

# Blended Wing Aerodynamic Research

Presented By Society of Women Engineers Research Committee:

Hannah Morris, Morgan Conklin, Tatiana Torriani, Michelle Clifford, Seerat Sangha, Dr. Tom Gally

Department of Mechanical and Aerospace Engineering

## ABSTRACT

In this study, a blended wing body (BWB) aircraft model was designed, and will be fabricated and tested with the objective of maximizing aerodynamic efficiency as well as determining if boundary layer ingestion from top surface mounted engines results in less drag. The purpose of this study is to prove that BWB aircraft designs are more efficient than traditional cylindrical fuselage and wing designs. Wind tunnel testing as well as computational fluid dynamic (CFD) analysis is expected to support this hypothesis. Both of these tasks are to be completed or are currently in progress. Drag reduction from boundary layer ingestion as well as a more aerodynamic body are the two focus points of this project. Showing that both of these factors are improved by using a BWB design (and thus result in less energy required to fly) is the goal of this study.

## BACKGROUND

### Blended Wing Body

#### What is it?

- Aircraft designed with a flattened fuselage, often in the shape of an airfoil, which produces significant amounts of lift
- High lift to drag ratios (L/D) due to the lifting body

#### What are the design advantages?

- L/D can be up to 50% higher than conventional designs
- Up to 30% less fuel is used compared to traditional design due to drag reduction (more fuel efficient)
- Produce less noise with top-mounted engines
- Has a large internal volume for the size of the aircraft

### Boundary Layer Ingestion

#### What is a boundary layer?

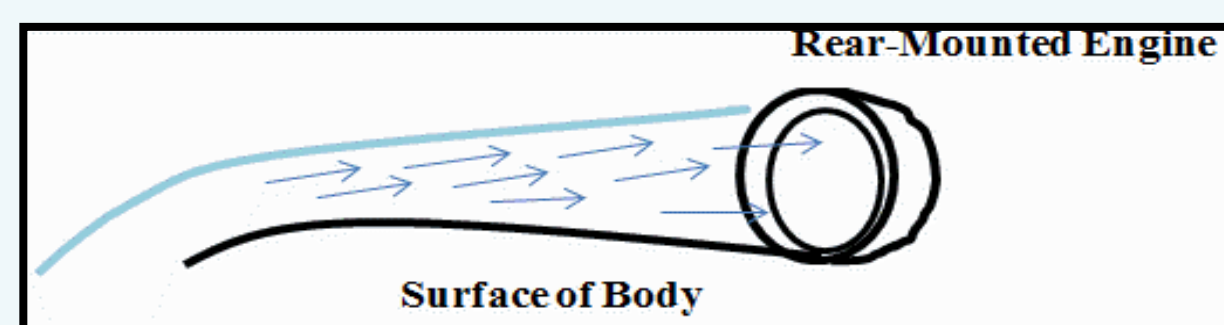
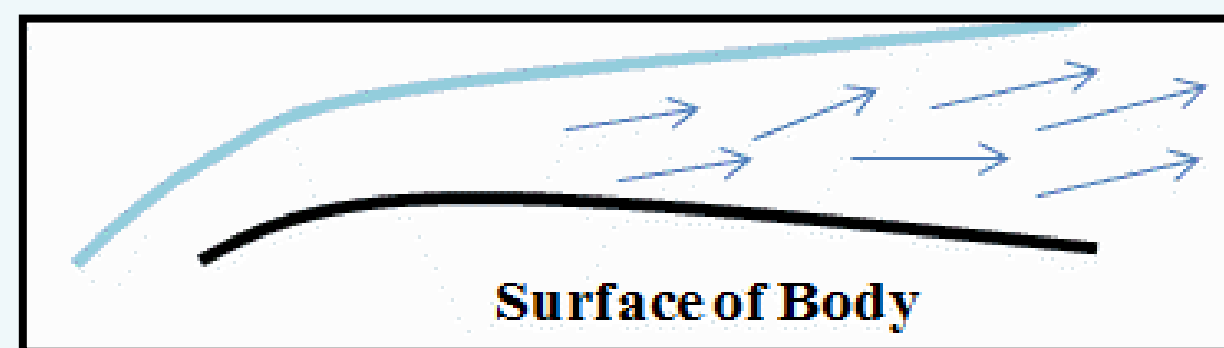
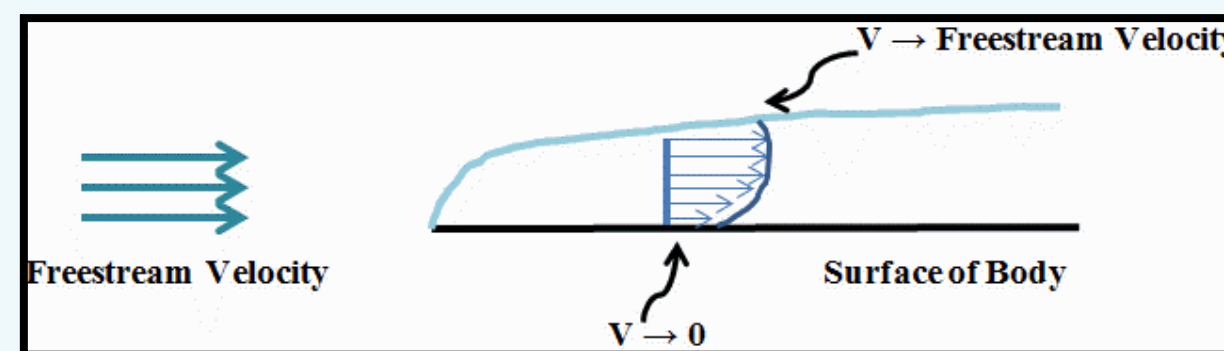
- A very small layer of fluid (in this case air) moving over the surface of a body where viscous effects (or friction) are significant
- The flow of air over the body slows to approximately zero at the surface
- Velocity increases in vertical "layers" until eventually reaching the freestream velocity

#### What is boundary layer separation?

- When the boundary layer separates from the surface, drag increases
- Increased drag reduces efficiency

#### What is boundary layer ingestion?

Before the boundary layer is able to separate, it is sucked into the engine to reduce the separation drag off the trailing edge of the aircraft, thereby increasing efficiency.



## RESEARCH PROCESS

- Design a BWB with top mounted nacelles
- Use computational fluid dynamics (CFD) to analyze the flow and boundary layer ingestion into the nacelles
- Refine nacelle-body connection for optimal boundary layer ingestion
- Use wind tunnel testing to confirm boundary layer ingestion and its positive aerodynamic effects
- Compare aerodynamic wind tunnel results to a traditional tube and wing aircraft (Boeing 787)
- Measure the speed of the fans at which the total load on the wind tunnel pyramidal balance is zero
  - The difference in rpm of the fans will give the difference in thrust required to overcome drag
  - This then gives the difference in drag for each model
  - This can be performed for various angles of attack to get a larger data set for model comparison

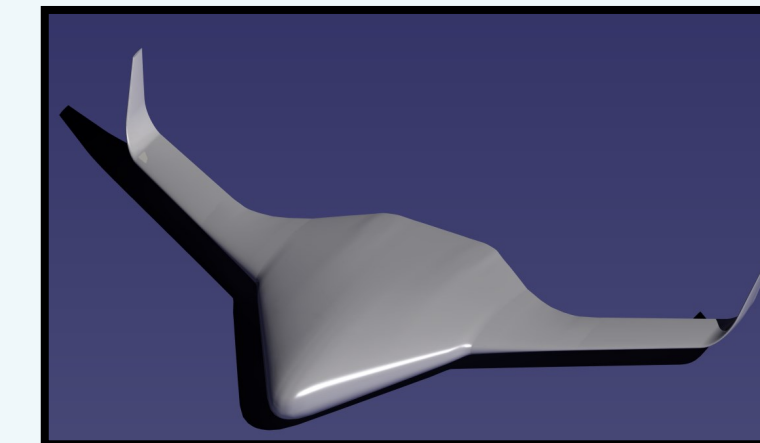
## THE DESIGN

### Airfoil Selection

- Supercritical airfoils were selected for the body and wing in order to delay any top surface shock waves as far aft as possible to reduce the effects of wave drag on the body
  - SC2-0518 for the body—max thickness is 18%*c*
  - SC2-0410 for wing—max thickness is 10%*c*

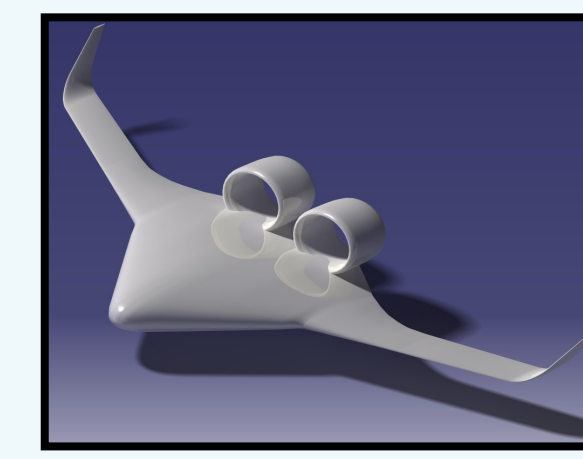
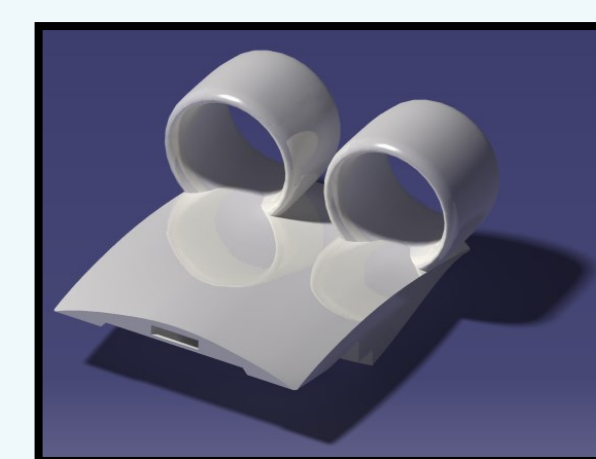
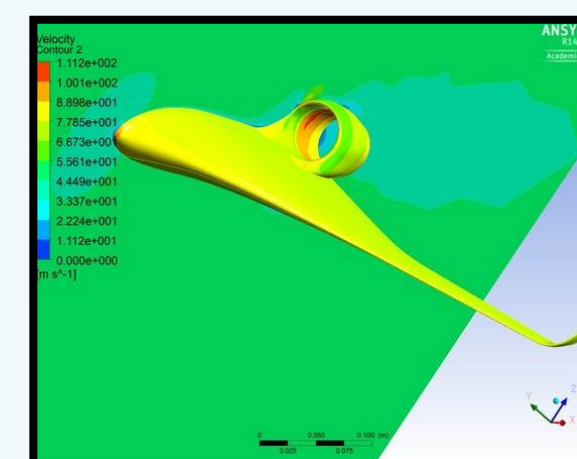
### Sizing

- BWB was designed to have 2 ft. wingspan, same as Boeing 787-800 model
  - In order to have comparable lift per unit span with wind tunnel testing
  - 1:100 scale to actual size



### Nacelle Implementation

- Electric ducted fans (EDF) were purchased to produce the suction needed for boundary layer ingestion in wind tunnel
  - Had to produce enough thrust to overcome drag when in wind tunnel
  - Turnigy 50mm 10 blade Alloy EDF 3300KV selected
  - These fans must be implemented into the BWB and the 787 in order to maintain a fair comparison
- CFD will be used to find optimized nacelle-body blend before the a new nacelle top piece will be printed
- 787 wings are being remodeled in CAD with new nacelles for EDFs



## THE COMPARISON

### Boeing 787-800 Dreamliner

This commercial jetliner is one of the most efficient aircraft in its class by consuming up to 20% less fuel than any other aircraft of similar size. This aircraft was chosen for comparison for its efficiency within the commercial transport class (The Boeing Company, 2014).

- Wingspan: 197 ft.
- Cruise Speed: 0.85 Mach
- Cargo Volume: 4,400 ft.<sup>3</sup>

## COMPLETED TASKS

- The clean BWB design is completed and has been rapid prototyped
- The BWB is being remodeled in CATIA to be more compatible with FLUENT
- The Boeing 787-800 wings are being remodeled in CATIA in order to implement the same nacelle size that will be used on the BWB for similar drag comparison

## UPCOMING TASKS

- Nacelle connection optimization analysis will be performed on the BWB using FLUENT
- The top nacelle piece will be rapid-prototyped with the best design for the nacelle connection
- The Boeing 787-800 wings will be rapid-prototyped with the larger nacelles
- Wind tunnel testing will be completed at the beginning of next semester

## EXPECTATIONS

- Less thrust from the EDF's is required to overcome drag for the BWB body compared to the Boeing 787-800 during wind tunnel testing
- Drag reduction is noticed between blow through wind tunnel test and EDF boundary layer ingestion test

## REFERENCES AND ACKNOWLEDGEMENTS

The Boeing Company (2014). Boeing 787-800 Dreamliner. Referenced from: <http://www.boeing.com/boeing/commercial/787family/787-8prod.page>

### Thanks to:

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