Scaling of the U13A Remote Controlled Helicopter

Engineering Analysis

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Overview

- Project Description
- Analysis Overview
- Blade Analysis
- Landing Gear Analysis
- Modeled U13A Helicopter
- Gantt Chart
- Summary
- References

Problem Description

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

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.

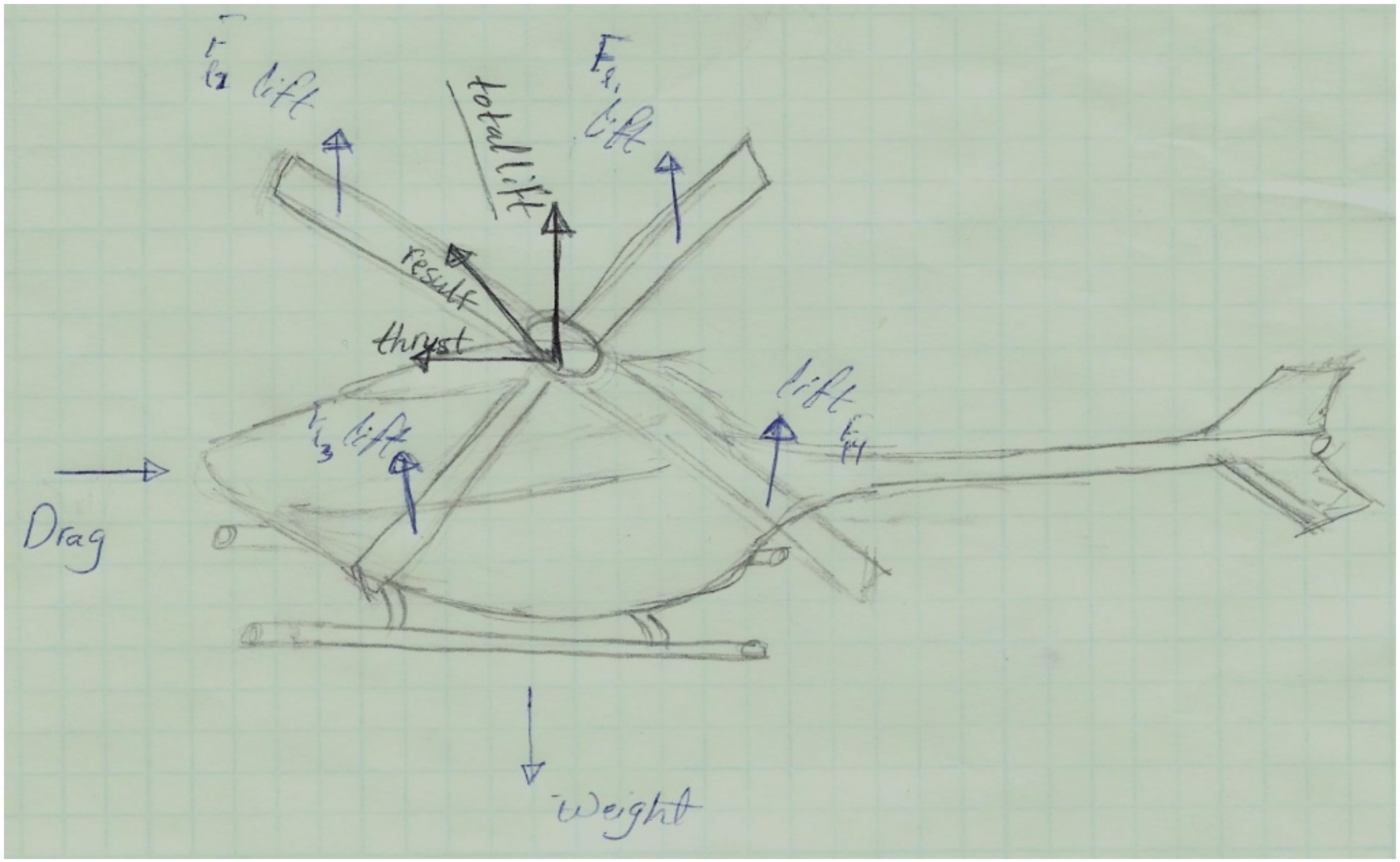
Assumptions

- The total weight of the helicopter is three-times the original helicopter's weight.
- Length of the blades 1.5 times greater than scaling requirement.
- Width scaled up to 1.2 inches.

Assumptions

- Coefficient of drag 0.1.
- Average angular velocity 1600 RPM.
- Coefficient of lift 0.4.
- Voltage 7.4V Current 30A.

Forces on Rotor in Flight



Force Analysis

- Lift greater than drag and will result in bending upward.
- Power: $P = V * I = (7.4\ V)(30\ A) = 222\ W = 163.9\ \frac{ft - lb}{s} = 0.298\ hp$
- Power loading: $PL = \frac{P}{A} = \frac{0.298\ hp}{\pi(\frac{7.5"}{12"/ft})^2} = 0.2428\ \frac{hp}{ft^2}$
- Thrust loading: $TL = 8.6859 * PL^{-0.3107} = 13.48\ \frac{lb}{hp}$
- Lift: $L = TL * P = \left(13.48\ \frac{lb}{hp}\right)(0.298\ hp) = 4.02\ lb$
- Drag:

$$D = 4 * \frac{1}{2} * C_D * \rho * A * {U_{avg}}^2 = 2 * 0.1 * 0.062\ \frac{lbs}{ft^3} * \frac{(0.1" * 7.5")}{(12"/ft)^2} (\frac{104.75 + 0}{2} \frac{ft}{s})^2 = 0.1417\ lbs$$

Blade Strength Analysis

- Treat as a simple cantilever of constant width and thickness along the length
- Maximum moment: $\mathrm{M} = (7.5")(1.005\ \mathrm{lbs}) = 7.5375\ in - lbs$
- Maximum stress: $\sigma = \dfrac{My}{I} = \dfrac{(.05")(7.5375\ in - lbs)}{\dfrac{(1.2")(0.1")^3}{12}} = 3768.75\ psi$

Blade Material Selection

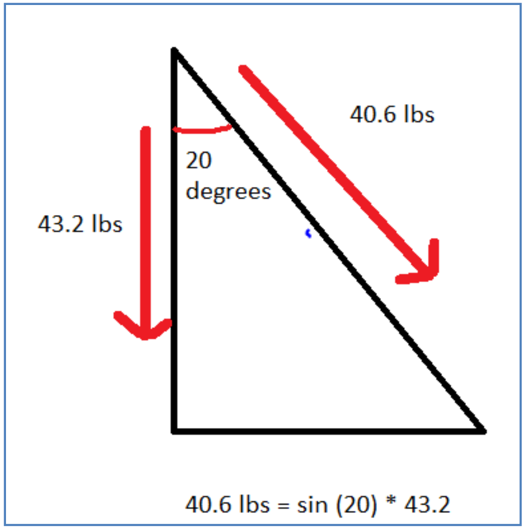
- Polypropylene cheapest, great impact resistance, handles all stresses.
- Wood second cheapest, handles all stresses, not great impact resistance.
- Carbon fiber and fiber glass expensive, lightweight, poor impact resistance.

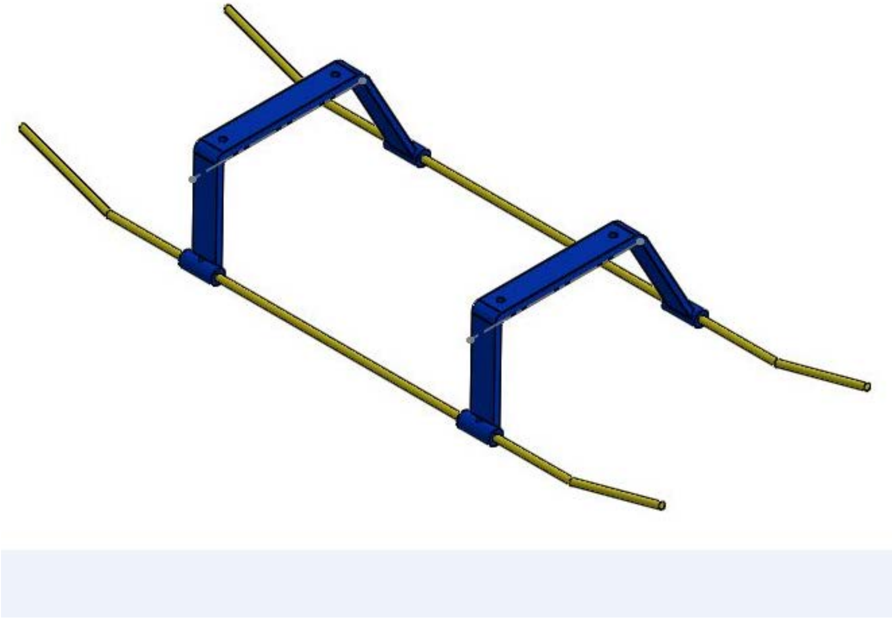
Landing Gear Analysis

- 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 $F_I = \frac{W*h}{s}$
- Total force is 172.8 lbs





Landing Gear Analysis

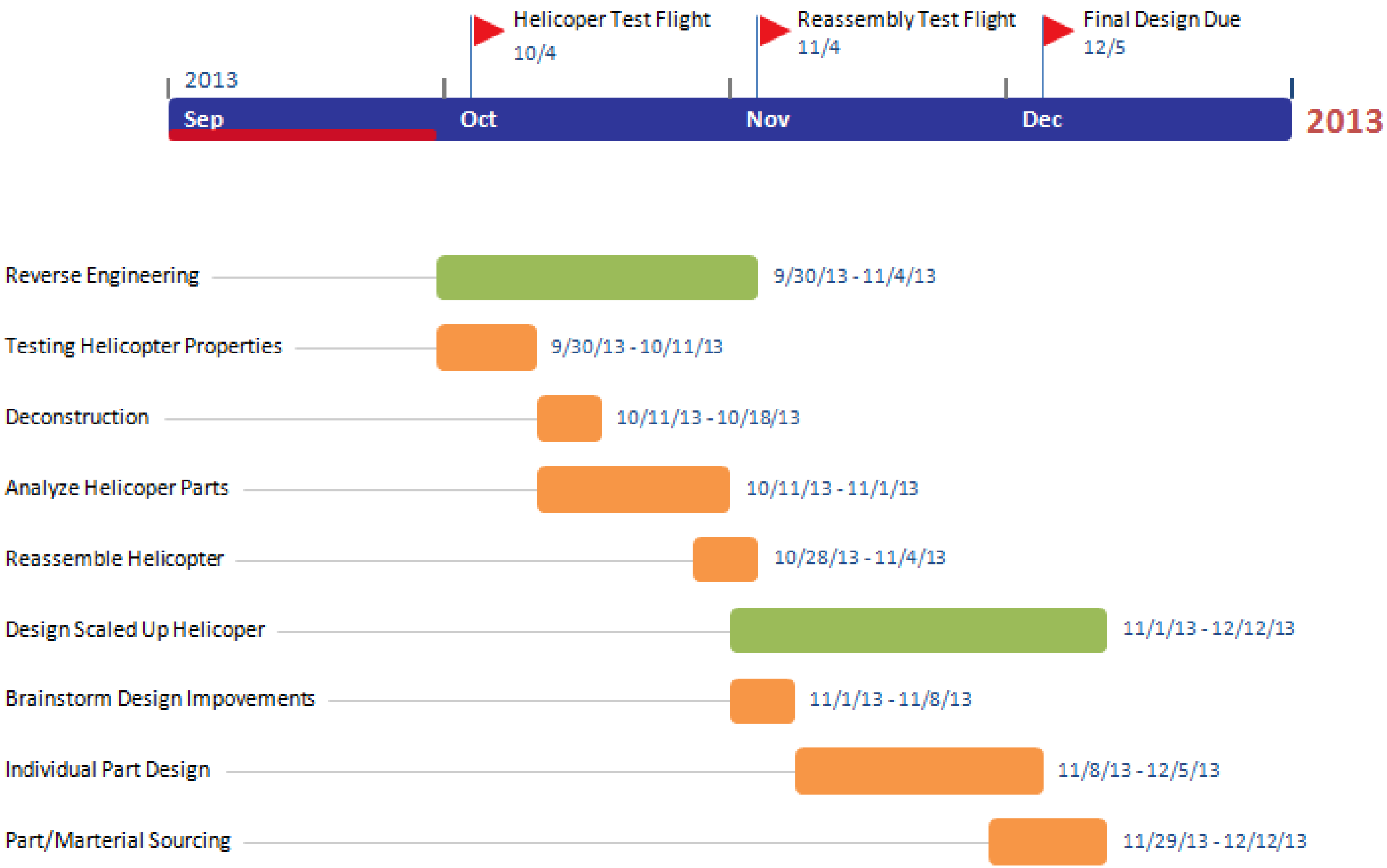
- Total compressive force on leg is 40.6 lbs
- Compare stress in leg to the UCS
- Stress is $\sigma = \frac{F}{A}$
- Using A = 0.15 in^2 the stress is 270.6 PSI
- 270.6 PSI < 1450 PSI so the landing gear will survive 6 ft fall

Modeled U13A

- Tasks over the last three weeks
  – Modeled
  – Analysis
- Over the upcoming weeks
  – Finish modeling and scaling
  – Finish material selection

Modeled U13A

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

Summary

- We are scaling the U13A helicopter by 1.5.
- Our team decided that the blades and landing gear needed the most engineering analysis due to their importance towards the helicopter.
- After analysis of the blades, we found the max moment is 7.5375 in-lb and the force to be 3768.75 psi.
- Polypropylene was chosen for the blade material based upon its material strength.

Summary Continued

- Using the material ethylene vinyl acetate, we found that the scaled landing gear will easily survive a 6 foot fall.
- We showed the current model of the U13A helicopter and highlighted what will be changed from the original design.
- Gave an update on where our team is currently at and were we progressing toward in the coming weeks.

References

- Wolfgang, R.C., 2006, “Lift Produced by Multi-Blade Heads”, from http://rc.runryder.com/helicopter/t276865p1/
- Squire, J., 2010, “Airfoil lift and drag coefficients”, University of Maryland Baltimore County, from http://www.csee.umbc.edu/~squire/cs455_lairfoil.shtml
- Heli Chair, 2011, “Aerodynamics 101”, from http://www.heli-chair.com/aerodynamics_101.html
- Heliguy, 2010, “Remote Control Helicopters FAQ”, from http://www.heliguy.com/nexus/newbie.html
- Seddon, J., 1990, *Basic Helicopter Aerodynamics*, Mackays of Chatham, Chatham, Kent.

Questions?