Electric Aircraft Tug

SMITH COLLEGE OF ENGINEERING & TECHNOLOGY

ROCKY MOUNTAIN POWER FOUNDATION

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MOTIVATION

- There is an increased need to save emissions and costs from jet engines at airports.
- As air travel expands, greater amounts of noise are created, which can cause hardship for surrounding neighborhoods and wildlife.
- Air travel is expensive. Reduced cost for airports and airlines could pass onto the consumer.

The figure below represents the benefits of implementing a new way of taxiing aircraft using the attachment and technology in this electric tug. (Analysis only represents Boeing 737 sized aircraft at the Denver International Airport for 10 years)

- $74,761,332 Saved in Fuel Cost
- $62,353,656 Net Savings
- 6.56 Cost/Benefit Ratio

5,855 /year

1,236,938 /year

Intangible Benefits

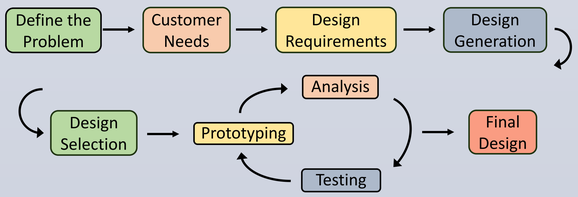
- Noise Reductions
- Reduces Jet Blast
- Increase Safety
- Improve Reliability in Poor Weather
- Reduce Engine Maintenance

INTRODUCTION

- The project aims to design an attachment for autonomous aircraft towing at airports, reducing emissions and noise by modifying the method by which planes taxi.
- The attachment will operate with minimal human interaction, allowing for remote or autonomous control of aircraft movement, reducing the need for manual towing.
- A new attachment design is needed to allow the aircraft's steering to remain engaged, enabling smoother taxiing operation and autonomous detachment.



DESIGN PROCESS



PROBLEM DEFINITION

Secure an aircraft to an electric tug for taxiing and remote detach.

CUSTOMER NEEDS

1. Can be used without detaching the aircraft steering mechanism
2. Easy to use
3. One person can operate by themselves
4. Doesn't damage the nose wheel or aircraft
5. Holds the wheel securely during taxiing
6. Able to accommodate different wheel designs of small aircraft
7. Able to support the weight of the aircraft
8. Can be operated safely
9. Easy to maintain and service
10. No adapter or modification needed for aircraft
11. Able to be released remotely
12. Cost effective

DESIGN REQUIREMENTS

Design requirements were developed to translate key customer needs into measurable criteria, tailored specifically to the aircraft used in the tug testing process (Diamond DA20, DA40, Piper Seminole PA-44)

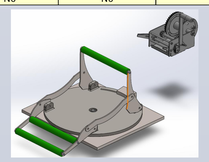
Requirement	Value	Unit
Nose wheel Turning	0	°
Aircraft Steering Detached	Y/N	
Time to attach once aligned with aircraft	>1	min
Time to detach at end of taxiway	>30	sec
Operated by one person at a time	Y/N	
Clearance between metal parts of aircraft and attachment	1	in
Parts in contact with metal on nose wheel are softer	Y/N	
Attachment has constant contact with aircraft	Y/N	
Accommodates different wheel diameters	11 - 14	in
Accommodates different wheel widths	4-5	in
Support the weight of the aircraft	>600	lb
Support acceleration and braking force		lb
Contains adequate warnings and emergency shutoff	Y/N	
Time to remove attachment from tug (Repairability)	>30	min
Aircraft requires adapter or modification	Y/N	
Remote detachment	Y/N	
Cost	>2000	$

IDEA GENERATION AND SELECTION

Multiple brainstorming sessions were conducted to generate a range of design concepts. Each concept was evaluated using a scoring matrix, and the top three were further assessed based on predefined selection criteria. Concept A was the leading design based on the highest score and was selected for prototyping.

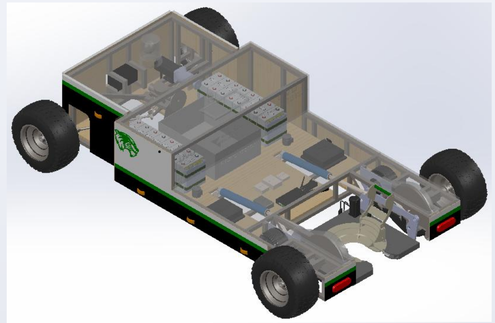
		Concepts							
		A		B		C		Current Design	
Selection Criteria	Weight	Score	Weighted	Score	Weighted	Score	Weighted	Score	Weighted
Secure - likelihood for aircraft to detatch from tug during taxiing.	4.875	5	24.375	3	14.625	3	14.625	2	9.75
Durability - ability to withstand wear, pressure, or damage	4	4	16	5	20	4	16	0	0
Ease of Attachment - amount of hands on work required to attach	3.5	5	17.5	2	7	2	7	4	14
Scalable - ability to accommodate larger aircraft with minimal design changes	3.25	5	16.25	4	13	3	9.75	1	3.25
Mechanical Complexity - Feasability to design and build within timeframe	3	1	3	3	9	4	12	5	15
Ease of Manufacture - estimated time to manufacture	2.25	2	4.5	3	6.75	3	6.75	5	11.25
Repairability - time and difficulty for repairs	2.125	3	6.375	5	10.625	4	8.5	5	10.625
Cost of materials	2	1	2	3	6	4	8	5	10
Net		88.0		81.0		74.6		63.9	
Continue?		Yes		No		No			

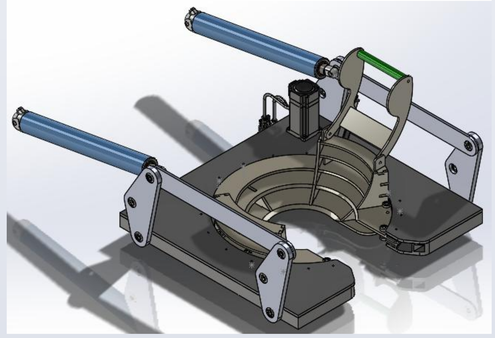




CAD CREATION

A high-fidelity CAD model of both the attachment and the complete tug assembly was developed using SolidWorks. This enabled effective visualization and verification of component and hardware clearances prior to manufacturing.



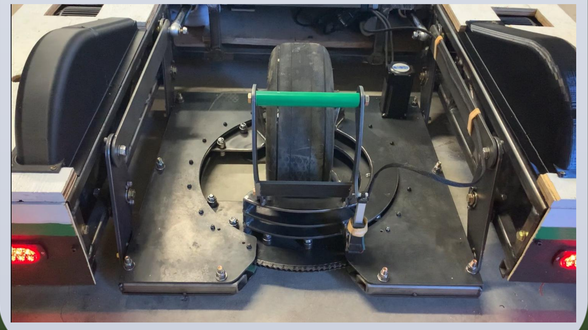


PROTOTYPING

Cardboard, wood and 3D-printed prototypes were first created to verify design and functionality. A fully functional prototype was then created and tested. The final working prototype used different manufacturing methods such as CNC milling, plasma cutting, and welding.

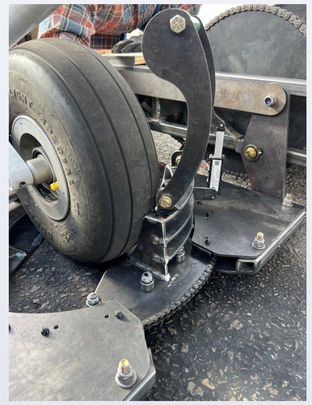




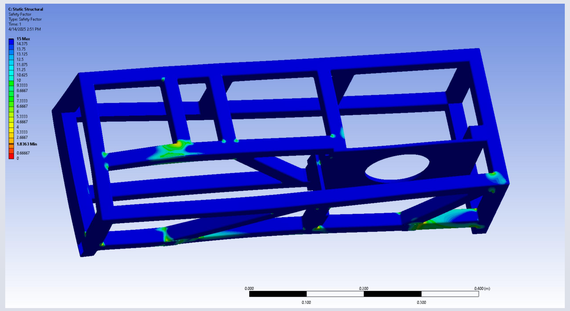


TESTING AND ANALYSIS

Many aspects of the attachment were tested. The most notable being: fitment and clearance with the nosewheel assembly, the ability to rotate the cradle mechanism and the ability of the linkage mechanism to lift the assembly and aircraft nose wheel.

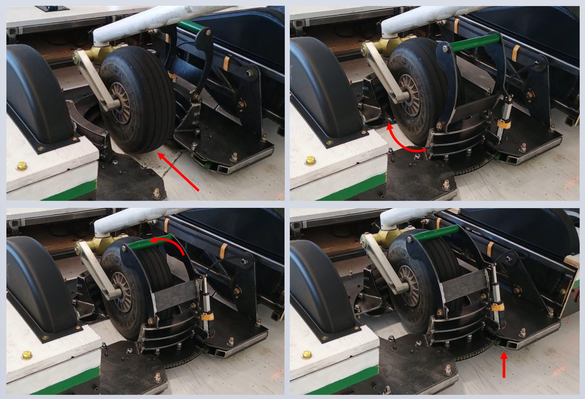


Additionally, an FEA analysis was performed on the frame and other components to verify that they would be able to support the forces present during operating conditions.



RESULTS

The attachment successfully secured the airplane wheel, towed it without issue, and detached automatically without requiring manual intervention or experiencing any component failures.



ACKNOWLEDGMENTS

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