REVERSE ENGINEERING OF MICRO AIR VEHICLE

Final Presentation

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Overview

- Project Description
- Problem Formulation
  - **Need and Goal**
  - **Objectives**
- Final Design
- System Integration
- Fairing Design
- Comparison
- Initial testing
- Final design modifications
- Cost Analysis
- Summary

Project Description

- Client is Dr. Kosaraju
- Task of scaling U13A remote controlled helicopter by 1.5
- Capability to have mission specific attachments

Need and Goal

Need:

The battery life is to short, and the helicopter is too small, for early warning and mobile vantage point for forest fires.

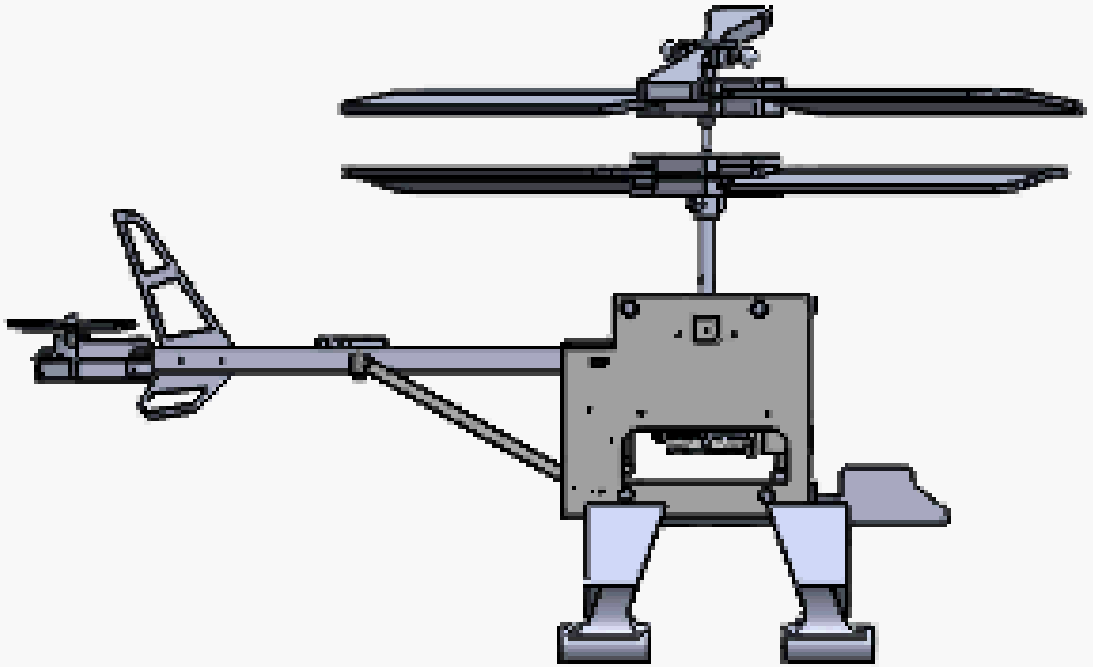
Goal:

Successfully upscale a remote controlled helicopter with the ability to add mission specific accessories.

OBJECTIVES

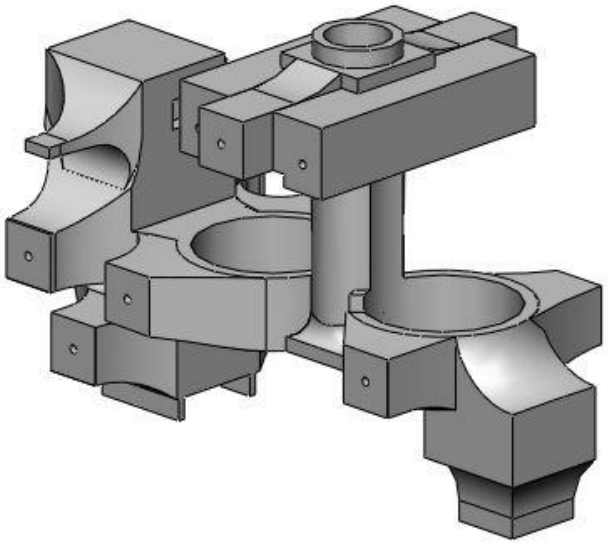
Objectives	Measurement Basis	Units
Designing and building a RC helicopter	Amount of materials	Dollars
Attachments	Camera Parts	Numbers
Batteries	Two sets of batteries	Dollars
Carrying capabilities	Weight	lbs
Lift capabilities	Height range	Meters

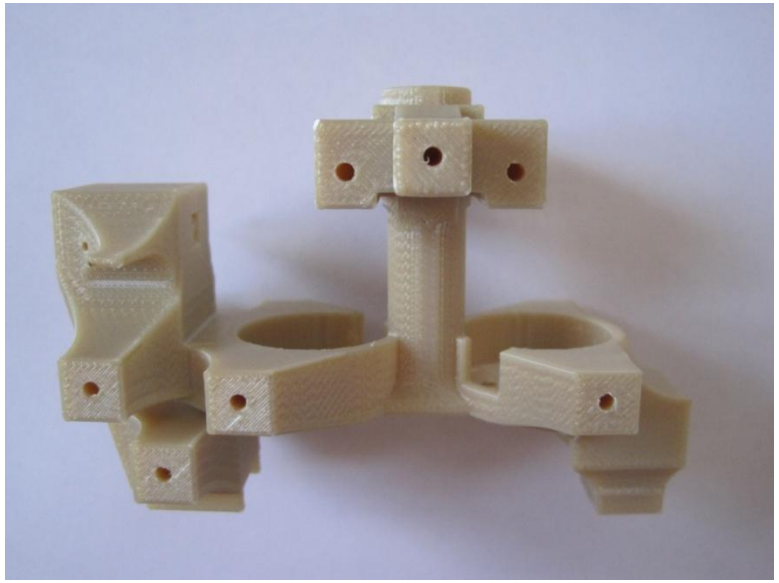
FINAL DESIGN



Main Core

- Large sections where screws attach
- Fillets on parts sticking out
- Bulky design

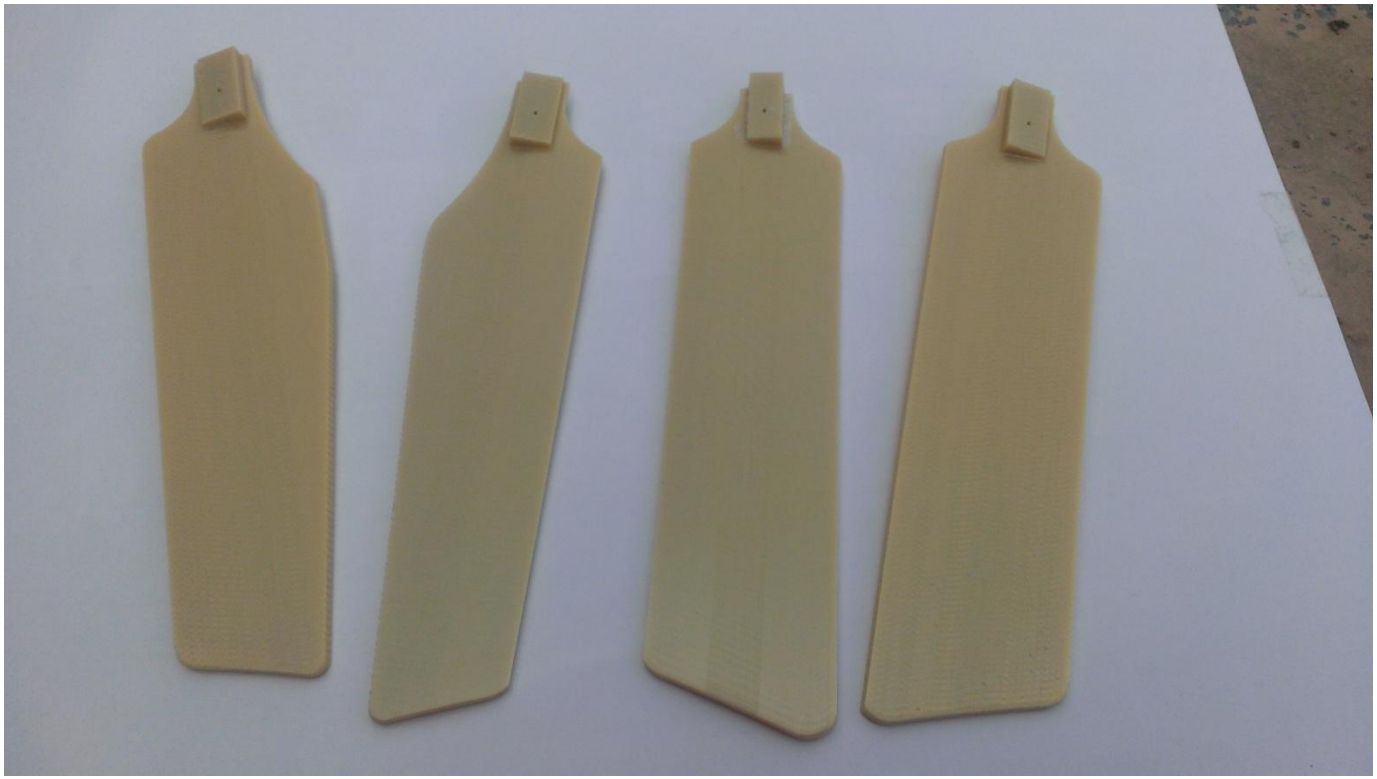




Main Core 3D printed using Ultem

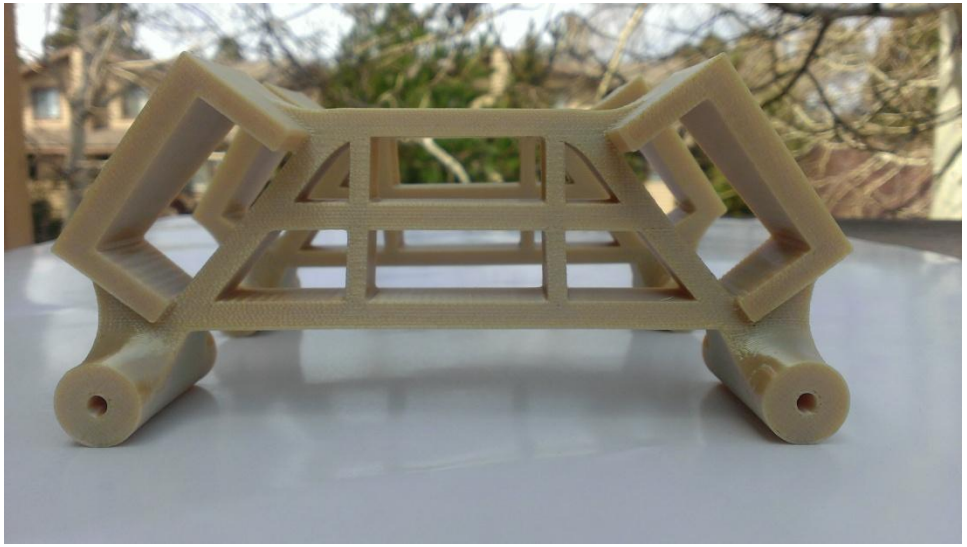
BLADES

Designed and Tested 4 different types of blade designs for varying performance and complexity in manufacturing

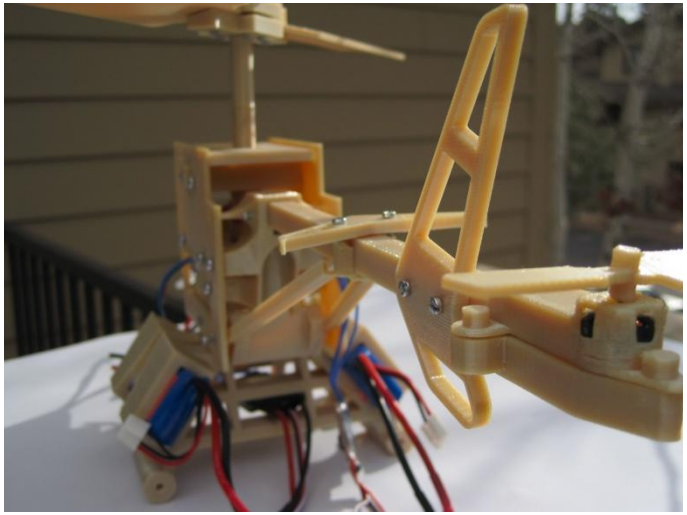


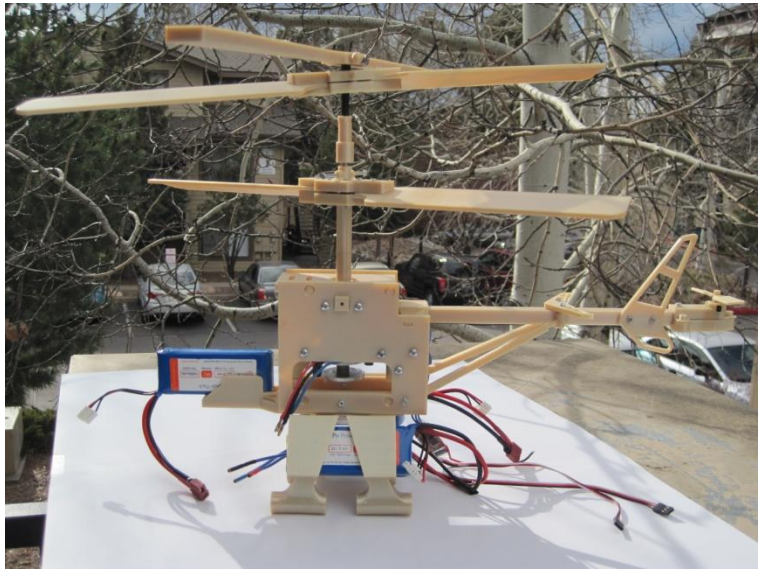
Landing Gear

- Enclosure for battery and electronics
- Impact support to the helicopter in the event of crash landing



Tail Structure





3D Printing Problems

- Ultem tolerance made prototypes not fit together perfectly
  - **e.g. base of blades do not fit into clamp**
- Top Rotor kept on slipping in the gear mesh
  - **Added a smaller shaft inside the gear to prevent it from wobbling**
- Too much weight was added to the helicopter
  - **Removed material from the major parts such as landing gear, main body, and side panels**

Weight Calculations

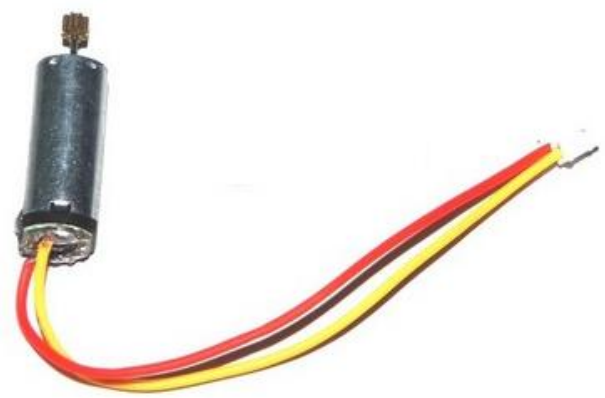
- Weight
  - **Batteries = 0.217 lb**
  - **4 Blades = 0.286 lb**
  - **Helicopter = 1.342 lb**
  - **Landing Gear = 0.378 lb**
- Total Weight = 2.034 lb

POWERTRAIN

- Original helicopter's powertrain had very simple design
- All powertrain components were modified to fit a larger helicopter
- Modifications were made to:
  - **Motors**
  - **Batteries**
  - **Speed Controllers**
  - **Transmitter/Receiver**

MOTORS

- Original motor specifications (exact specs not given):
  - **Two small brushed motors control the main rotor**
  - **One, even smaller brushed motor for the tail rotor**



- Scaled motor specifications:
  - **Two 5000 KV brushless outboard motors for the main rotor**
  - **One 1000 KV brushless outboard motor for the tail rotor**

Not only increased power of motors, but by making them brushless we get increased: efficiency, reliability, lifespan

BATTERIES

Original battery specifications

One 1S, 3.7 V, 580 mAh LiPo

Flight time approximately 7 min

Original battery

Scaled battery specifications

Three 2S, 7.4 V, 1600 mAh LiPo

Flight time approximately 15 min

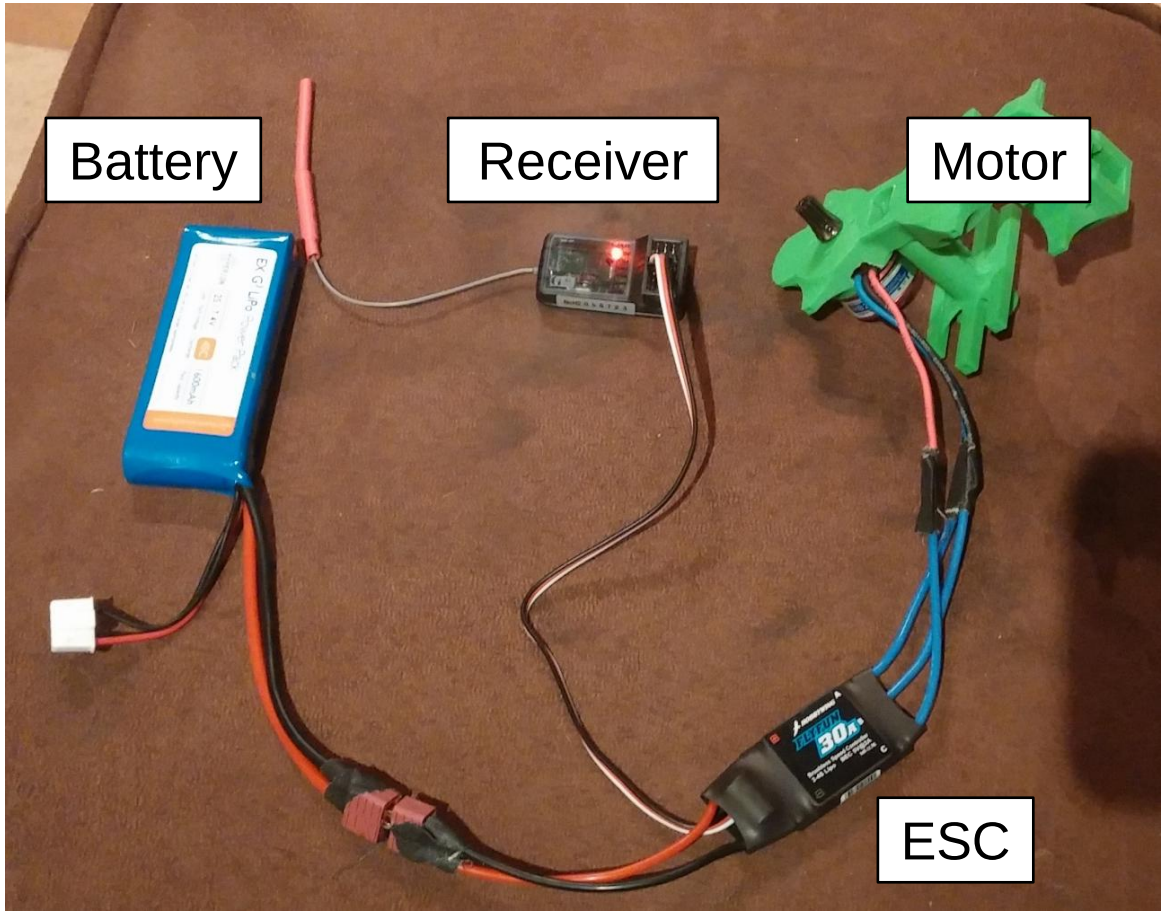
Scaled battery

Speed Controllers & Transmitter/Receiver

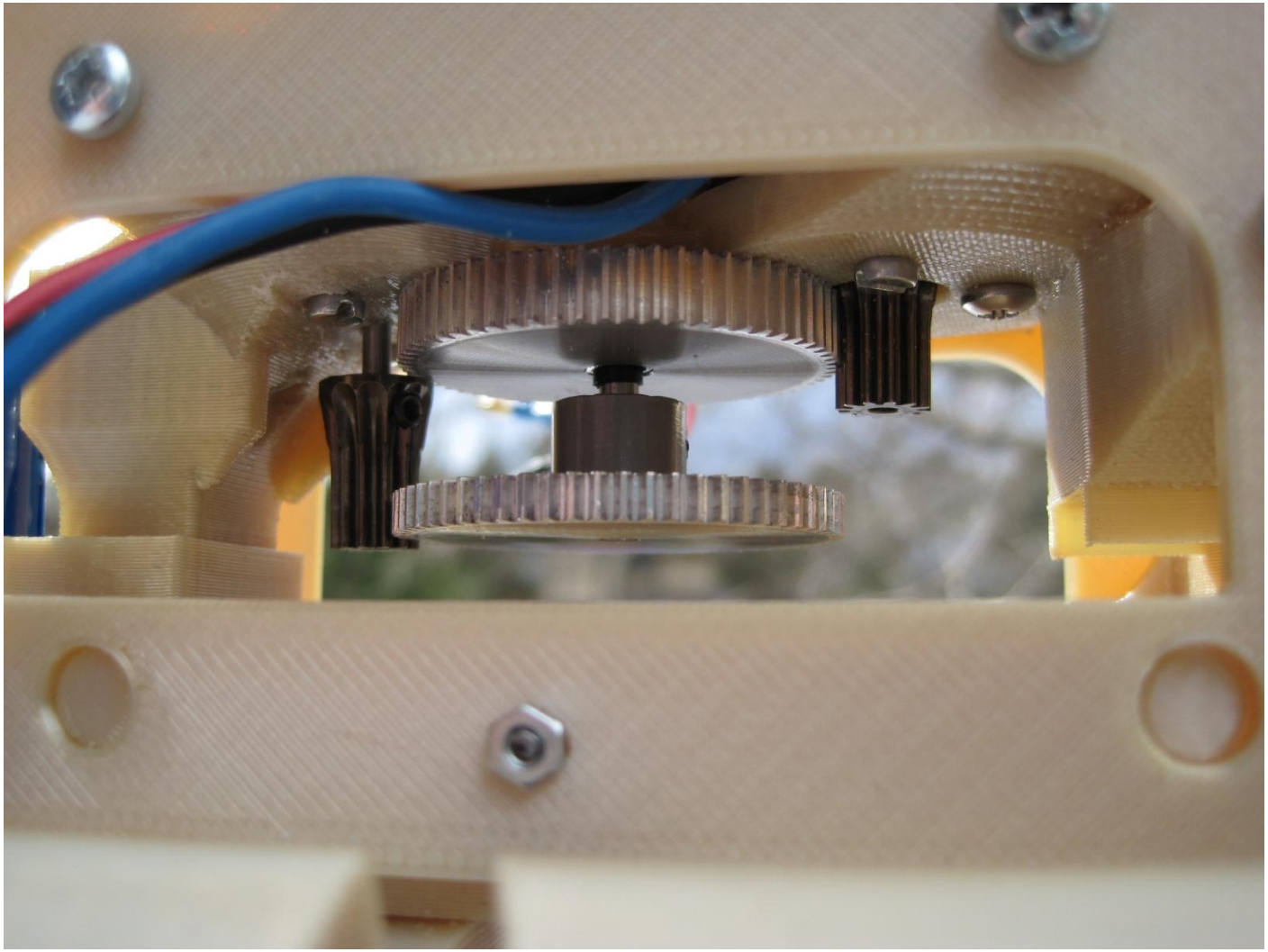
- Original specifications:
  - **No physical speed controller or receiver**
  - **PCB board used for both controlling speed and receiving transmissions**

- Scaled specifications:
  - **Three Electronic Speed Controllers (ESCs)**
  - **ESCs require much less extensive programming than PCB boards, accomplishing the same task**
  - **One 6-channel 2.4 GHz transmitter and receiver**

System Integration



System Integration



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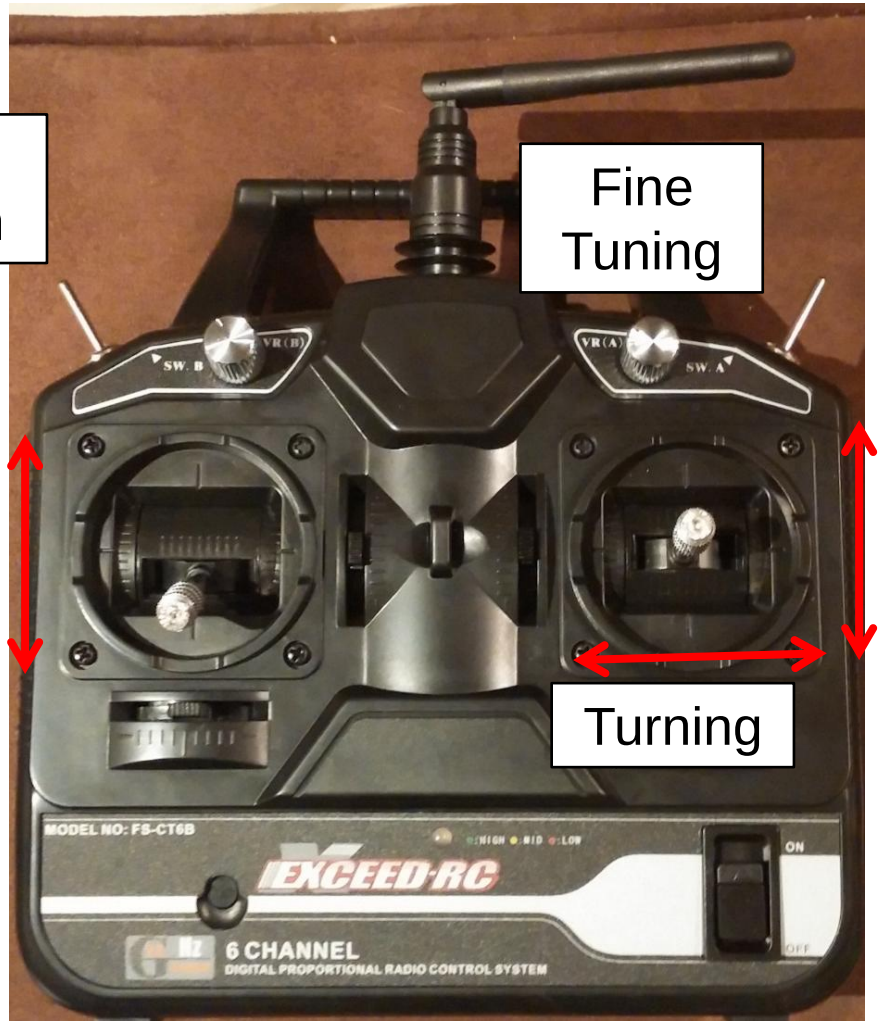


Transmitter Programming

Used two programs to program the transmitter

Most preset programs are designed for variable pitch helicopters or traditional airplanes

Both rotors are programmed to spin together

TRANSMITTER PROGRAMMING

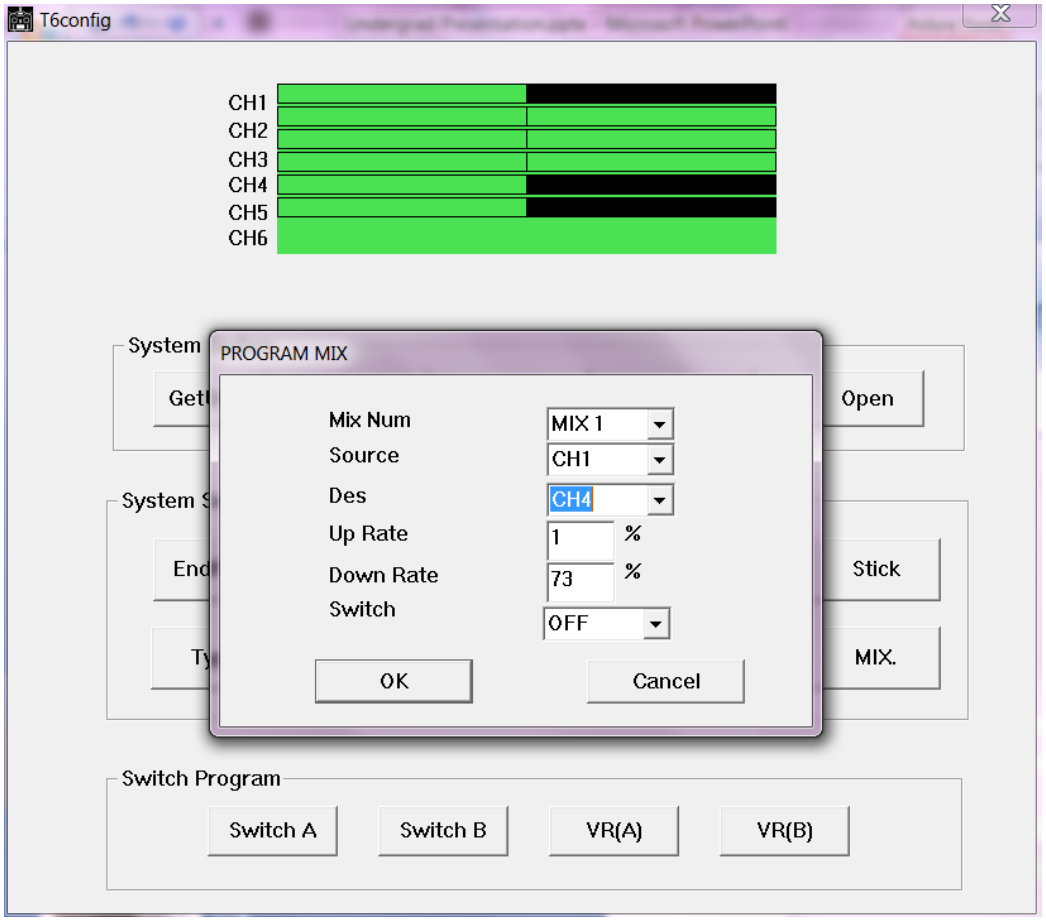
Configuration | Mixers

	Rev	Sub Trim	End Point 1	End Point 2	DR On	DR Off
Channel 1	☐	0 °	120 %	120 %	100 %	100 %
Channel 2	☐	0 °	120 %	1 %	55 %	100 %
Channel 3	☐	0 °	120 %	120 %		
Channel 4	☐	0 °	120 %	100 %	90 %	75 %
Channel 5	☐	0 °	100 %	100 %		
Channel 6	☐	0 °	100 %	100 %		

	Function		Function
Variable A	Disabled	Switch A	Disabled
Variable B	Disabled	Switch B	Throttle Cutoff

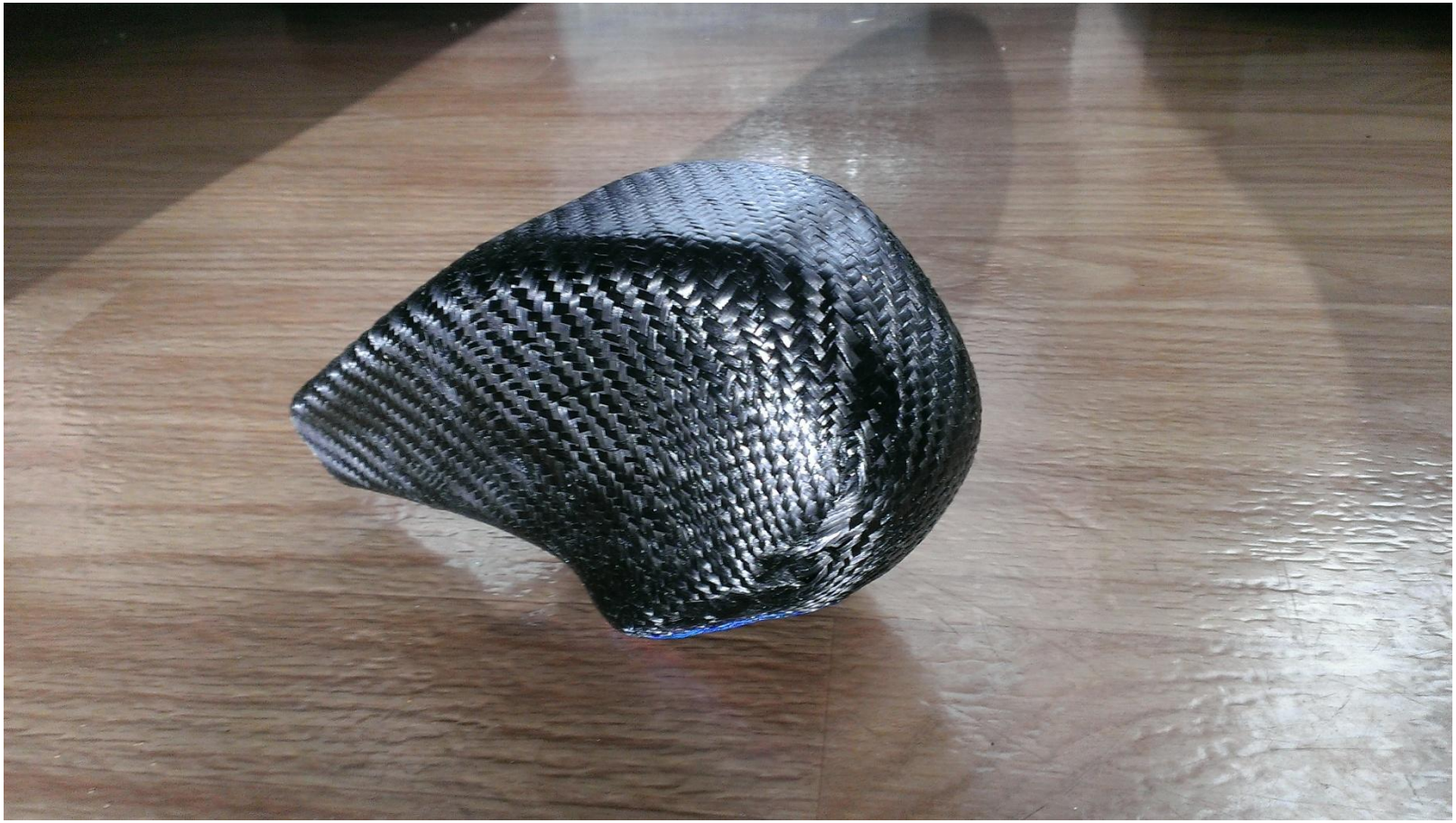
	Type
Mode	Mode 3
Configuration	Airplane

TRANSMITTER PROGRAMMING



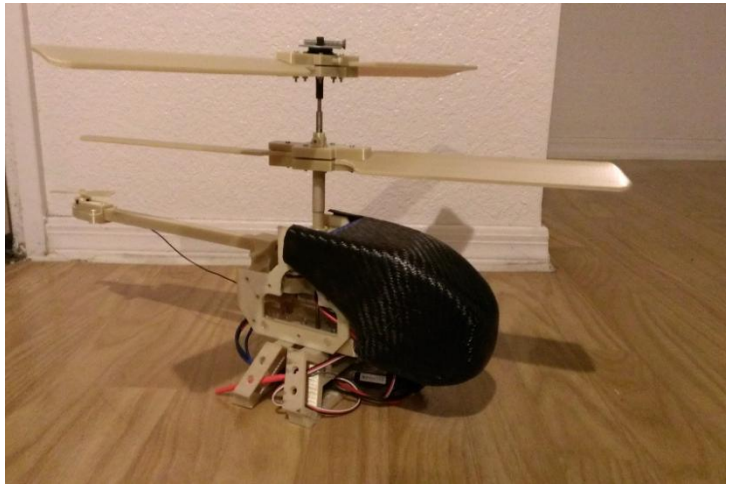
Fairing Design

Constructed with Carbon Fiber material



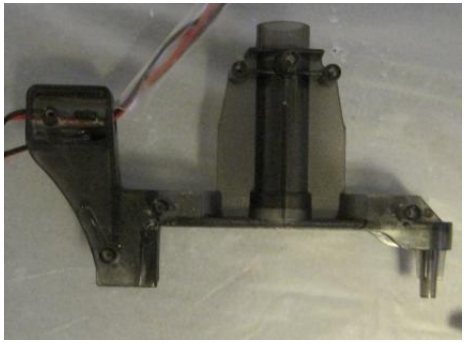
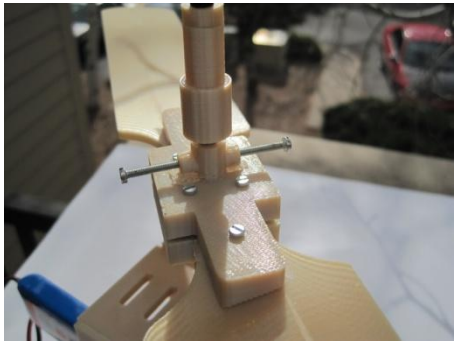
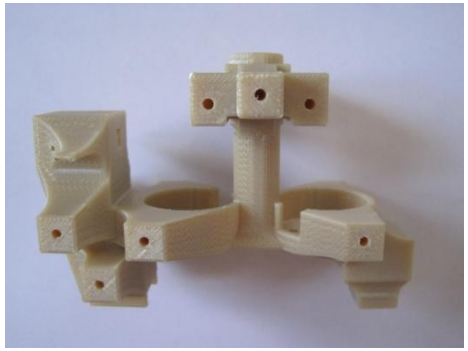
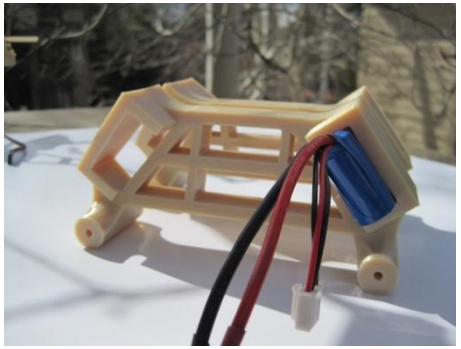
Comparison between Two Models

Original U13A



Up-scaled Model

Comparison between Two Models

	Blade Contact	Main Core	Landing Gear
Original U13A			
Up-scaled Model			

Initial Testing

Problems From Testing

- Too much weight in the main body
- Top rotor keeps slipping in the gear mesh
- The pin hole in the gear was stripped
- Calibrating the 6 channel remote control
- Shaft had a lot of uncontrolled movement

Design Modifications

- Reducing the weight
  - **Cutting out excess Ultem on the bottom plate**
  - **Cutting out excess Ultem on the landing gear**
  - **Drilling holes in the landing gear**
  - **Drilling holes in bottom plate**
  - **Decreasing outer diameter of spacers**
  - **Cutting down the side panels**
  - **Removing the top piece**

Cost Analysis

Quantity	Part	Name	Price Per Part	Price
2	Main 250 Motors	Hobbymate HB2622-5000kv Brushless Motor	$ 24.80	$ 49.60
1	Tail Rotor	12000KV Brushless Tail Motor for Micro Heli	$ 14.99	$ 14.99
2	Main Rotor ESC	New HobbyWing Flyfun ESC 30A	$ 17.49	$ 34.98
1	Tail ESC	New HobbyWing Flyfun ESC 10A	$ 11.99	$ 11.99
3	Batteries	HYPERION G3 EX 1600 MAH 2S 7.4V 45C/90C LIPOLY PACK	$ 25.95	$ 77.85
1	Top Shaft	HP Heli's Inner Main Shaft for the X-2 helicopter	$ 10.99	$ 10.99
1	Lower Shaft	HP Heli's Outer Main Shaft w/Gear for the X-2 helicopter	$ 10.99	$ 10.99
1	Transmiter-Reciver	Fly Sky CT6B OEM Version Exceed RC 6-Ch 2.4Ghz Transmitter w/ Receiver	$ 44.70	$ 44.70
2	Pinions	Mod 0.5, 10 Tooth, 2.3 mm ID Pinion	$ 1.99	$ 3.98
2	Large Gears	Mod 0.5, 80 Tooth, 6 mm ID Gear	$ 30.00	$ 60.00
1	Screws	LPPM3006 - M3 x 6mm - Thread forming screws For Plastic (100)	$ 2.40	$ 2.40
10	Pins	M2 - 8mm Roll Pins	$ 0.11	$ 1.10
1	Remote	Exceed-RC 6 Channel / Digital proportional Radio Control System	$ 49.99	$ 49.99
1	3d Printer Material	Ultem for Rapid Prototyping	$ 500.00	$ 500.00
Total				**$ 862.57**

SUMMARY

- Our task is to upscale a U13A helicopter by 1.5
- Calculated the power requirements based on modified Aerodynamics
- Designed a power train system for the up-scaled prototype
- Created 3D model of the prototype using Ultem on a Rapid Prototyping Machine
- Tested and redesigned the initial prototype to improve flight characteristics

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QUESTIONS?