

Subsonic Single Aft eNgine (SUSAN) Electrofan Motor Mounting Design and Structural Approach

LILIA MILLER

NASA GRC/LMM0



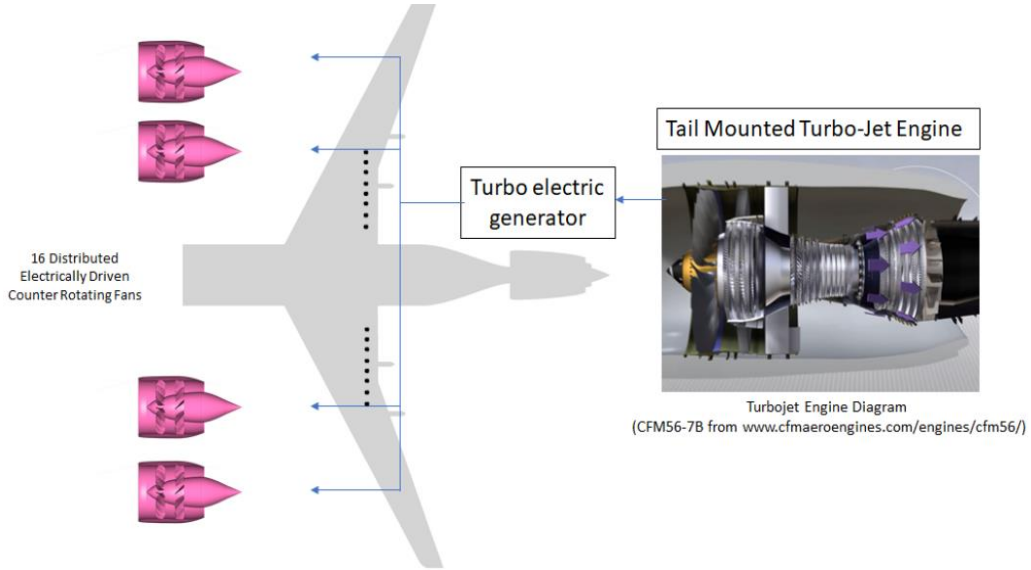
Concept Introduction

- SUSAN Electrofan is a transport aircraft concept which utilizes Electrified Aircraft Propulsion (EAP) to enable benefits which aim to reduce:
  - Fuel usage
  - Emissions
  - Cost

Concept Background

- Single aft mounted engine
- Distributed electric wing-mounted thrusters
- Turboelectric system optimizes efficiency of integrated propulsion / aircraft system and provide backup if the turbofan engine fails



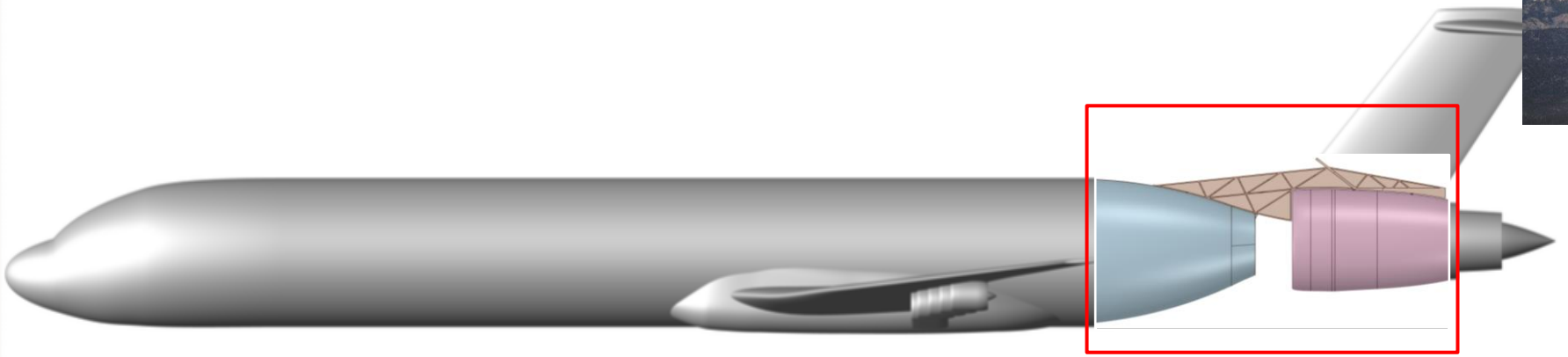


Turbojet Engine Diagram
(CFM56-7B from www.cfmaeroengines.com/engines/cfm56/)

Structural Approach

Aft Engine & Tail Mounting

- Vehicle concept investigates boundary layer ingestion as a method of increasing efficiency
  - Increases the effective lift/drag ratio of the aircraft
  - Leads to engine location at the aft end of the aircraft
- Mounting approach must support both the engine and the T-tail





Historical perspective: L-1011 Tristar aircraft with aft mounted engine

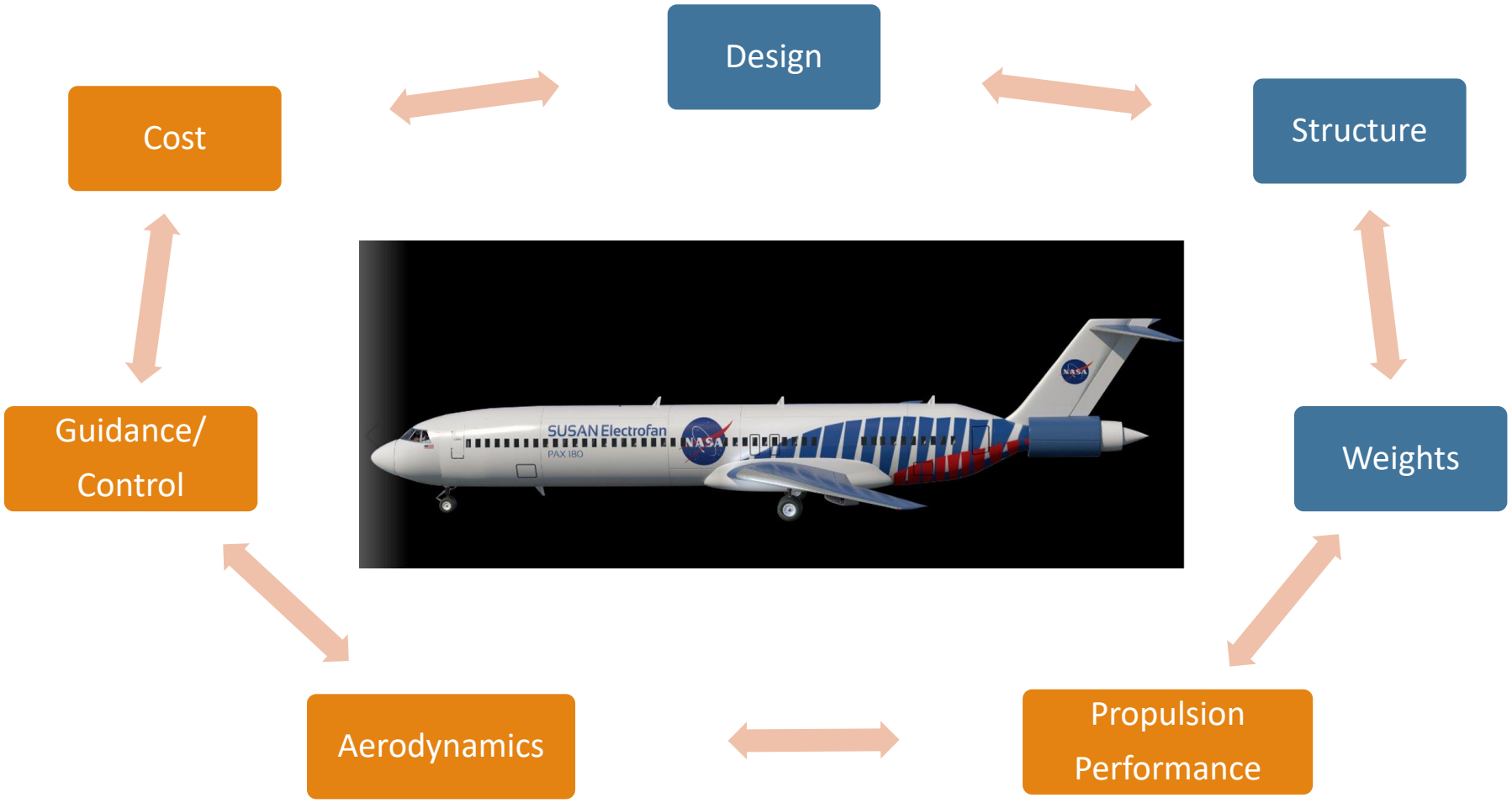


Artist Rendition of Aircraft

Challenges

- **How do you take a heavy turboelectric engine and incorporate it on the aft end of an aircraft and make it work?**
  - Maintain aircraft weight requirements
  - Center of gravity issues arise with a lot of weight located aft
  - Tail applying large moment on engine mount
  - Conforming to evolving aerodynamic needs and design

Iterative Process



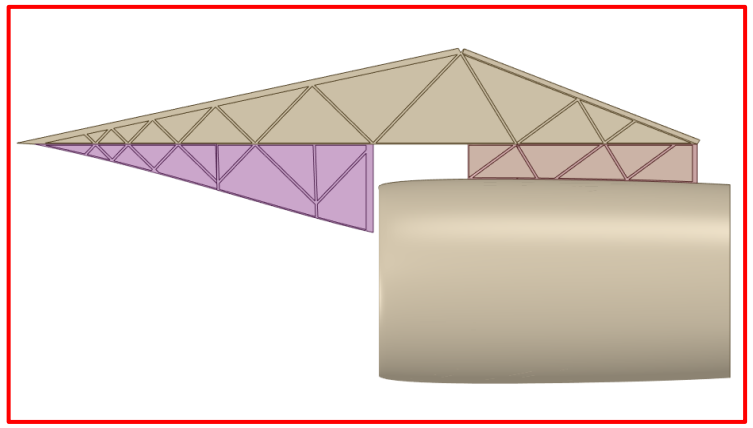
Defining Conceptual Requirements

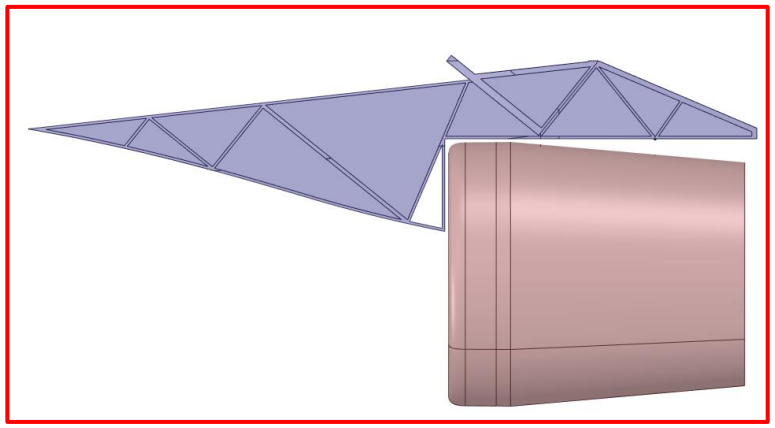
Requirements Driving Design

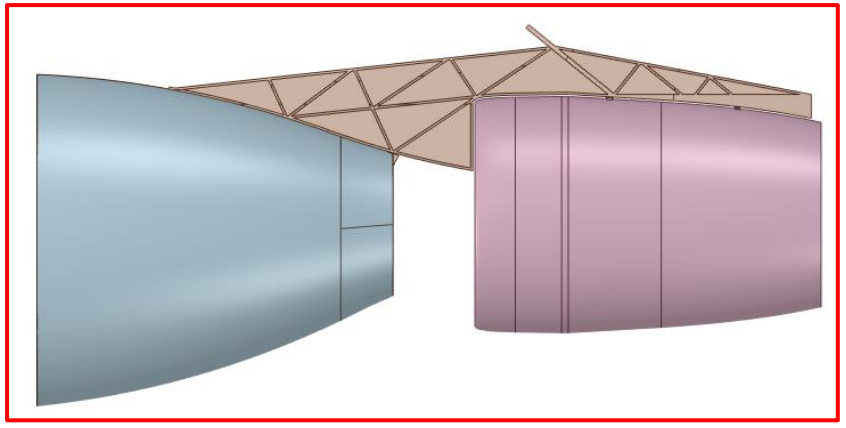
5. Fatigue/Failure

- Are NASA margins of safety being met?
- Skins will pick up shear loading
- Beam will handle tensile/compressive loads

Design Evolution



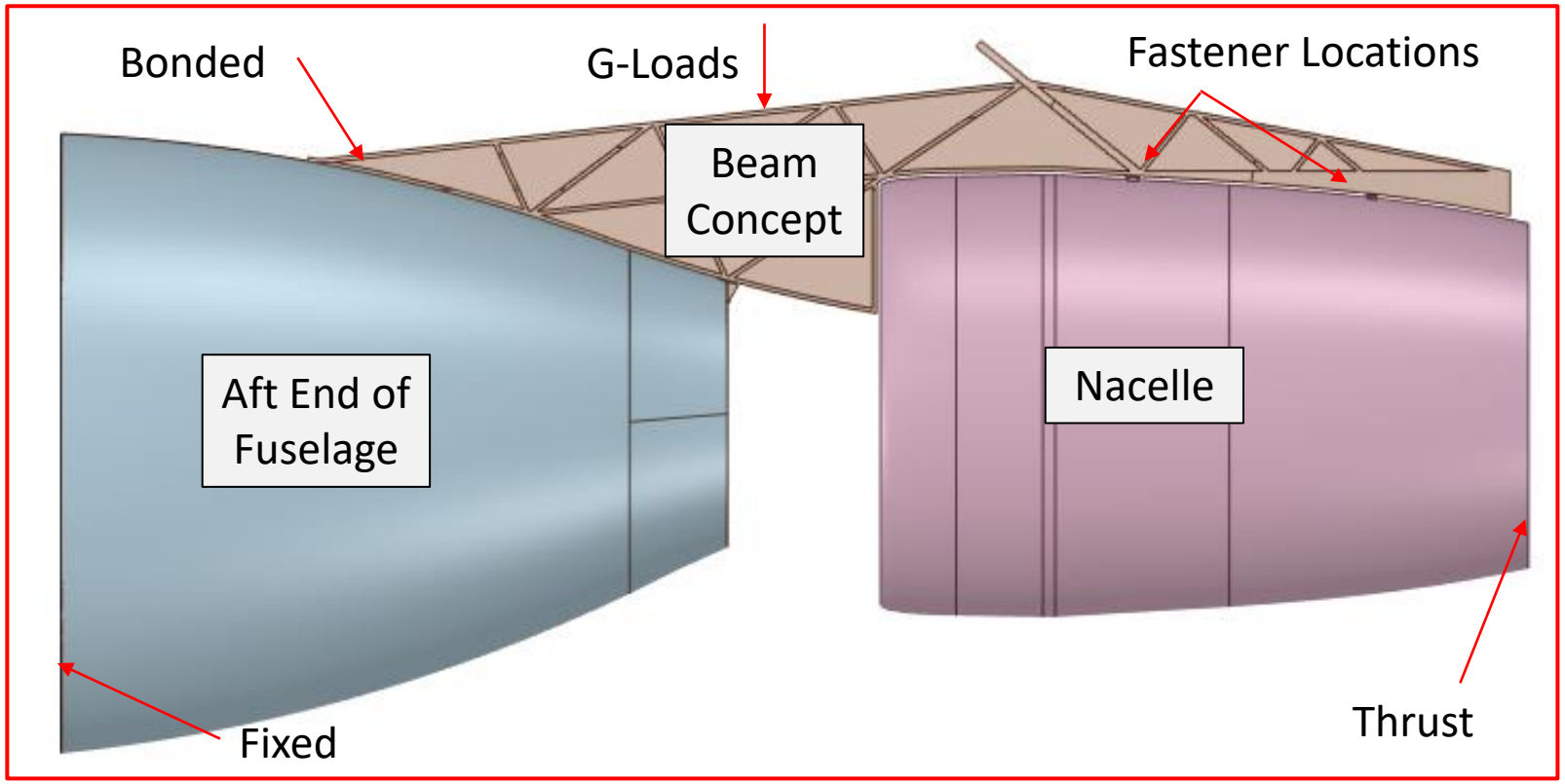




- **Objective**: develop and perform structural analysis on beam concept to:
  - Reduce high stress concentrations
  - Failsafe; If failure of skins occurs, beam can handle loads
- Evolving beam concept is driven by the evolving engine needs defined for the SUSAN Electrofan aircraft

Simplified Model Setup

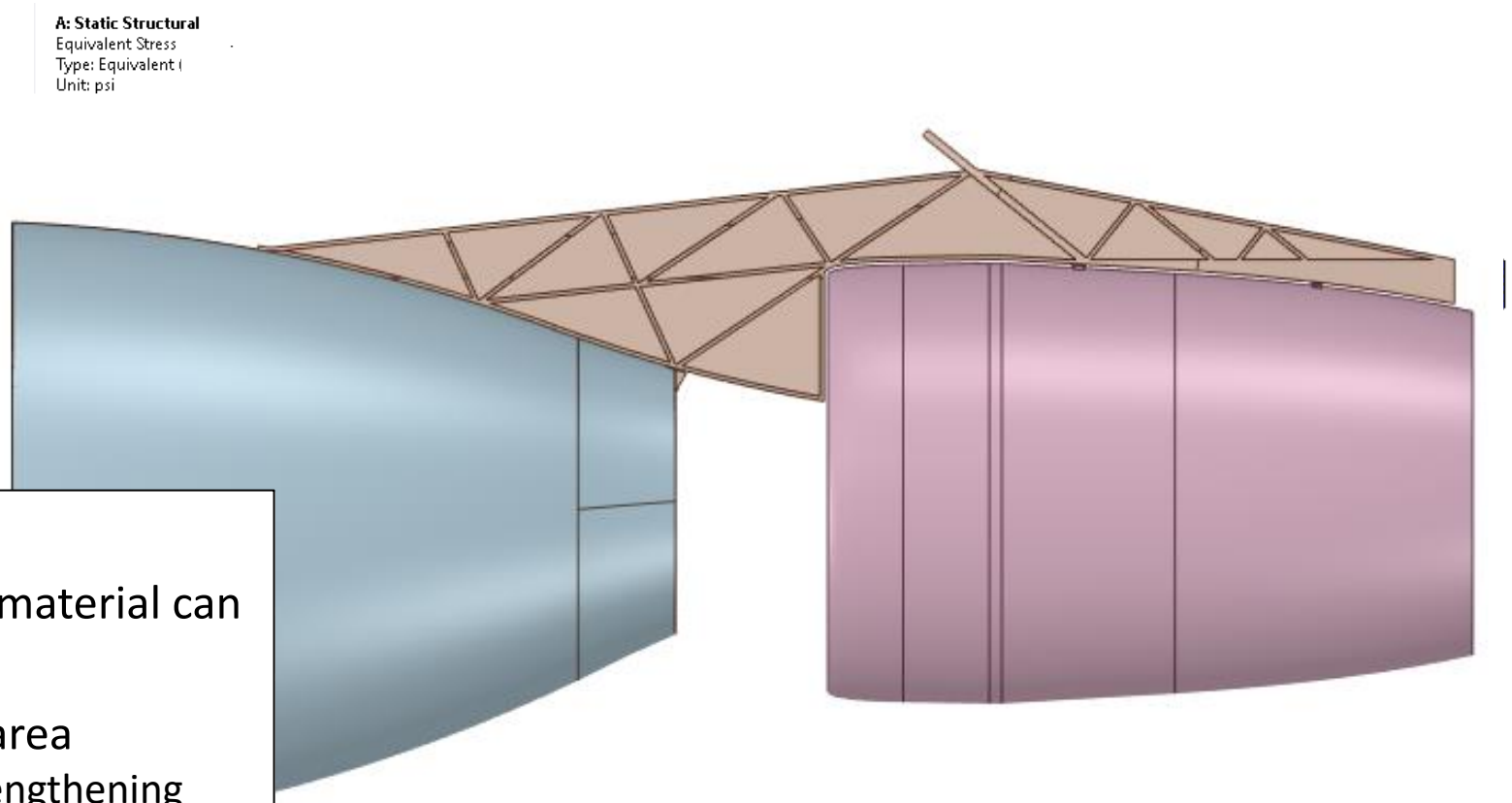
- Starting with simplified model to understand:
  - General load path
  - Critically stressed areas
  - Facilitate beam sizing
  - Feed any changes in OML/geometry to aero team
- Beam Material: Al 6061-T6
- Simplified Loads:
  - 30,000 lbf thrust from engine
  - Mass of engine weight (estimated 6,000 lb)



Structural Analysis

$$Margin\ of\ Safety\ (MoS) = \frac{Yield\ Stress}{Limit\ Stress * FoS} - 1$$

NASA Requirement: MoS ≥ 0



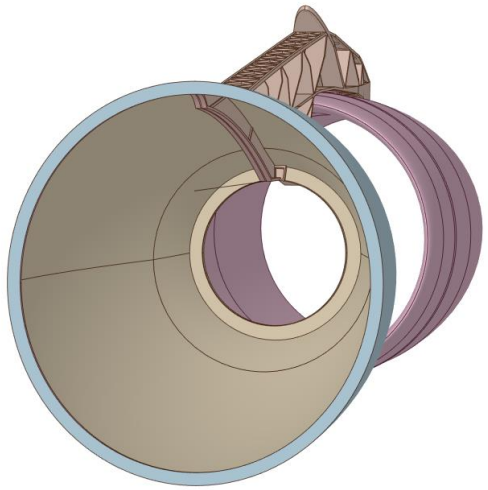
Takeaways:

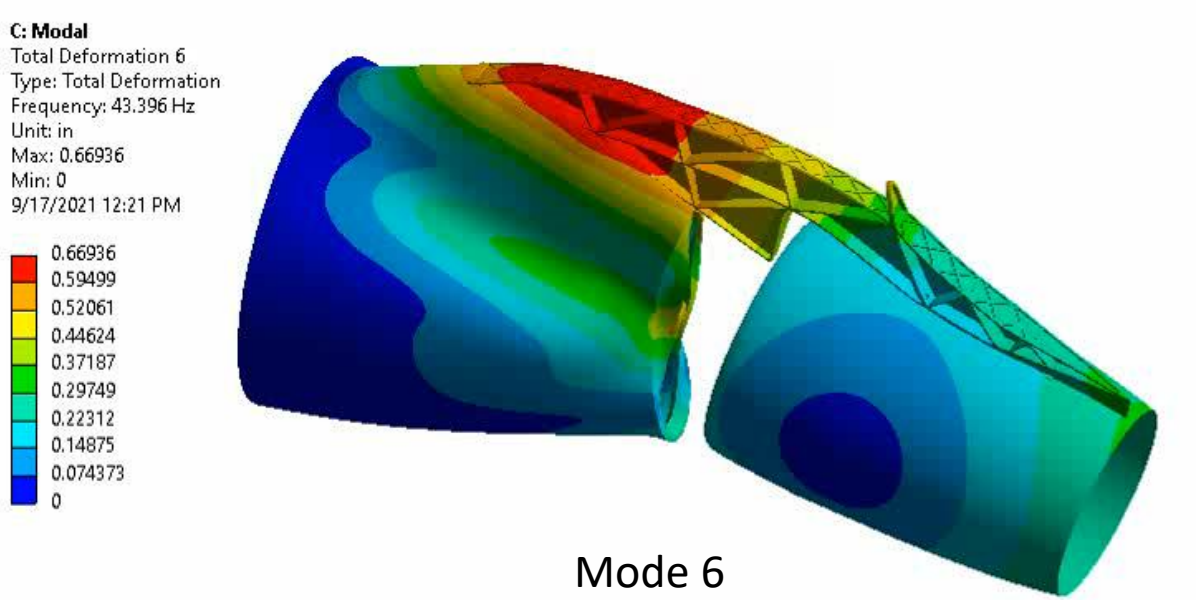
- Cold (blue) areas can show us where further material can be reduced to continue light weighting design

- Light weighting design produced high stress area
  - Resolve high stress areas in next iteration by strengthening (thickening) sections

Modal Response

- Modes will show us where structure needs to be stiffened
  - Adding skins will increase stiffness greatly
  - Mode 6 concerning: buckling of tail cone at fairly low frequency
- Modify bulkhead to spread load and prevent buckling of tail cone





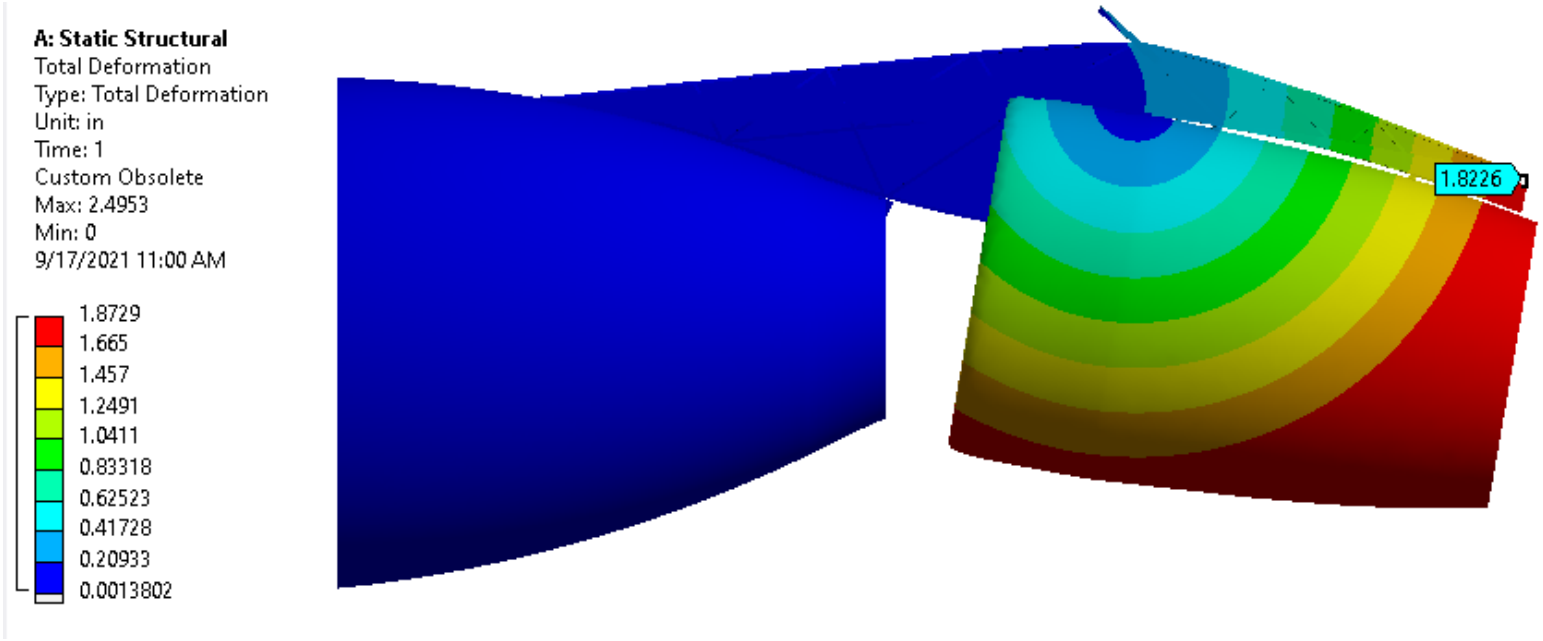
Mode 6

Deflected Shape

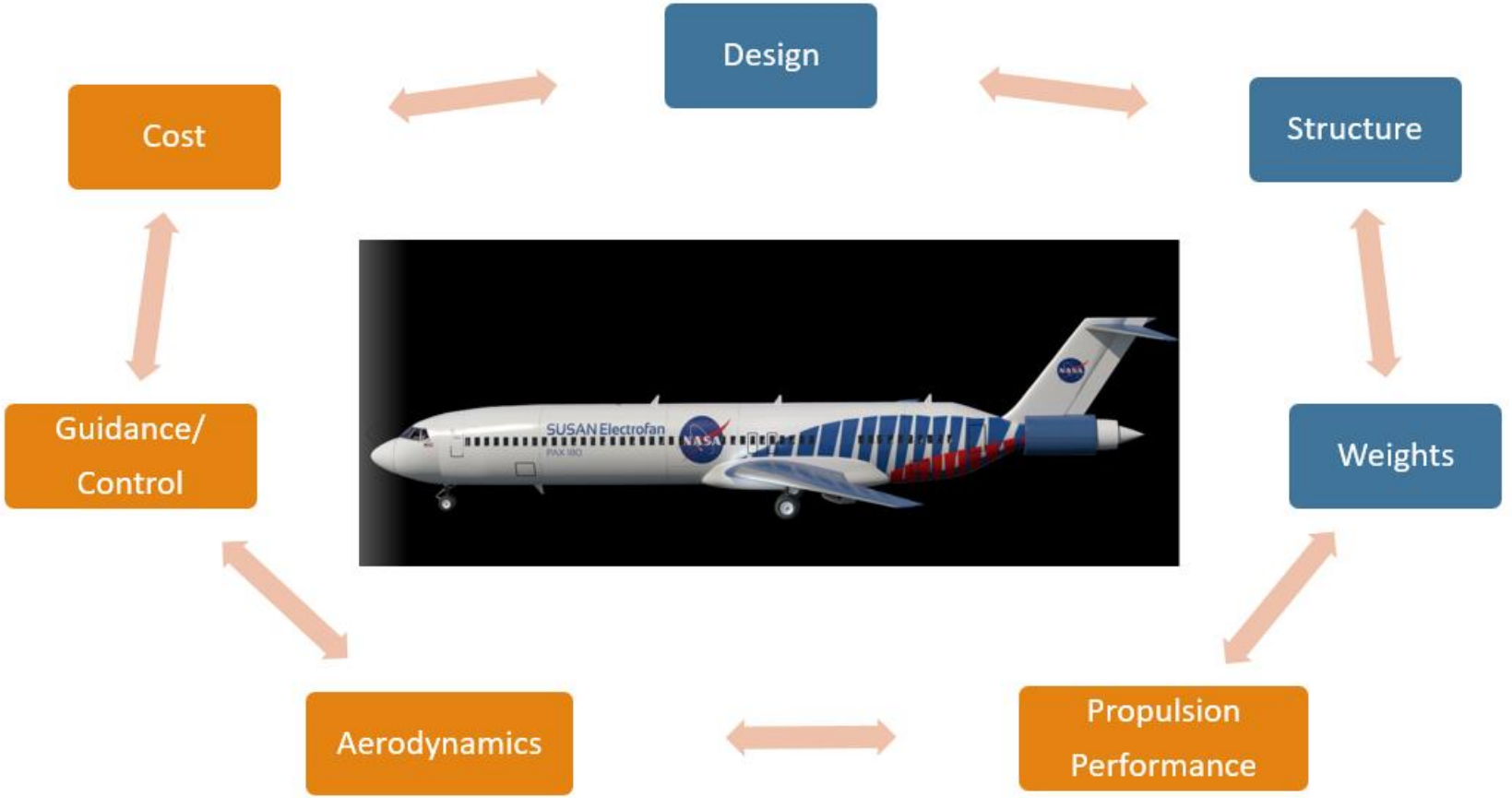
Takeaways:

-Deformation high at beam tip due to geometry and connections defined

- May need more support geometry at tip to prevent beam from bending as engine loads beam
- Resolve connection geometry on next iteration
  - Driven by the two forward bolts

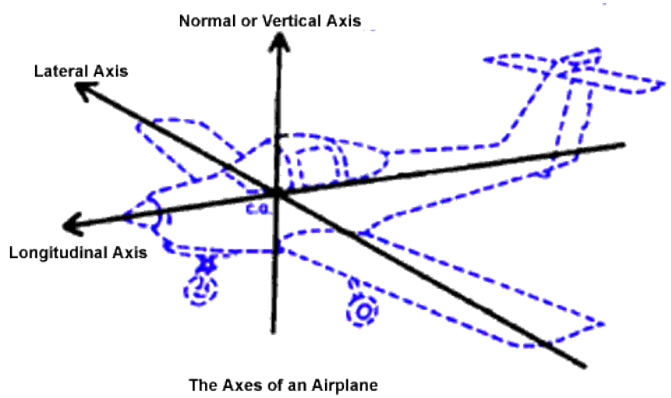


Iterations Performed in Response to Structural Analysis

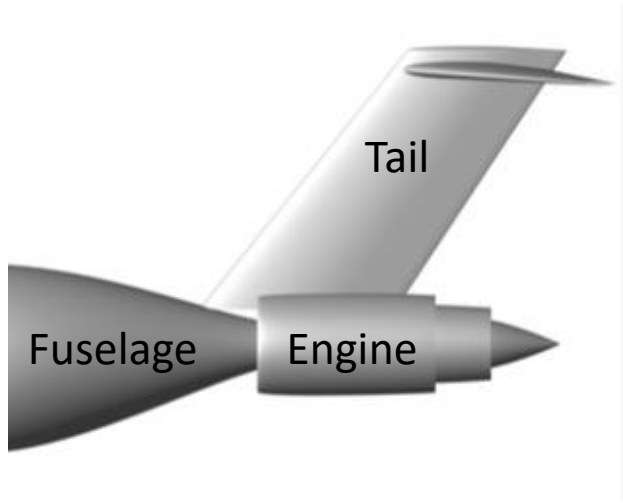


Future & In-Progress Work

- Skin geometry on beam
  - Skins will pick up shear loading
  - Beam will handle tensile/compressive loads
- Tail geometry and respective loads
  - Expect to see a large moment induced on beam from tail
- Additional supports included as needed in analysis iterations
  - Longitudinal direction currently supported by beam
  - Inclusion of lateral mounted beams can support engine from spanwise loads from vertical tail
- Detailed loads derived from FAR (Federal Aviation Regulations) requirements
- Optimize beam for light-weighting purposes



The Axes of an Airplane



Acknowledgements

- I would like to thank the following team members for their help and contributions to this task:
  - Tom Goodnight
  - Ralph Jansen
  - SUSAN Electrofan team

QUESTIONS/ COMMENTS