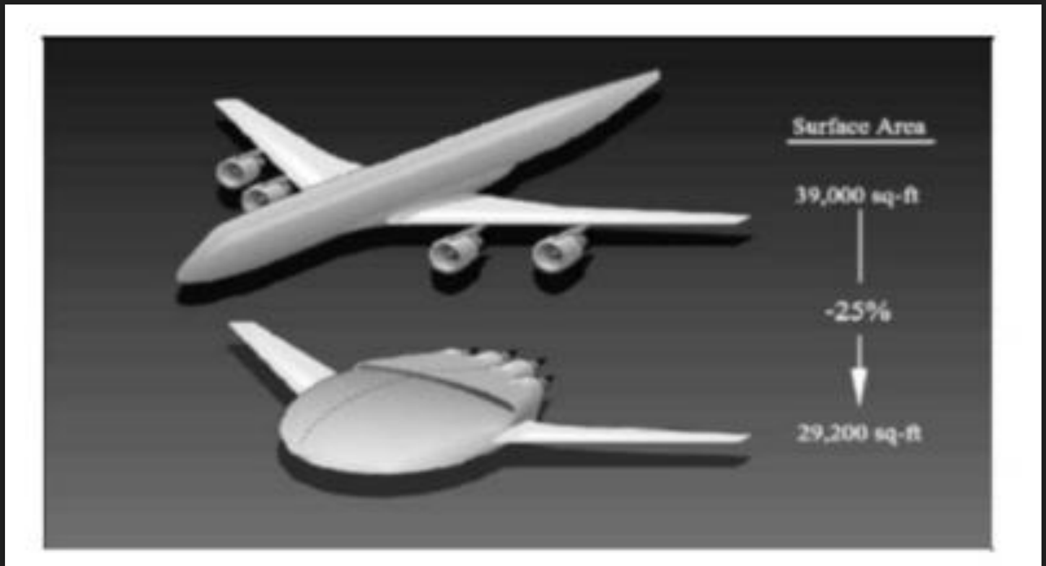
FORMULATION OF THE BWB CONCEPT

- When compared to the conventional aircraft, BWB has higher lift, higher L/D ratio, and lower fuel burn
- In BWB aircraft, wetted area is 7000ft less as compared to conventional aircraft with cylindrical fuselage
- Adding the required control surfaces to each configuration results in total wetted area difference of 14,300ft or a reduction in 33%

FORMULATION OF THE BWB CONCEPT



Cylindrical fuselage wing geometry



Total difference in wetted area

ADVANTAGES OF BWB AIRCRAFT

- Higher fuel efficiency
- Higher payload capacity
- Lower take-off weight
- Lower wetted surface area
- High L/D ratio due to a decreased relative wetted area (area which is in contact with the external flow)
- Lower production cost

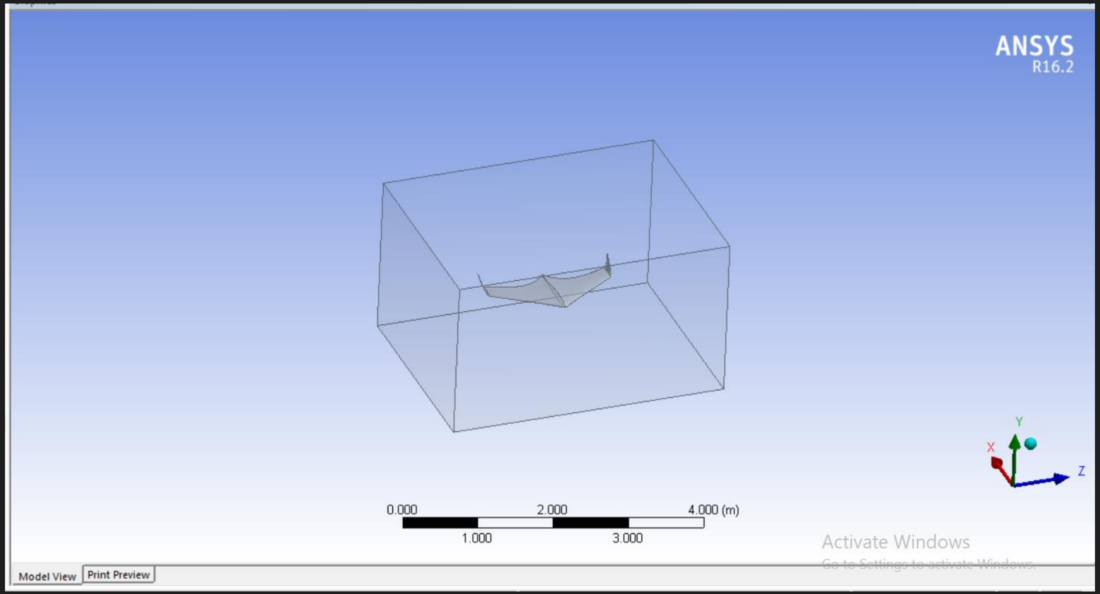
ANSYS

- ANSYS is a high performance general purpose fluid dynamics program that has been applied to solve wide-ranging fluid flow problems for over 20 years
- ANSYS Fluent consists of 4 software modulus such as-
    1. Design generation software (design modeler)
    2. Mesh generation software
    3. Physics pre solver (setup)
    4. Solver (solution)
    5. Post- processor (results)

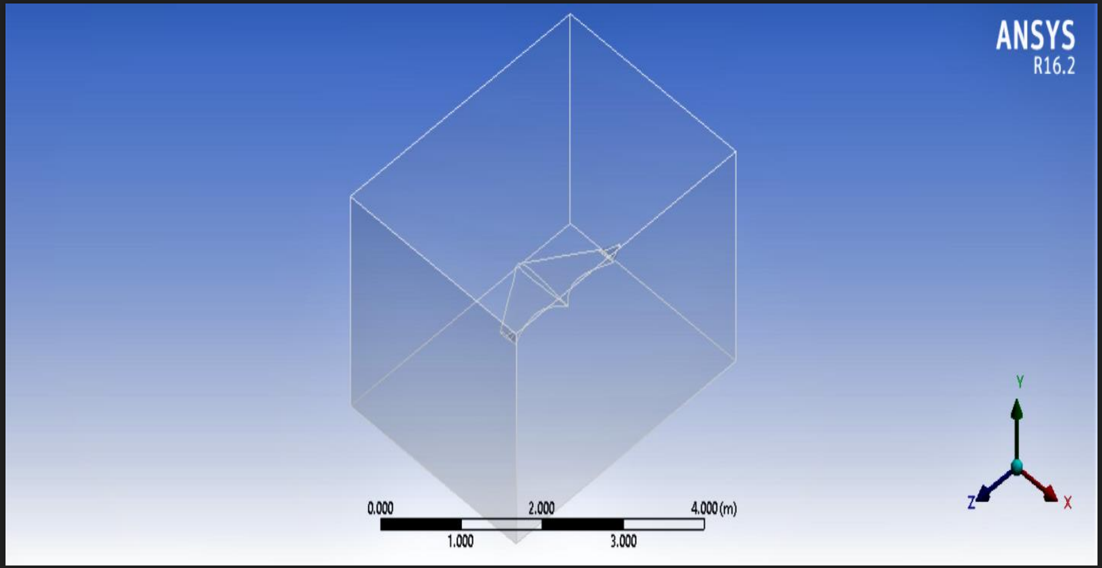
ANALYSIS OF BLENDED WING BODY AIRCRAFT UAV IN ANSYS FLUENT

- Geometry (design modeler)
  1. Uniform enclosure
  2. Naming of the tool body and target body
  3. Create Boolean
  4. Update
  5. generate

GEOMETRY



ENCLOSURE



BOOLEAN

MESHING

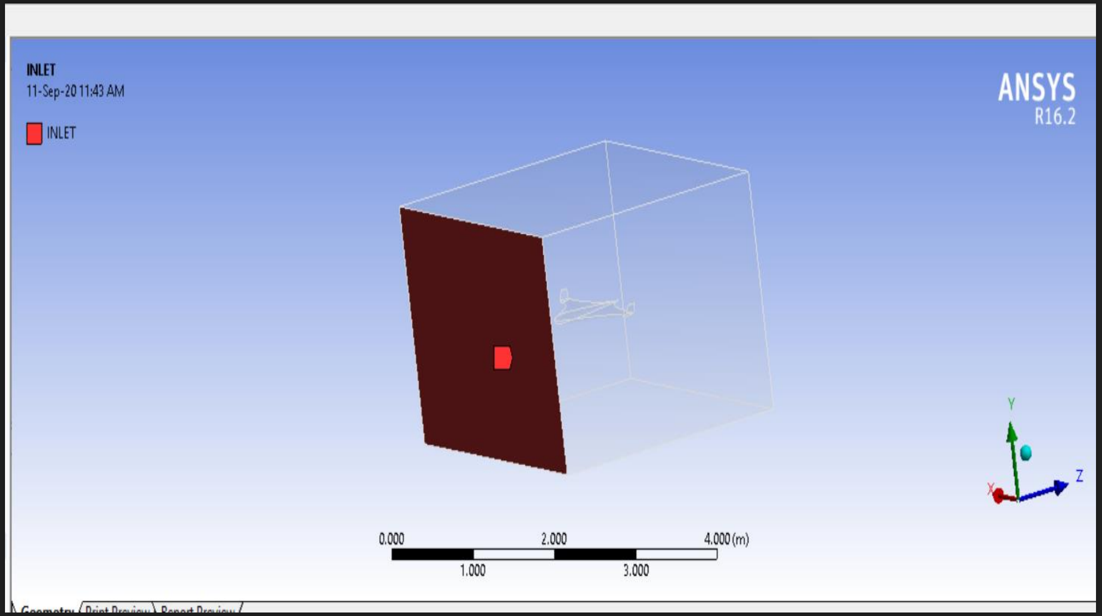
- Meshing

1. Start with the naming of the surfaces.
   - Inlet
   - Outlet
   - Wall
2. Sizing (relevant center) – medium
3. Update mesh

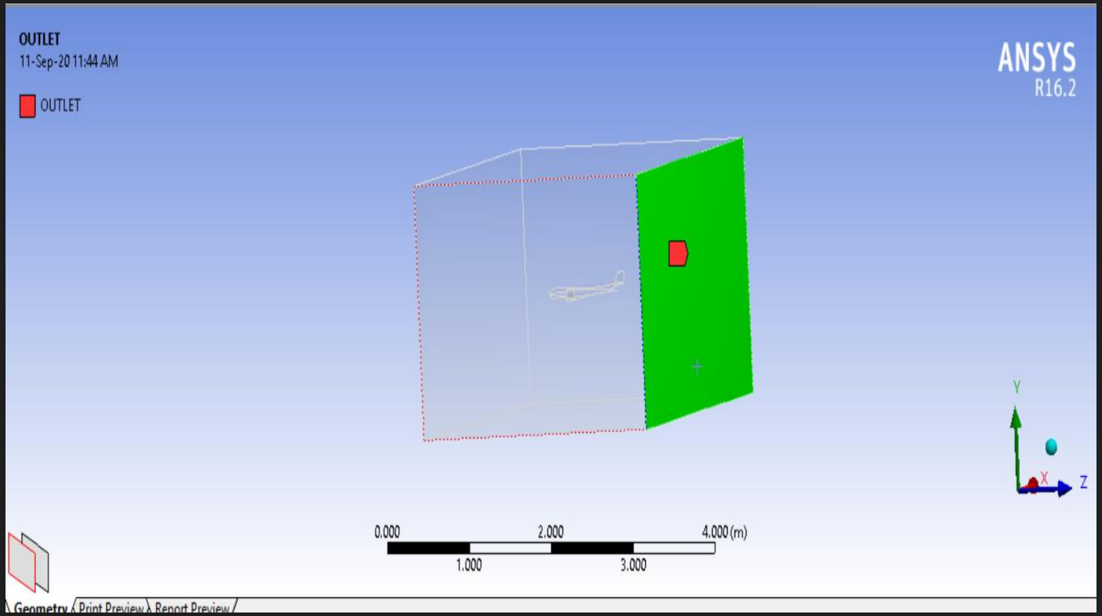
MESHING

- Meshing is the discretization of continuous body into finite no of elements
- Mesh process –
  1. Select physics preference in ANSYS Meshing(CFD).
  2. Select the meshing method (automatic).
  3. Insert local meshing setting.
  4. Preview and generate the mesh.
  5. Check mesh quality.

MESHING

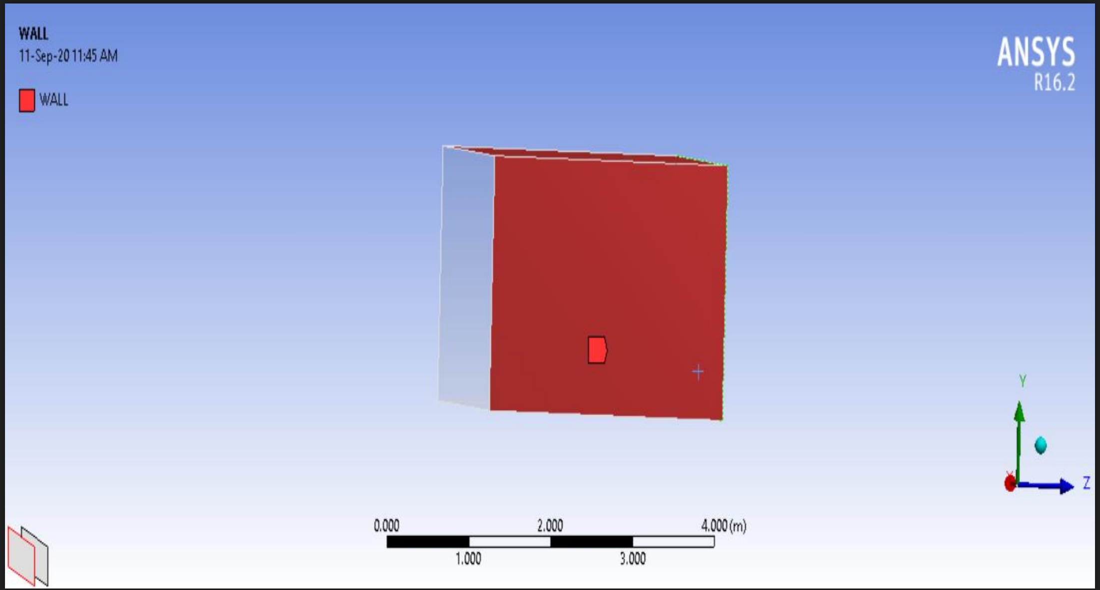


INLET

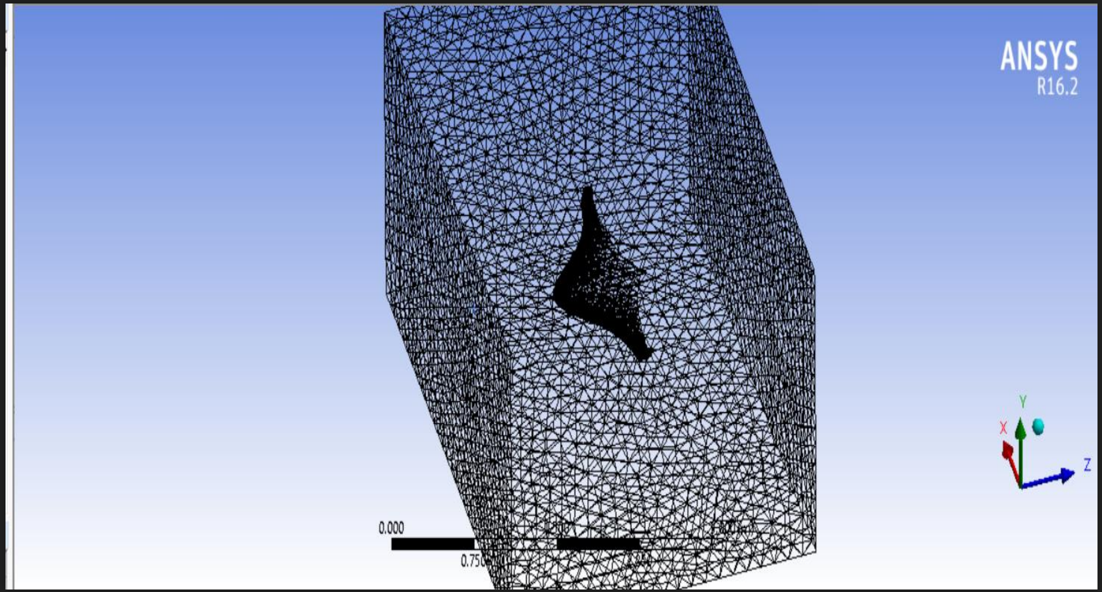


OUTLET

MESHING



WALL



WIREFRAME MESHING

DIMENSIONAL ANALYSIS

- A large number of physical parameters determine aerodynamic forces and moments.

Parameters	Symbols	Units
Lift per span	L '	MT^{-2}
Angle of attack	a	--
Freestream velocity	V_∞	LT^{-1}
Freestream density	ρ_∞	ML^{-3}
Freestream viscosity	μ_∞	$ML^{-1}T^{-1}$
Freestream speed of sound	a_∞	LT^{-1}
Chord	c	L

DIMENSIONLESS ANALYSIS

- BY Buckingham Pi theorem,

$$L' = f(a, \rho_\infty, V_\infty, c, \mu_\infty, a_\infty)$$

$$\Pi_1 = \bar{f}(\Pi_2, \Pi_3 \ldots \Pi_{N-K})$$

$\Pi_1 = L / 2\, \rho_\infty V_\infty^2\, c = c_\ell$ (lift coefficient).

$\Pi_2 = a = a$ (angle of attack).

$\Pi_3 = \rho_\infty V_\infty\, c / \mu_\infty = Re$ (Reynolds number).

$\Pi_4 = V_\infty / a_\infty = M_\infty$ (Mach number).

$$c_\ell = \bar{f}(a, Re, M_\infty)$$

- In our simulation we have kept Reynolds number (63,000), Mach (0.14) constant and varied alpha as 0,5,10,20,30,35 (degrees).

SETUP

- Setup
  1. Model – (k- epsilon)
  2. Boundary conditions – Inlet velocity (50 m/s)
  3. Solution methods
  4. Monitor
  5. Solution initialization
  6. Run calculation – number of iteration
  7. Graphics

VIDEO EVIDENCE

SolidWorks

- Solidworks is a Solid modeling computer-aided design (CAD)computer program
- Most commonly used software among engineers and designers.
- Reason to choose this software :-
  - Ability to import different type of data
  - Flexibility
  - Accessibility
- This software provides an innovative way to solve project challenges

CONCEPTUAL DESIGN

- AIRFOIL SELECTION:
  - In the conceptual design phase, the airfoil details of different airfoils were analyzed
  - Airfoil investigation database from airfoiltools.com was used
  - The Martin Happerle, MH-45 was selected
  - The same airfoil is used from wing root to tip
- Reasons for selecting MH-45:
  - High maximum lift coefficient
  - Successfully used in tailless model aircraft

DETAILS OF DESIGN

Parameters	Dimensions	Parameters	Dimensions
Thickness	9.85 %C	C_m	+0.0145
Camber	1.7 %C	Max C_L Angle	9.5^0
Trailing-Edge Angle	4.4^0	Max L/D	66.664
Lower Flatness	66.6%	Max L/D Angle	6.5^0
Leading Edge Angle	0.7%	Max L/D C_L	0.792
Max C_L	0.888	Stall Angle	6.5^0

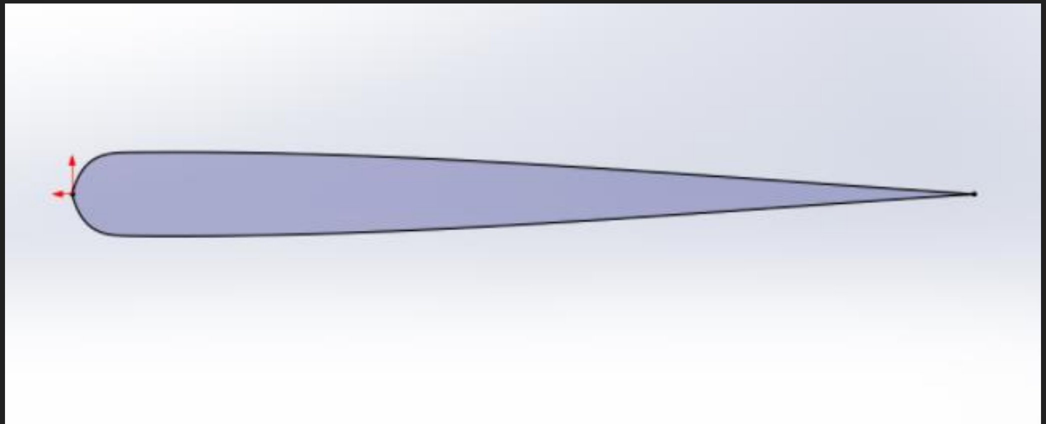
Airfoil Characteristics

Parameters	Dimensions	Parameters	Dimensions
Centre Chord	0.89 m	Half Span	0.86 m
Root Chord	0.42 m	Sweep Angle	30^0
Tip Chord	0.26 m	Dihedral Angle	0^0
Twist Angle	0^0	Surface Area	0.714 m^2

BWB Dimensions

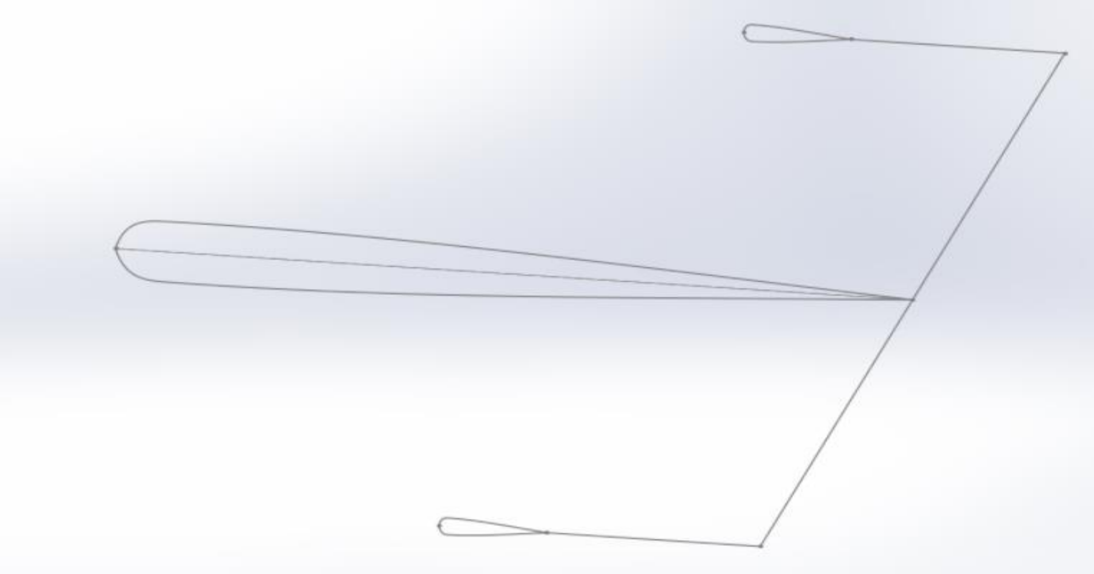
DESIGN PROCESS

- STEP 1- Importing of an airfoil coordinates in solid works inform of .txt or .csv Format.



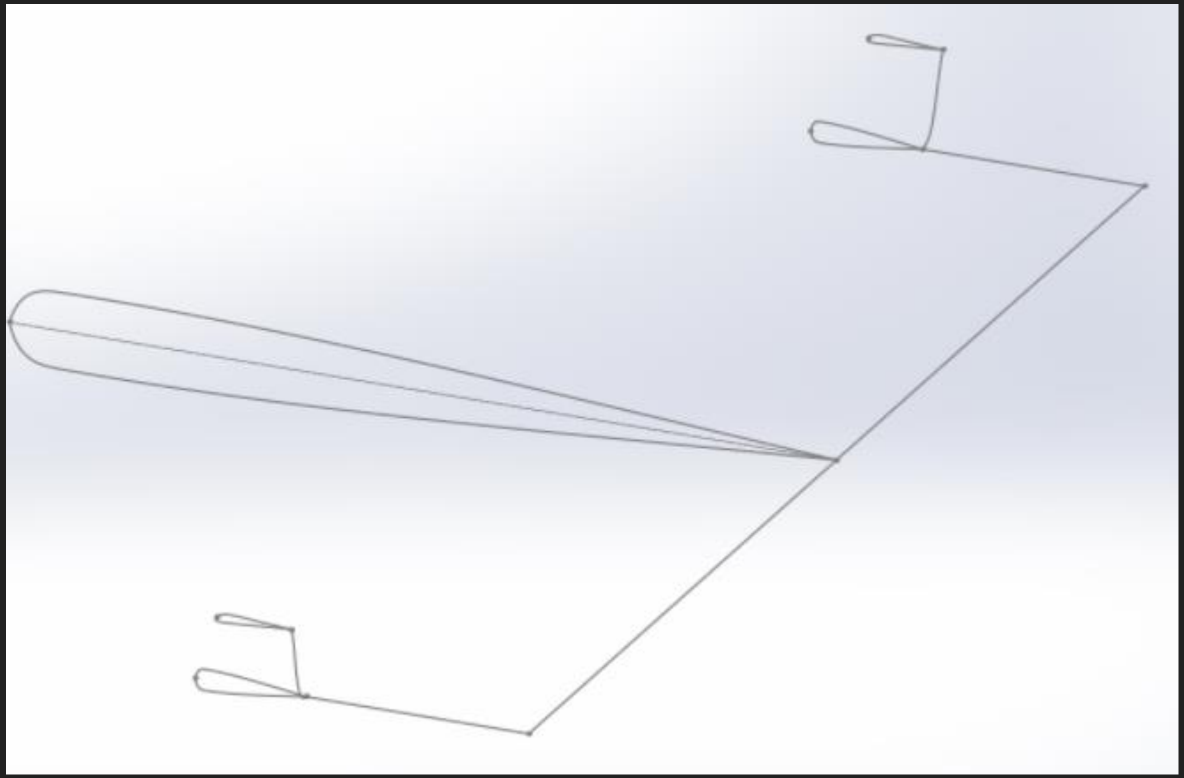
DESIGN PROCESS

- STEP 2 - Resizing the projection of airfoil in different planes according to dimensions.



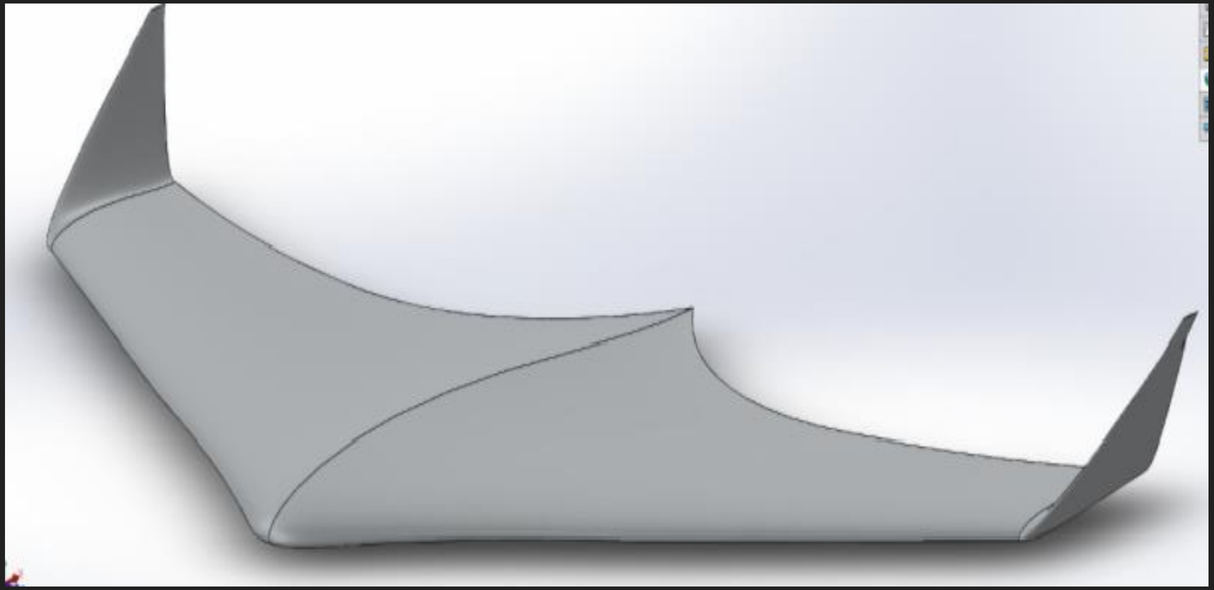
DESIGN PROCESS

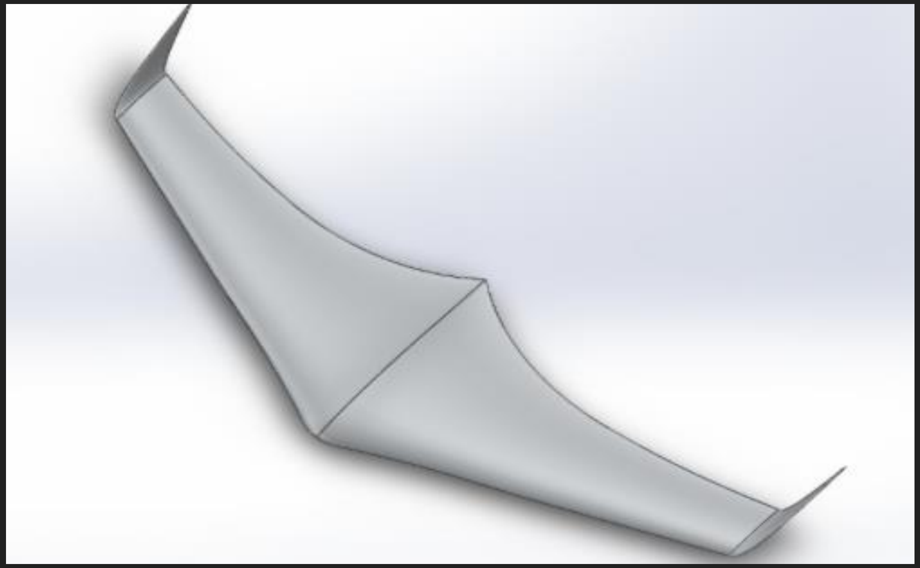
- STEP 3 - Creating a projection of wingtip in the perpendicular plane to create winglets.



DESIGN PROCESS

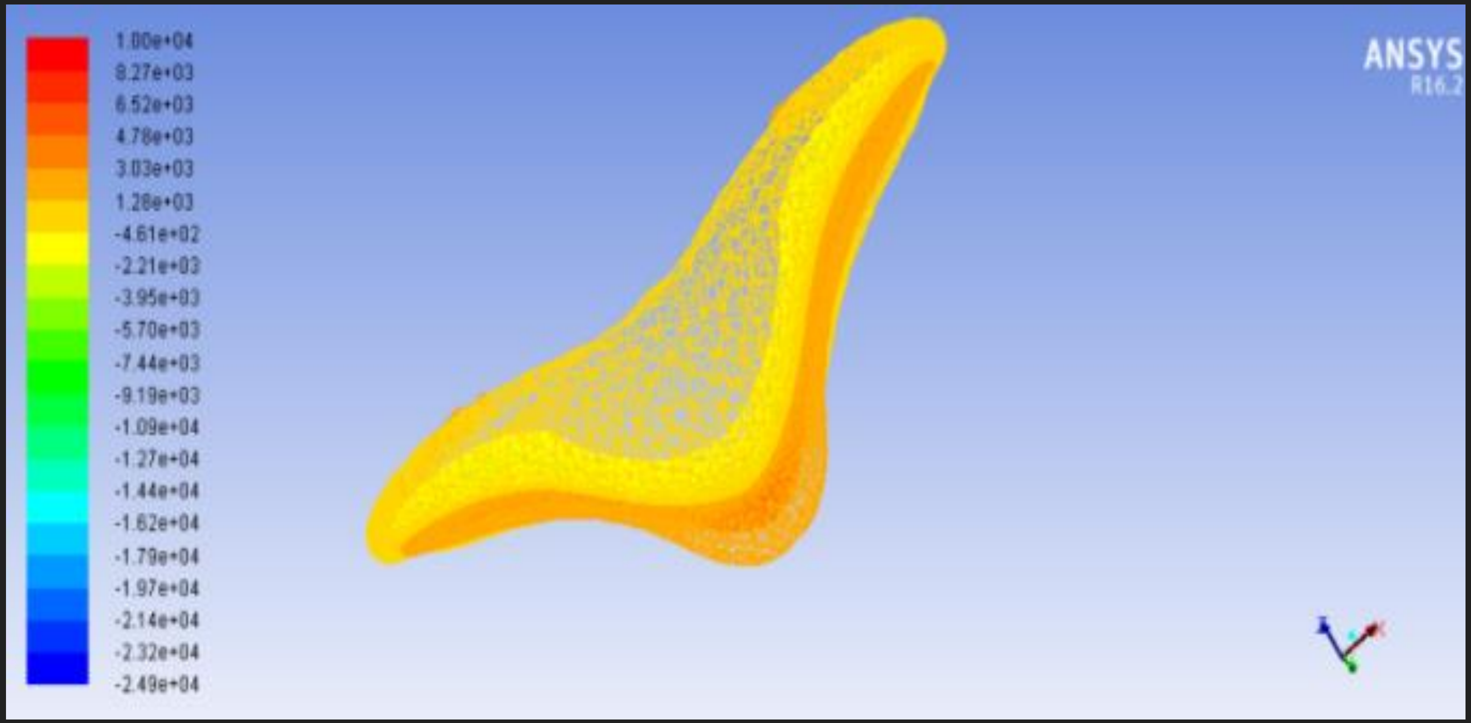
- STEP 4 –Creating loft (BLEND) between these surfaces to get the final model ready.





RESULTS

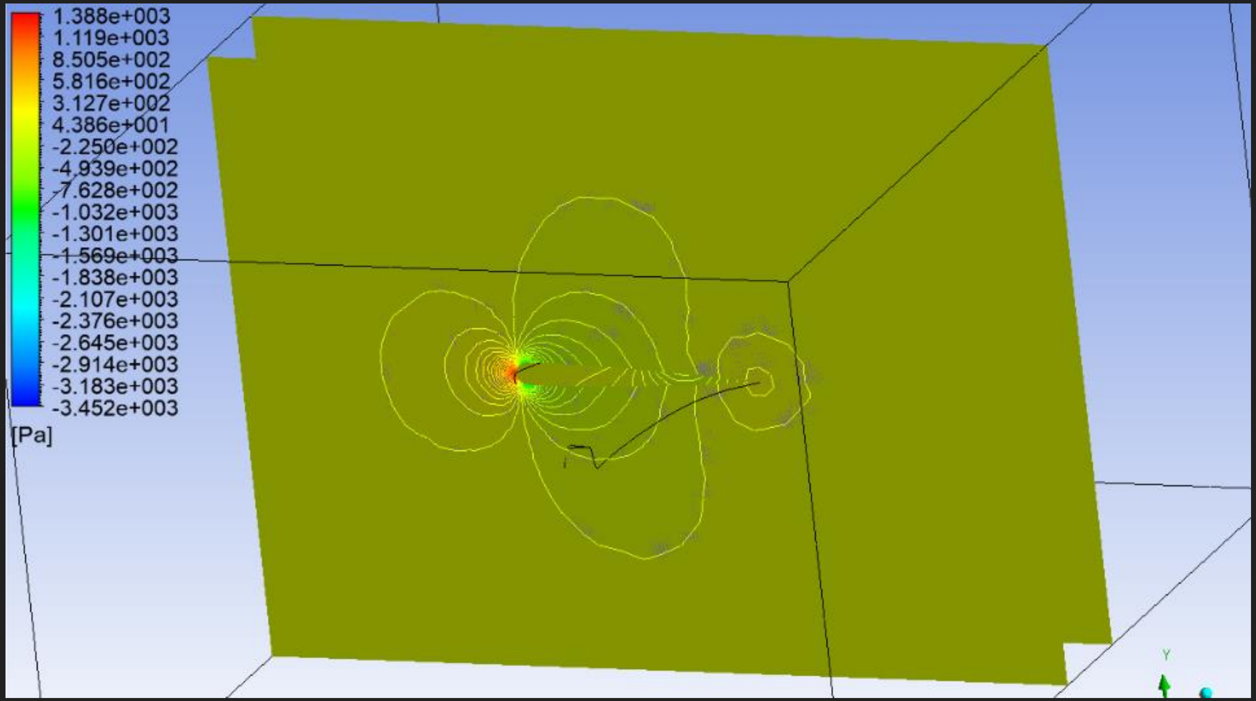
- This simulation result is for Mach (0.14), Reynolds number (63,000) and alpha (0^0)

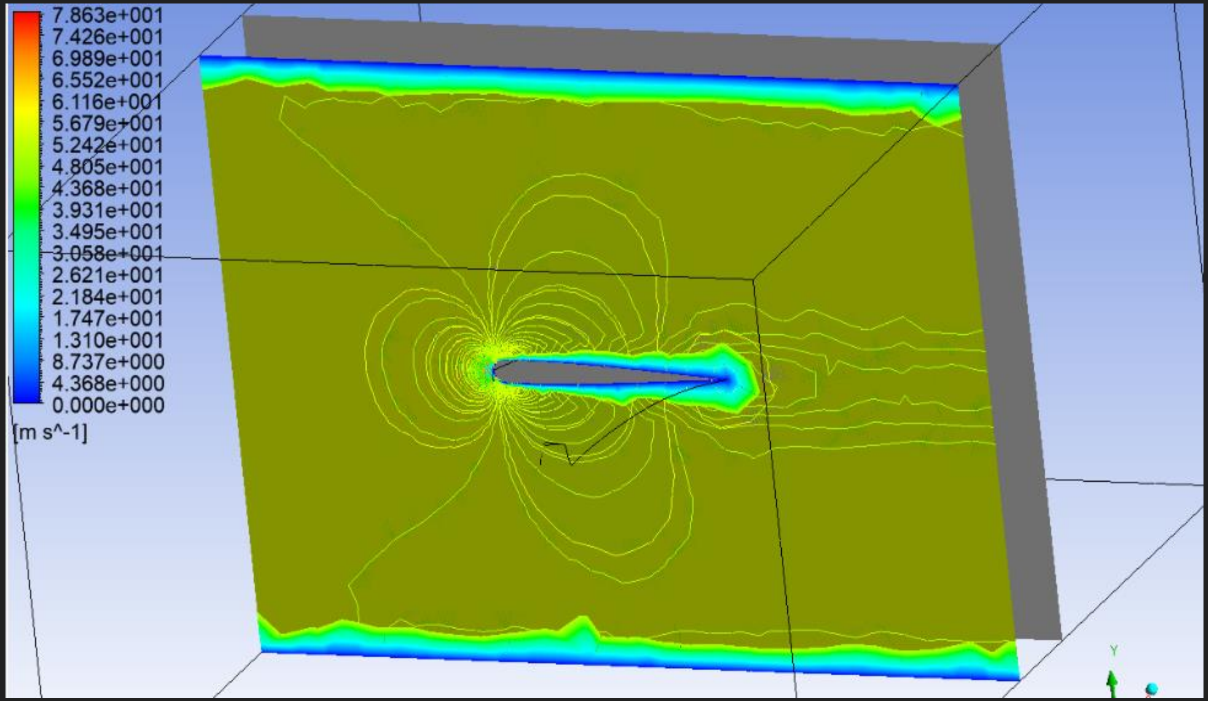


Pressure Distribution Over BWB

RESULTS

- Contours:





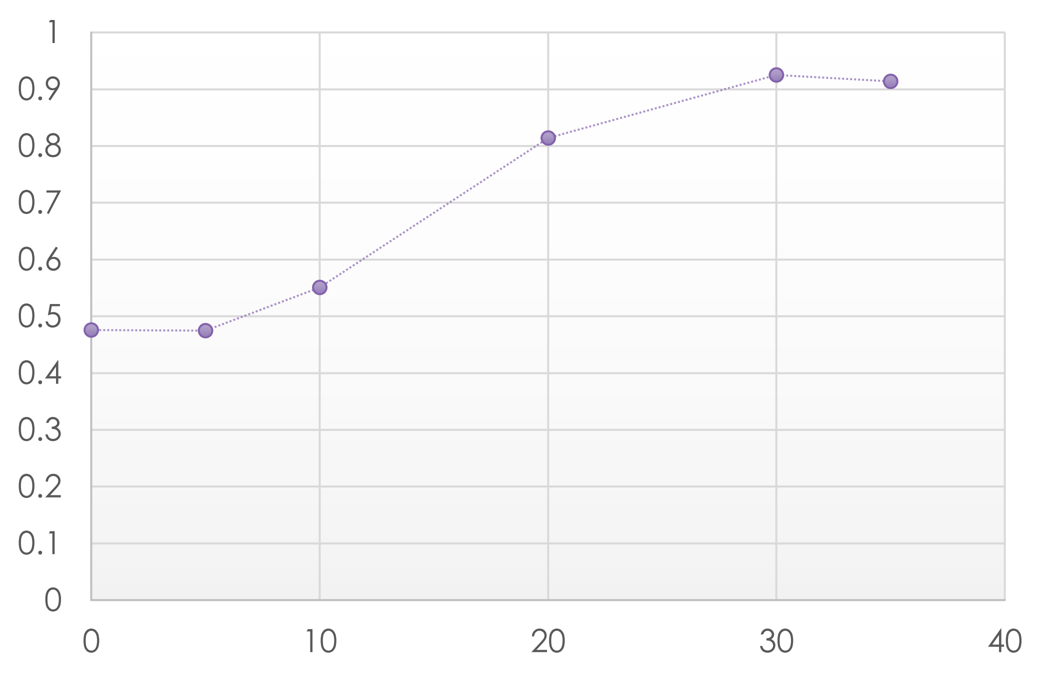
Pressure Contour Over Center Plane (alpha=0^0)

Velocity Contour Over Center Plane (alpha=0^0

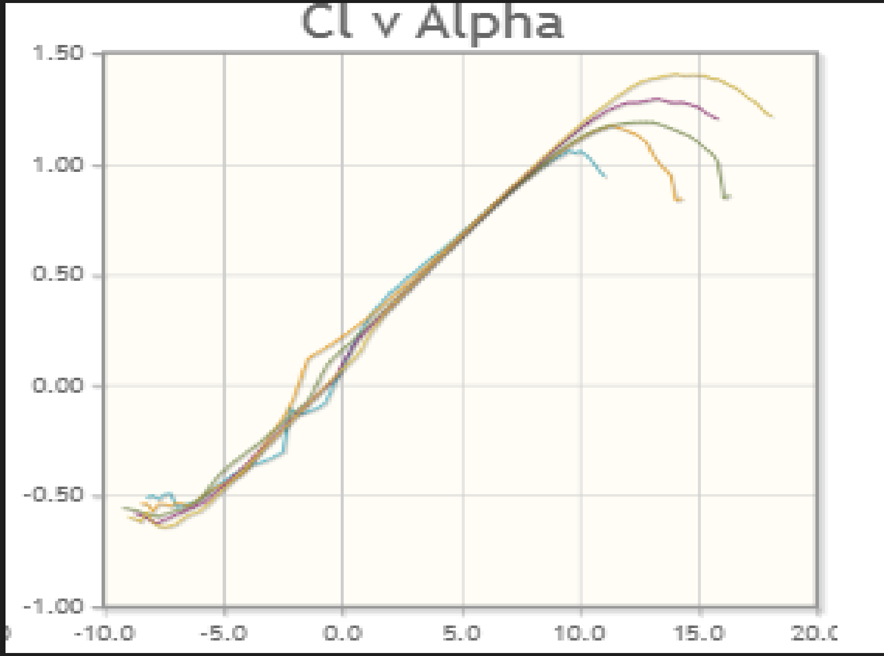
RESULTS

AoA	Lift Force	Drag Force	L/D	q	S	C_L	C_D	C_L/C_D
0	521.3	15.4	33.85	1531.25	0.714	0.476	0.014	33.85
5	520.3	15.7	33.14	1531.25	0.714	0.475	0.014	33.14
10	603.0	17.1	35.20	1531.25	0.714	0.551	0.015	35.20
20	890.0	18.66	47.68	1531.25	0.714	0.814	0.017	47.68
30	1012.1	27.81	36.38	1531.25	0.714	0.925	0.025	36.38
35	999.3	27.96	35.31	1531.25	0.714	0.914	0.025	35.31

PLOTS

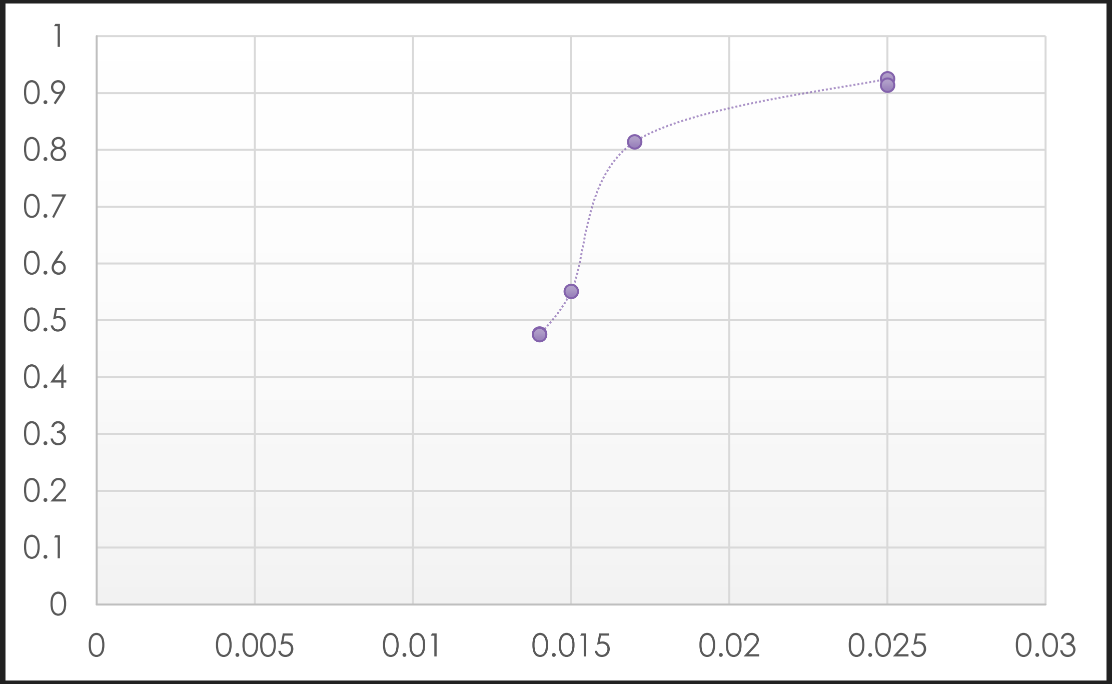


Variation of C_L with Alpha (Calculated)

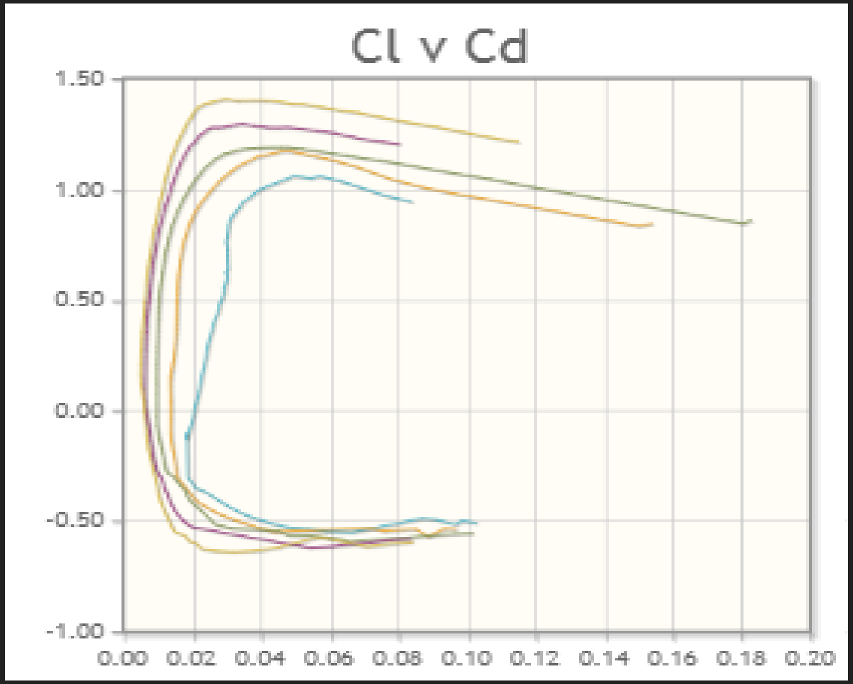


Variation of C_L with Alpha (Experimental)

PLOTS

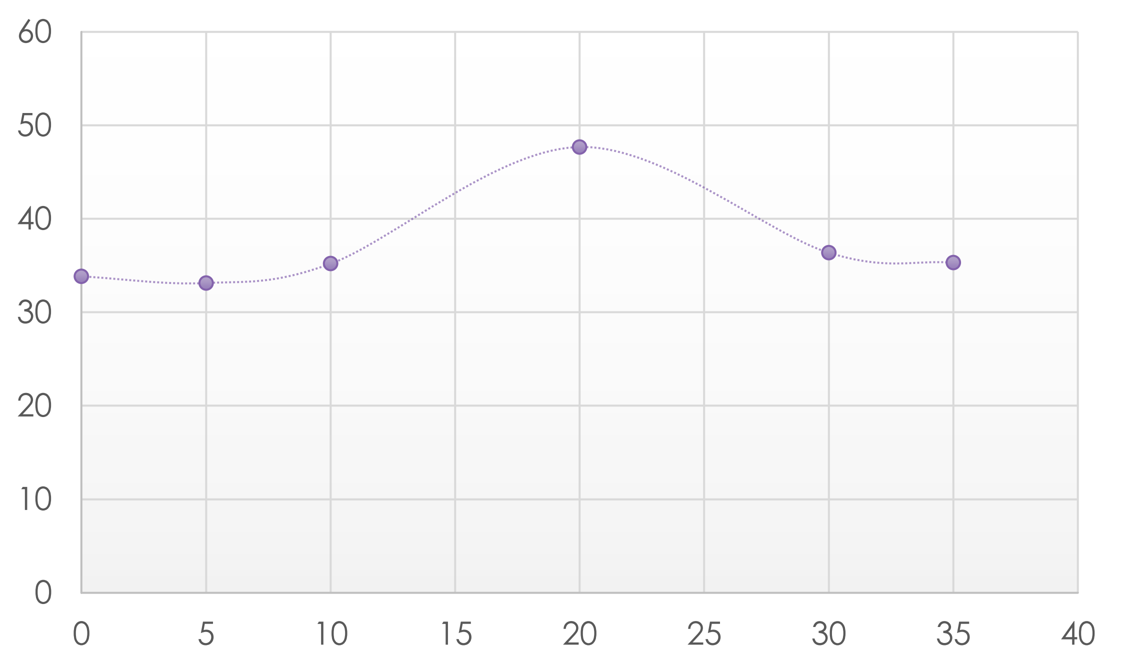


Variation of C_L with C_D
(Calculated)

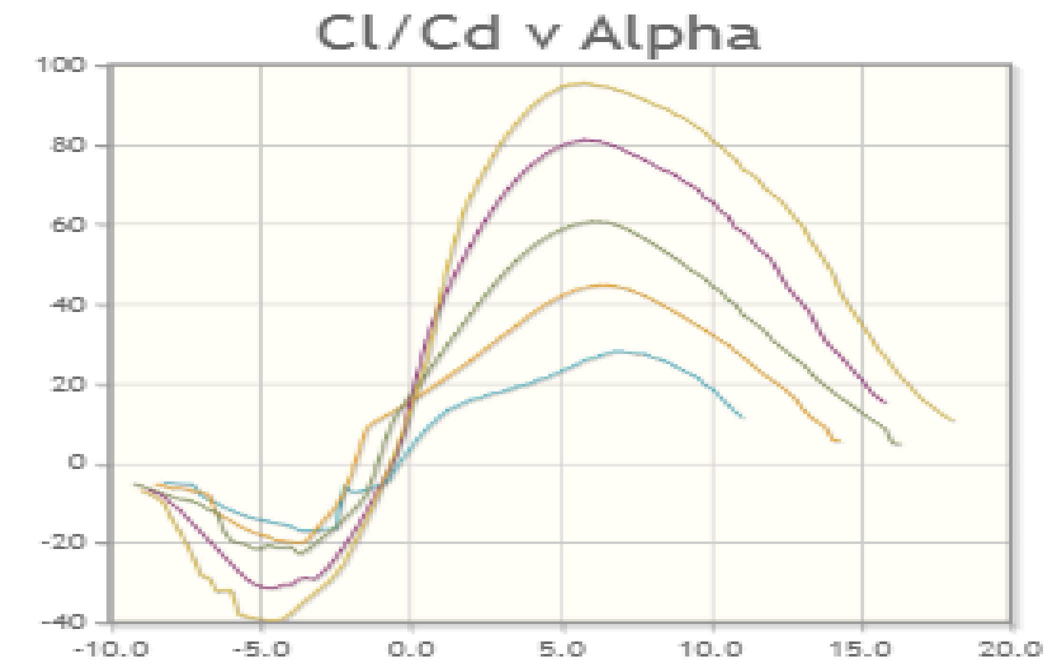


Variation of C_L with C_D
(Experimental)

PLOTS



Variation of L/D with Alpha
(calculated)



Variation of L/D with Alpha
(experimental)

PROBLEMS FACED

- OPEN-SOURCE Softwares
- De-featuring of Geometry
- ANSYS free version
- Finding of Cracked ANSYS.

CONCLUSION

- The lift-to-drag ratio (L/D) is a very significant parameter
- Higher lift to drag ratio leads to better fuel economy, climb performance, and glide ratio

AIRCRAFT	L/D ratio
Boeing-747	17.7
Lockheed-U-2	25.6
Airbus A-320	19.2
BWB Design	33.85

Lift to Drag Ratio (cruise) of different aircraft.

- The lift generated by the BWB was found to be more than the conventional aircraft
- Drag is also less
- The fuselage of the BWB generates lift which was confirmed by the analysis of the center body

REFRENCES

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THANK YOU