# Scaling of the U13A Remote Controlled Helicopter

Project Proposal

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12/9/13

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# Problem 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 U13A is too small.

**Goal:**

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

# Objectives

| Objectives | Measurement Basis | Units |
|---|---|---|
| Design and build a RC helicopter | Amount of materials | Dollars |
| Attachments | Camera parts | Dollars |
| Batteries | Two sets of batteries | Dollars |
| Carrying Capabilities | Weight | lbs |
| Waterproof Materials | Cost for materials | Dollars |
| Lift Capabilities | Height range | Meters |

# Quality Function Deployment

| | | | Engineering Requirements | | | | |
|---|---|---|---|---|---|---|---|
| | | | Yield Strength | Weight | Power | Length | Lift |
| Customer Requirements | **Scale** | Scale Ratio to 1.5 | 0 | 5 | 0 | 10 | 7 |
| | **1** | Perfomance | 5 | 0 | 0 | 0 | 7 |
| | **5** | Durability | 7 | 0 | 0 | 0 | 0 |
| | **7** | Flight Duration | 0 | 0 | 7 | 0 | 0 |
| | **10** | Attachments | 1 | 5 | 5 | 0 | 0 |
| | | Total | 50 | 55 | 99 | 10 | 42 |
| | | **Units** | psi | lb | ft-lb/s | in | lbf |
| | | | **Engineering Targets** | | | | |

# Concept Generation and Selection

- Blades
- Landing Gear
- Battery

# Blades

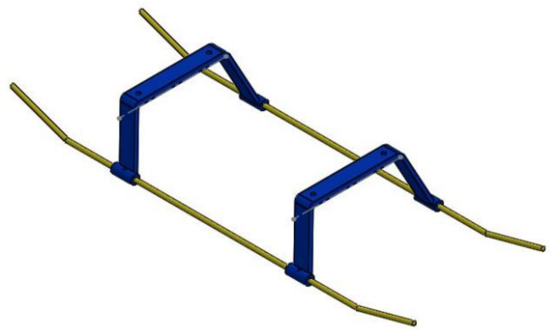
- Problem: Blade Contact


- Solution: Rigid Upper Blade Design

| Blade Contact: | Column1 | Colum | Col | Column4 | Col |
|---|---|---|---|---|---|
| Category | Ease of Design | Safety | Cost | Estimated Life | Total |
| Raised Upper Rotor | 3 | 5 | 8 | 7 | 5.8 |
| Durable Blade Material | 7 | 5 | 4 | 6 | 5.5 |
| Rigid Blade Design | 8 | 5 | 8 | 8 | 7.1 |
| Weight (%) | 20 | 30 | 20 | 30 | |

# Landing Gear

- Problem: Helicopter lands on its side

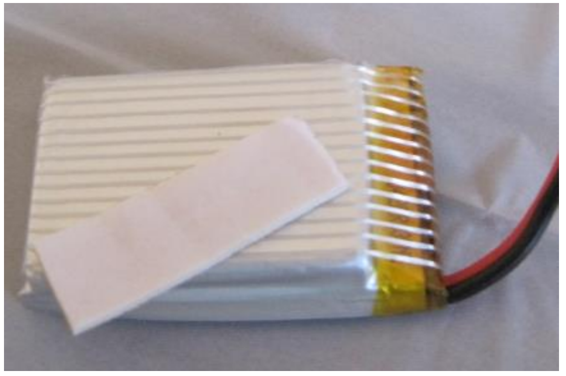


- Solution: Larger Rounded Landing Gear

| Landing Gear: | Column1 | Column2 | Column3 | Column4 | Colu | Colum |
|---|---|---|---|---|---|---|
| Category | Helicopter Weight | Take-off/Landing | Stability on ground | Landing Impact | Cost | Total |
| Larger Landing Gear (Flat) | 7 | 5 | 7 | 7 | 5 | 6.4 |
| Smaller Landing Gear (Flat) | 1 | 1 | 4 | 6 | 7 | 3.2 |
| Smaller Landing Gear (Rounded) | 1 | 2 | 4 | 8 | 7 | 3.8 |
| Larger Landing Gear (Rounded) | 7 | 8 | 7 | 9 | 5 | 7.4 |
| Weight % | 30 | 20 | 20 | 20 | 10 | |

# Battery

- Problem: Short Battery Life



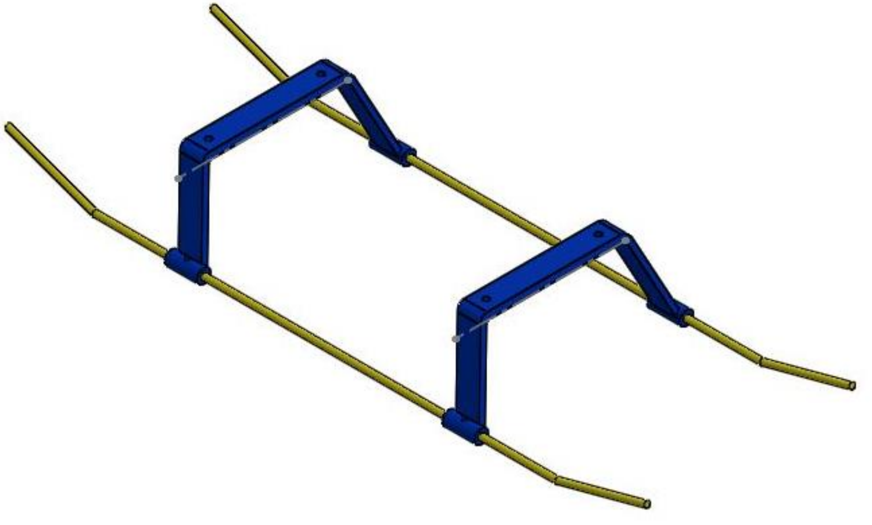
- Solution: Set batteries in series

| | Voltage | Capacity | Weight | Durability | Cost | Total |
|---|---|---|---|---|---|---|
| Single LiPo | 5 | 5 | 10 | 4 | 9 | 6.15 |
| LiPos in Parallel | 5 | 10 | 7 | 8 | 6 | 7.1 |
| LiPos in Series | 10 | 5 | 8 | 8 | 6 | 7.45 |
| **Parallel+Series** | **10** | **10** | **6** | **8** | **3** | **7.9** |
| Weight (%) | 25 | 30 | 25 | 5 | 15 | |

# Analysis Overview

- Areas for engineering analysis
- Blades


- Landing gear



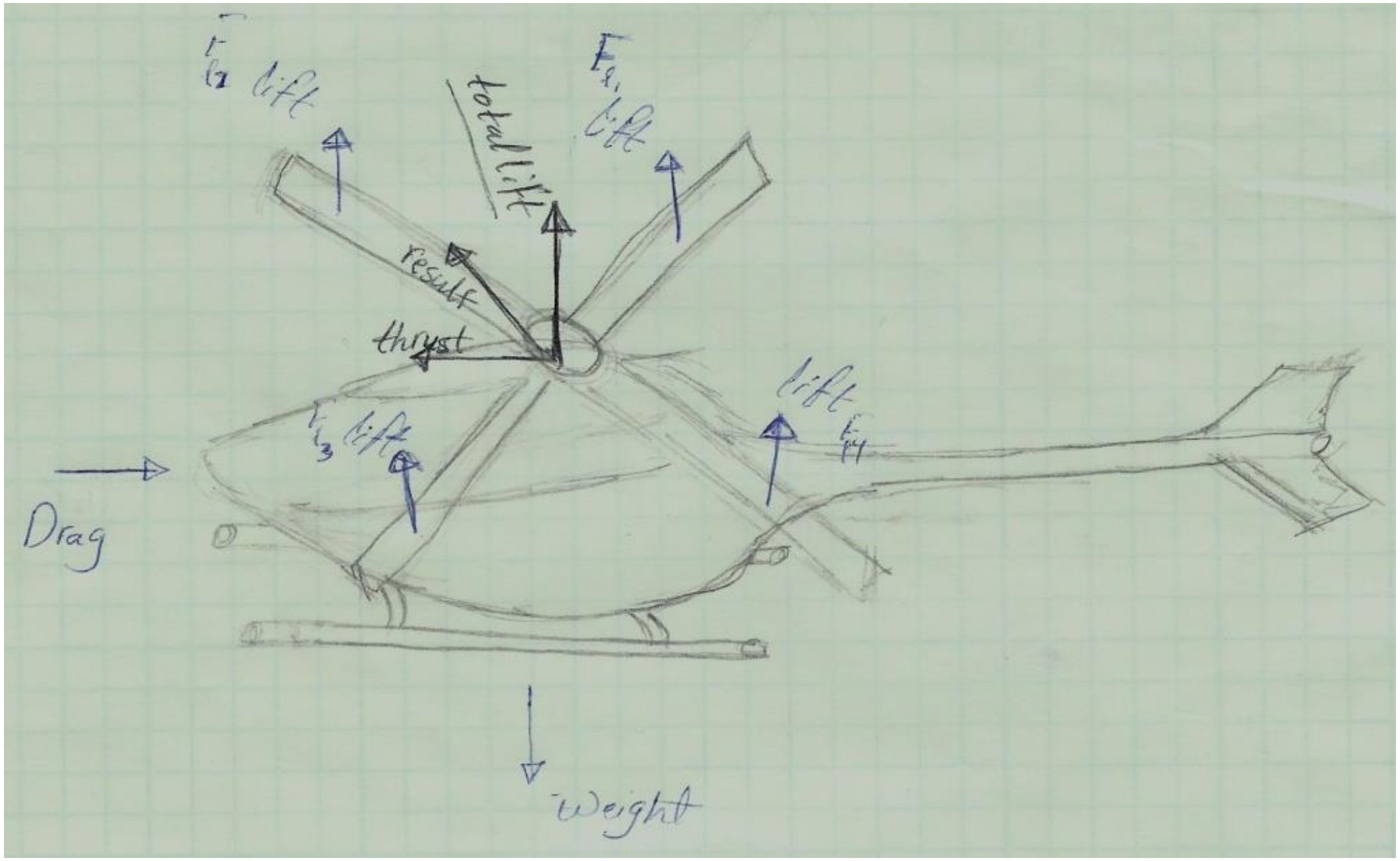
# Blade Analysis

- Goal of analysis:
  - Find approximate lift force to be generated by the scaled helicopter.
  - Calculate the max stresses occurring in the blades.
  - Choose a suitable blade material.

# Blade Dimensions & Assumptions

- Length = 7.5 inches.
- Width = 1.2 inches.
- Thickness = 0.10 inches.
- Coefficient of drag = 0.1.
- Angular velocity = 1600 RPM.
- Coefficient of lift = 0.4.

# Forces on Rotor in Flight

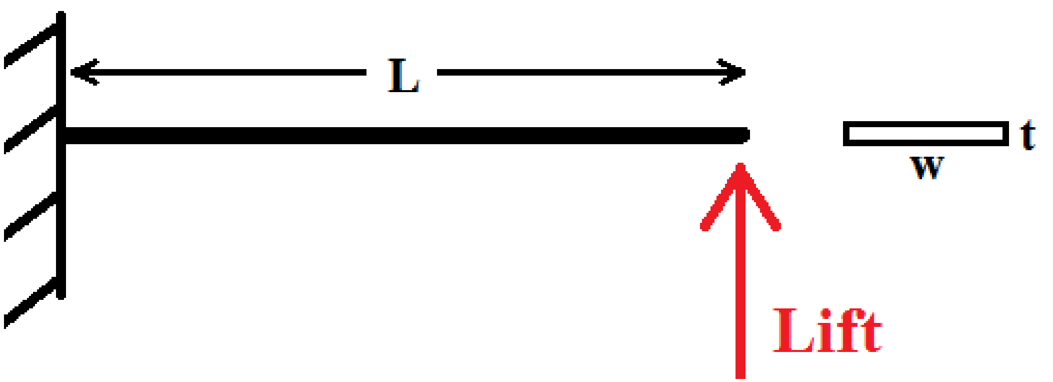


# Force Analysis

- Lift greater than drag and will result in bending upward.
- Power = 0.268 hp
- Power loading = 0.2184 hp/ft$^2$
- Thrust loading = 13.94 lbs/hp
- Lift = 3.74 lbs/rotor (1.87 lbs/blade)
- Drag = 0.1417 lbs per rotor

# Blade Strength Analysis

- Treat as a simple cantilever of constant width and thickness along the length with a point load at its tip.




- Maximum moment = 14.025 in-lbs
- Maximum stress = 7012.5 psi

# Common RC Blade Materials

- Polypropylene cheapest, great impact resistance, but cannot handle stresses.
- Wood second cheapest, handles all stresses, not great impact resistance.
- Carbon fiber and fiber glass expensive, lightweight, poor impact resistance.
- No great choice → rapid prototyping provides additional options.

# Rapid Prototyping the Blades

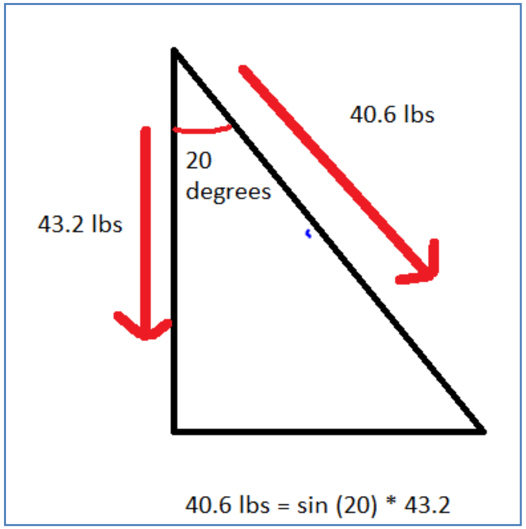
- 3D printing allows for easily reproducible custom blades.
- Two options for blade material: ABS & Ultem
  - Can handle necessary stresses
  - Great impact resistance
- Either material will work for this application
  - 1st choice is Ultem, however, availability is not 100% guaranteed.

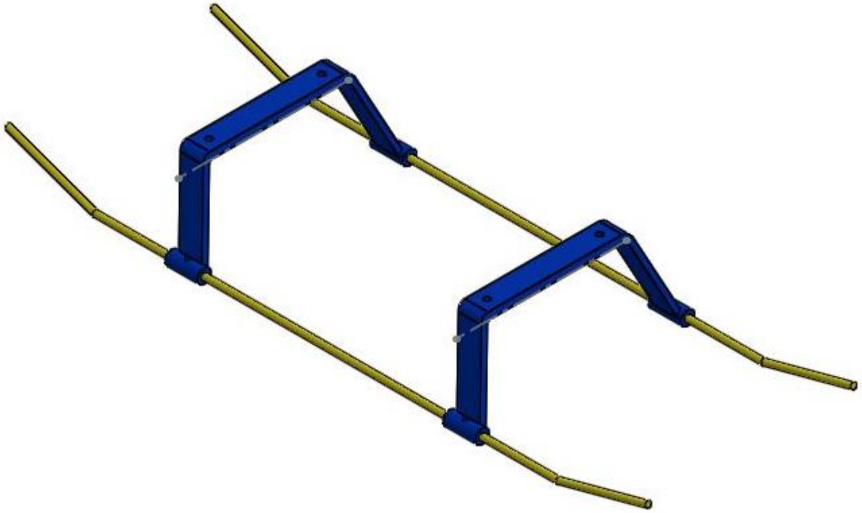
# Landing Gear Analysis

- Material is Ethylene Vinyl Acetate (EVA)
- Material has a compressive strength of 1450 PSI and tensile strength of 2000 PSI
- Excellent shock absorbing properties
- We want it to simply deform and spring back for short or non energetic landings but to break for high energy landings.

# Landing Gear Analysis

- Landing gear needs to survive a 6 ft drop with abrupt stop
- Impact force equation $F_I = \dfrac{Wxh}{s}$
- Total force is 172.8 lbs



# Landing Gear Analysis

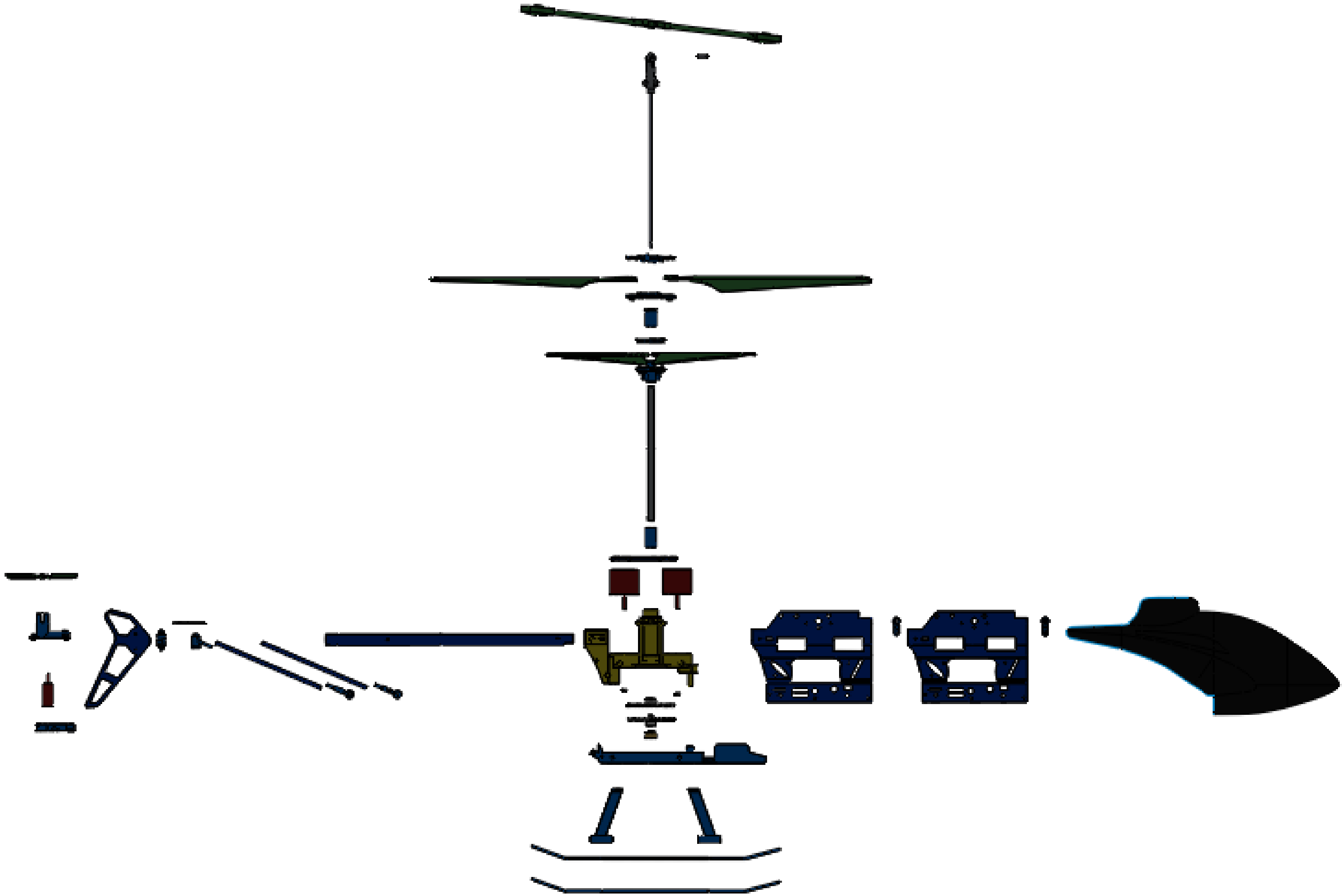
- Total compressive force on leg is 40.6 lbs
- Compare stress in leg to the UCS
- Stress is $\sigma = \frac{F}{A}$
- Using A = 0.15 $in^2$ the stress is 270.6 PSI
- 270.6 PSI < 1450 PSI so the landing gear will survive 6 ft fall

# Modeled U13A

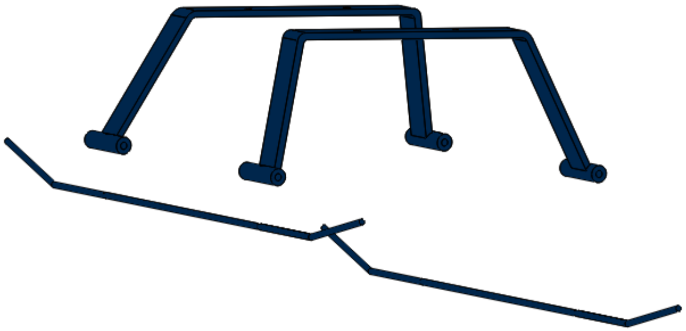
- Tasks over the last three weeks
  - Final Model
  - Material Selection
- Things to do in upcoming weeks
  - Order Parts
  - 3D Printing

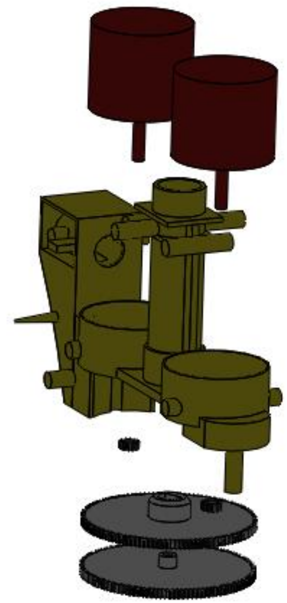
# Modeled U13A

# Exploded View of Model



# New Components





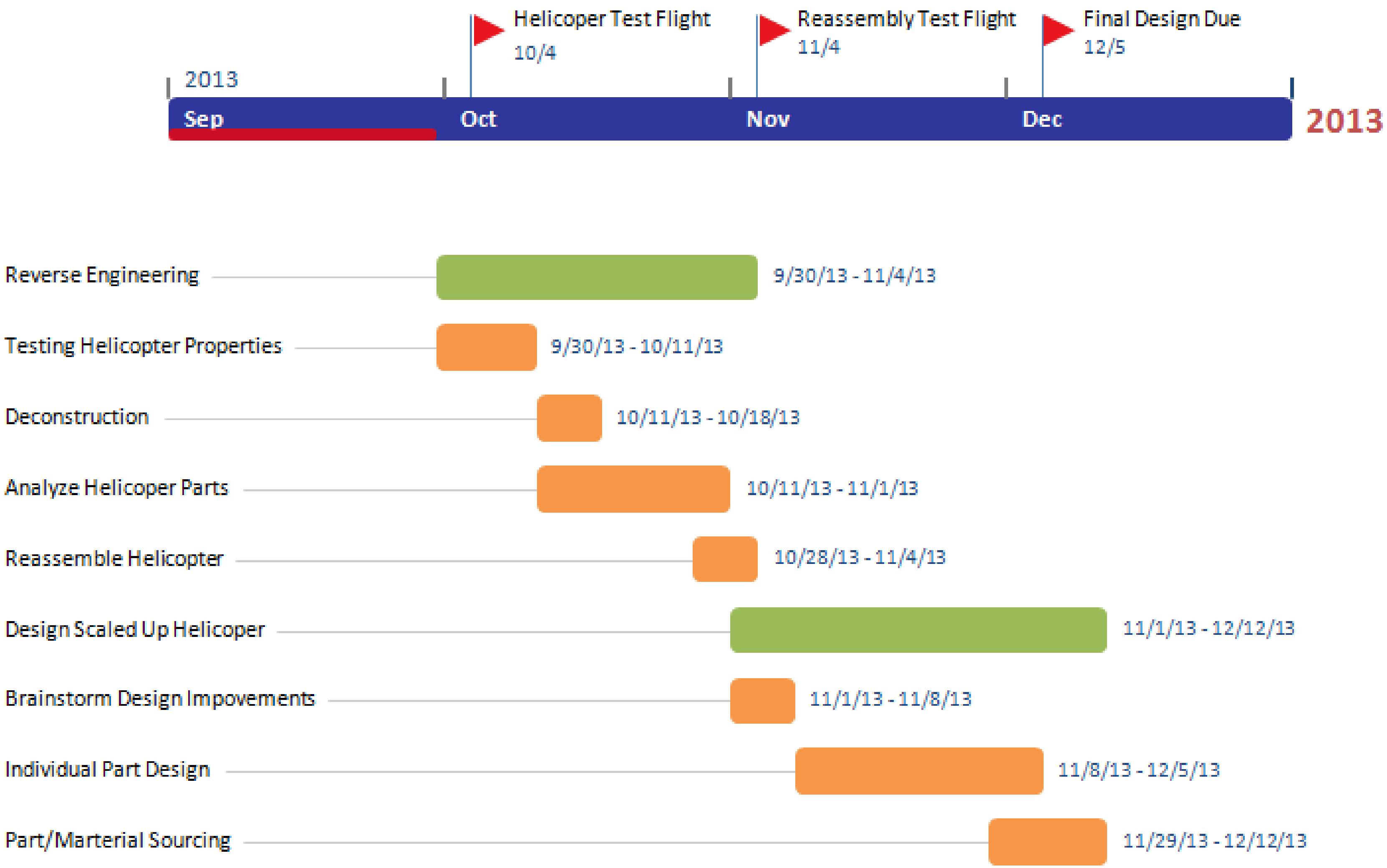
# Cost Analysis

| 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 | Small Gears | 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 | $ 2.00 | $ 4.00 |
| 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 | Camera | Wholesale - New mini Wireless Spy Camera Hidden cam Security kit | $ 30.43 | $ 30.43 |
| 1 | 3d Printer Material | ABS Polymer for Rapid Prototyping | $ 500.00 | $ 500.00 |
| **Total** | | | | **$ 798.00** |

# Cost Analysis Continued

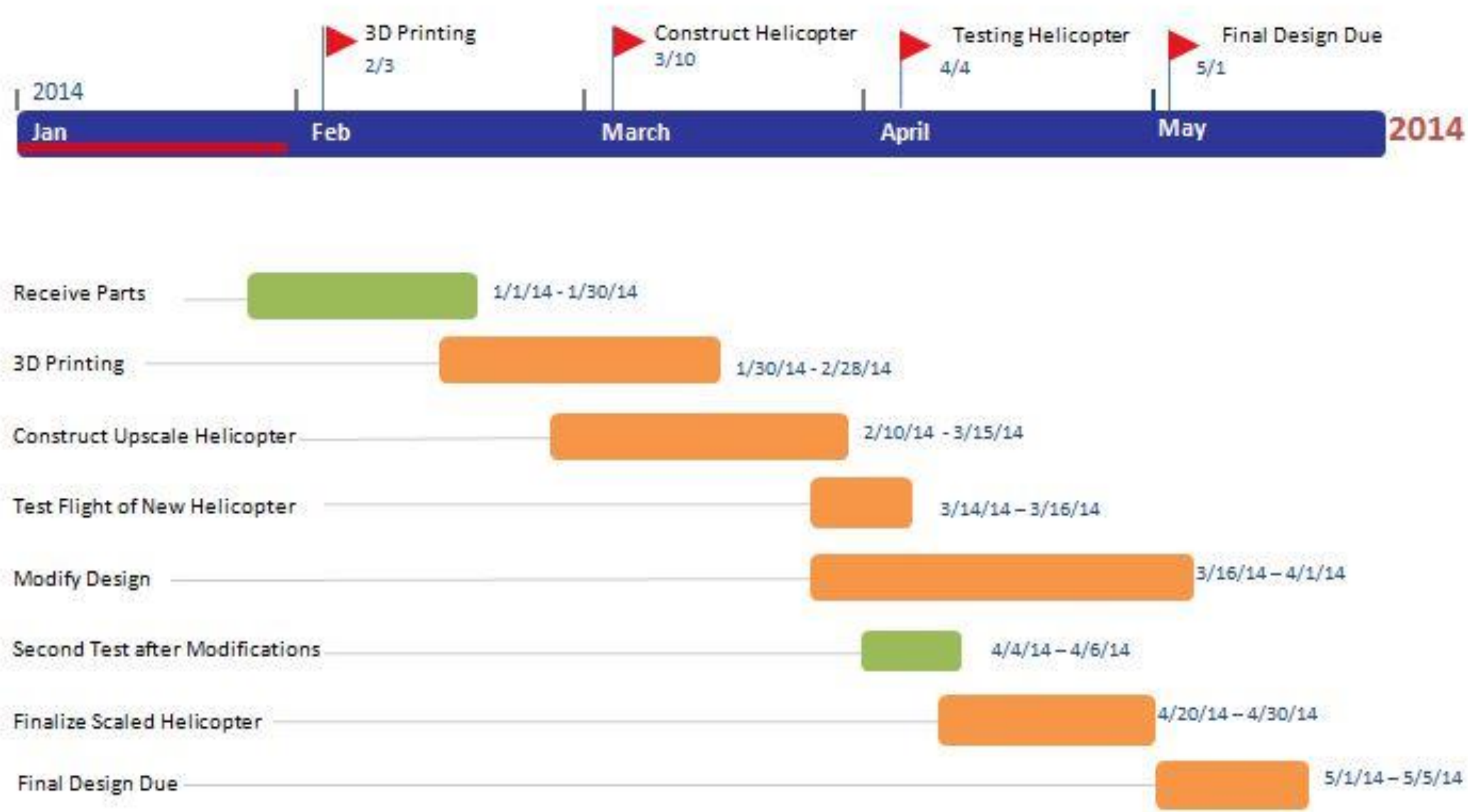
- Biggest expense is polymer material but is being paid for by student fees
- This material will be used for almost every structural material in helicopter
- Electronic components are second most expensive
- No manufacturing costs to consider

# Gantt Chart



Helicoper Test Flight
10/4
Reassembly Test Flight
11/4
Final Design Due
12/5
2013
Sep
Oct
Nov
Dec
2013
Reverse Engineering
9/30/13 - 11/4/13
Testing Helicopter Properties
9/30/13 - 10/11/13
Deconstruction
10/11/13 - 10/18/13
Analyze Helicoper Parts
10/11/13 - 11/1/13
Reassemble Helicopter
10/28/13 - 11/4/13
Design Scaled Up Helicoper
11/1/13 - 12/12/13
Brainstorm Design Impovements
11/1/13 - 11/8/13
Individual Part Design
11/8/13 - 12/5/13
Part/Marterial Sourcing
11/29/13 - 12/12/13

# Spring Gantt Chart



# Summary

- Our task is to upscale a U13A helicopter by 1.5.
- The need is that we have a small helicopter and our goal is to upscale the helicopter by 1.5.
- Stated what our objectives were.
- Calculated the requirements on the QFD table.
- The concept and generation that our team chose to analyze were the blades, landing gear, and battery.

# Summary Continued

- During the process of selection, there were three main problems: chips in the blades, helicopter landing on its side, and short battery life.
- Our team then decided that the blades and landing gear needed the most engineering analysis due to their importance towards helicopter.
- During the blade analysis, we found the forces on the rotors in flight, and calculated the maximum moment to be 14.025 in-lbs and maximum stress = 7012.5 psi.

# Summary Continued

- Rapid prototyping was chosen based on the material selection. Our team decided to 3D print the blades because it can be easily reproduced if a blade fails. ABS & Ultem was the material that can handle the stress load.
- Using the material ethylene vinyl acetate, we found that the scaled landing gear will easily survive a 6 foot fall.

# Summary Continued

- We showed the current model of the U13A helicopter in both assembled and exploded views and highlighted what the main parts were going to be used in rapid prototype.
- Performed a cost analysis on the number of parts to order.
- Gave an update on where our team is currently at and provided a spring project plan.

# References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# Questions?