



Two Seat Turbine Trainer Helicopter

Executive Summary

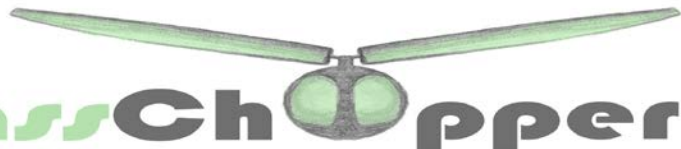
In response to the 2006 Annual AHS International
Student Design Competition – Undergraduate Category
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Outline

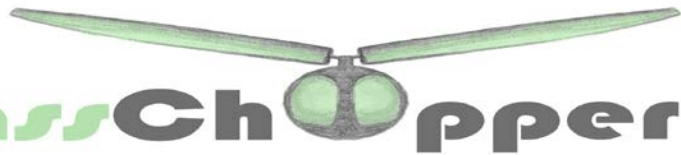
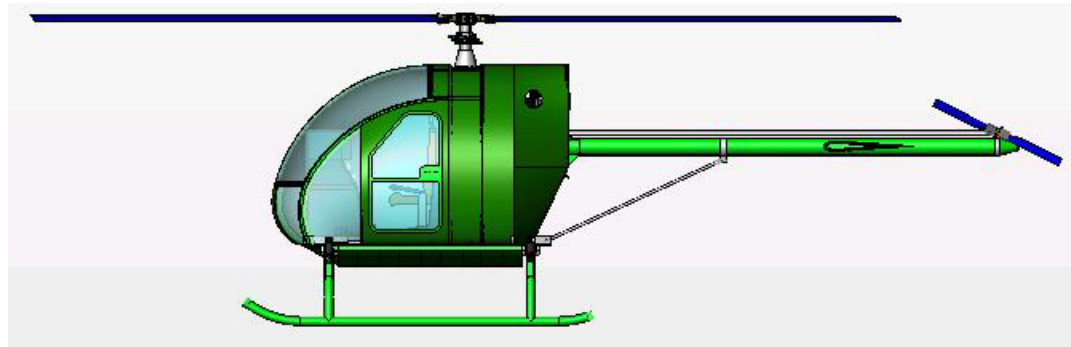
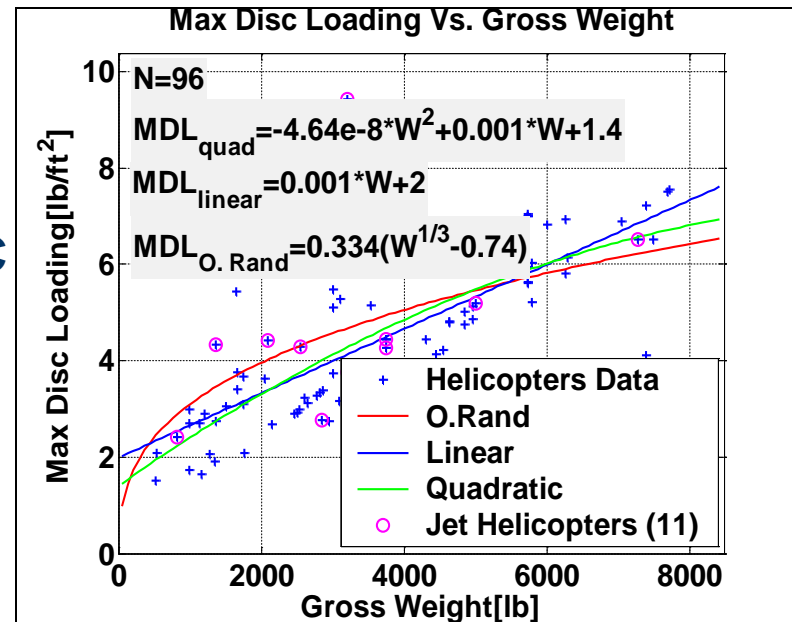
1. Discussion of the Design
2. Story of the Team
3. Acknowledgements



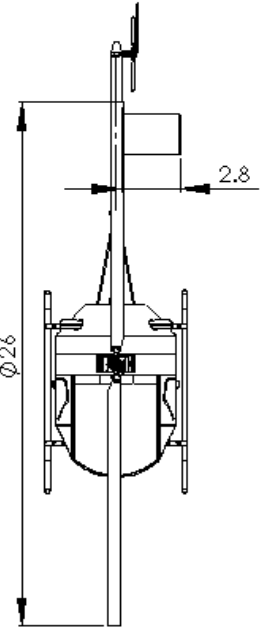
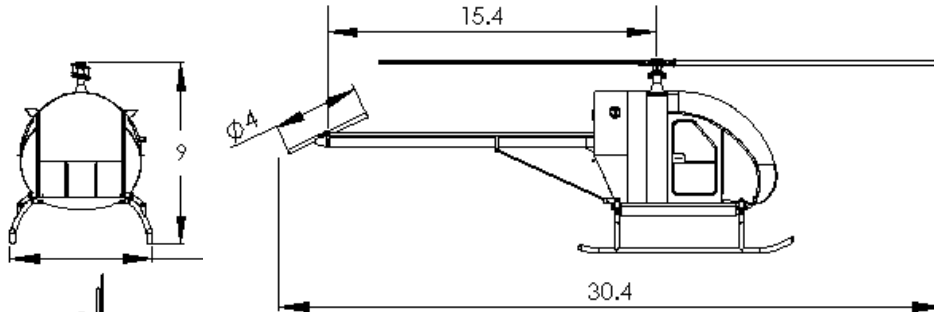
GrassChopper

GrassChopper Preliminary Sizing

- RFP requirements:
 - 2-Place training helicopter
 - 440[lb] payload
 - 2[hr] HOGE at 6[kft] on ISA+20°C
- Sizing: O. Rand & V. Khromov method
- Databases
 - RAPID/RaTE package
 - JANES
 - Manufacturers' official sites
- Key trade studies:
 - Gross Weight
 - Disc Loading
 - Engine Power



Physical Data



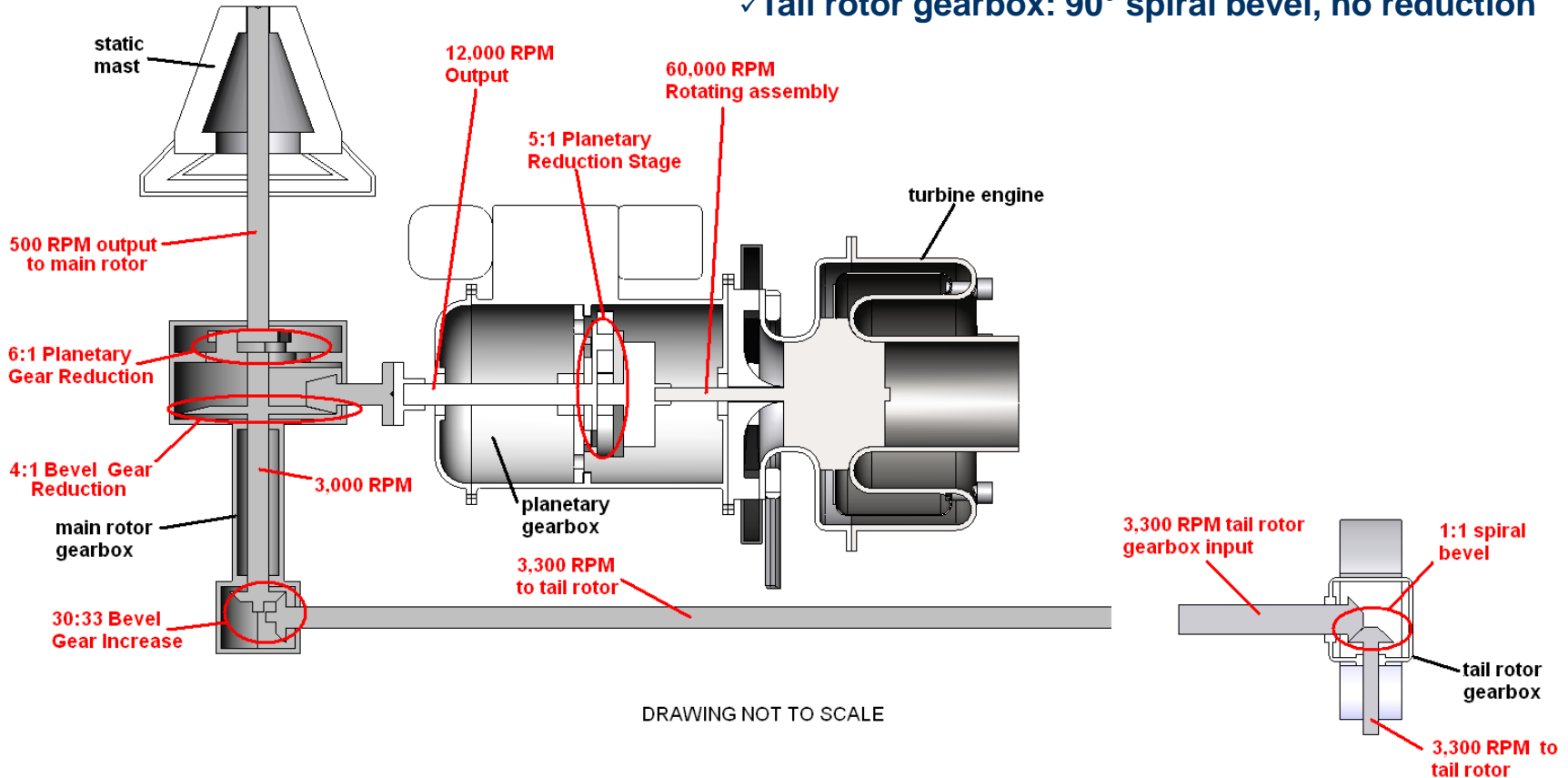
all dimensions are in [ft]

Gross Weight [lbs]	1540
Empty Weight [lbs]	806
Payload [lbs]	44
Number of seats	2
Main Rotor Dia. [ft].	26
Tail Rotor Dia. [ft]	4
Fuel weight [lbs]	276
Installed Max Cont Power [hp]	202.5
Total length [ft]	30.4
Total height [ft]	9
Total width [ft]	6.7
Number of Blades	2



Drive System

- ✓ Inexpensive, innovative gas turbine engine, PSU250
- ✓ Static mast design
- ✓ Main rotor gearbox: spiral bevel and planetary reduction
- ✓ Planetary engine gearbox integral with engine
- ✓ Tail rotor gearbox: 90° spiral bevel, no reduction



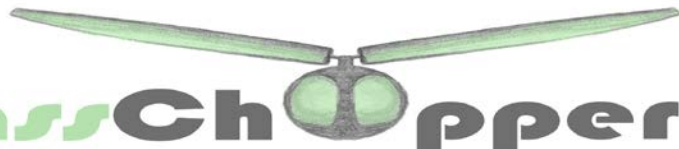
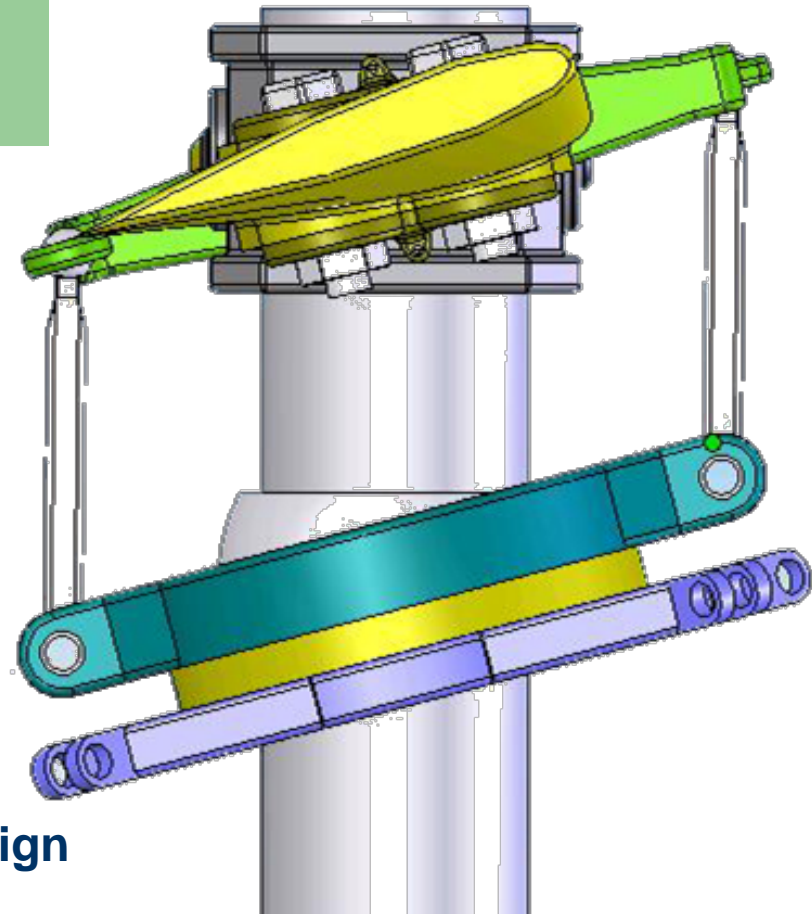
Hub Design

- Design Goals:

- Minimize cost
- Maximize reliability
- Maximize maintainability
- Reduce complexity

- Solutions:

- Conventional swashplate design
- 2-Bladed seesaw rotor
- Manually actuated controls
- All-Extrude aluminum blades:
 - Low Price
 - High Stiffness
 - Simple, familiar manufacturing processes



Main Rotor Design

- Design Goals:

- Efficient Hovering
- Good autorotative performance
- Superior forward flight performance

- Solutions:

- Large disc diameter
- NACA 23012 airfoil
- All extrude blades: low drag, high inertia



Anti-Torque System

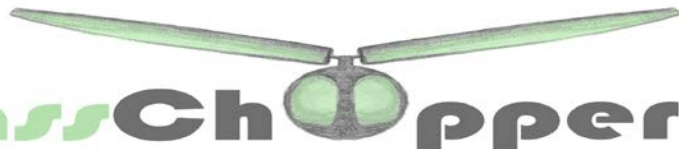
- Options considered:

- Laterally ejected jet: Heavyweight
- Side wing: Complicated
- Hydraulic or Electrically driven motor: Heavyweight



- Final design:

- Conventional tail rotor: Simple aerodynamic research



Structure

Crashworthiness was a primary driving factor in the design of the structure

● Front Bulkheads

- Favorable Crash-Resistance Characteristics (ACSDG)
- High compressive/bending stiffness (Box Beams (1" x 2.75"))

● Rear bulkhead

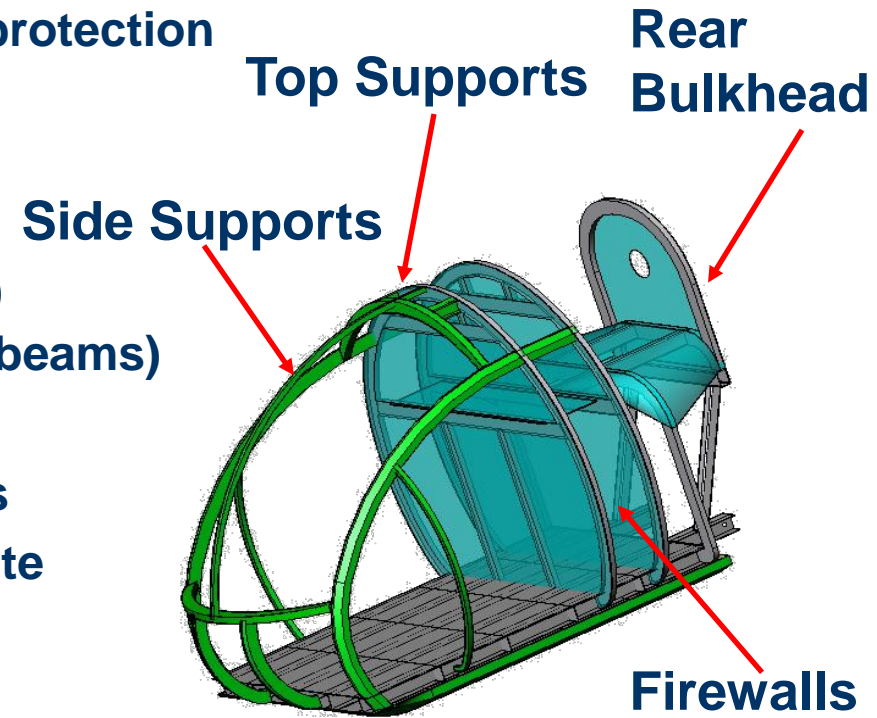
- Prevents engine damage during rollover
- Holds firewall for tailboom protection

● Cabin Structure

- Load path for landing skid
- Rollover protection
- Top supports (2.4" I-Beams)
- Side supports (closed-type beams)

● Firewall

- Protection of essential parts
- Integrated ceramic composite
- 0.1 inch thickness



Cockpit Features

Avionics

- designed to enable maximum view range
- shaded indicators (prevents reflections)

warning lights:

clutch, MR temp, MR chip, TR chip, starter on, low fuel.

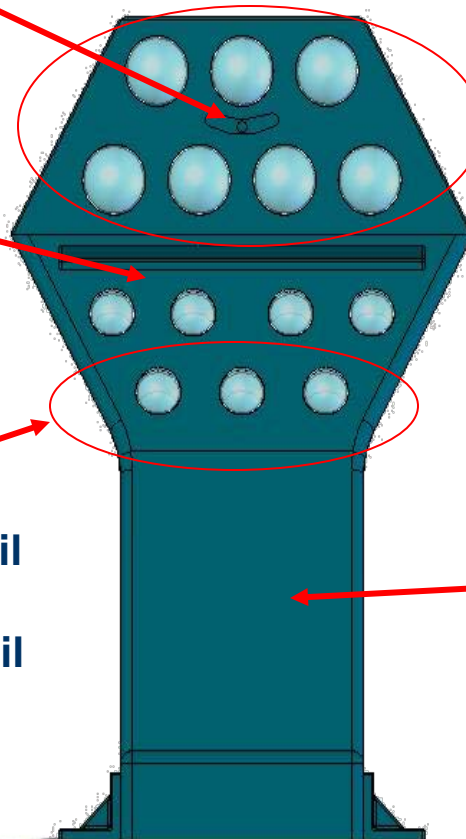
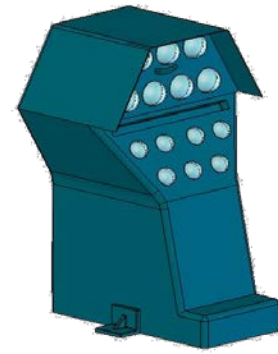
Ball

Engine gauges: torque, gas producer RPM, exhaust temperature, Indicators: fuel, engine oil temperature and pressure, transmission oil temperature\pressure, and voltmeter

Flight instruments:

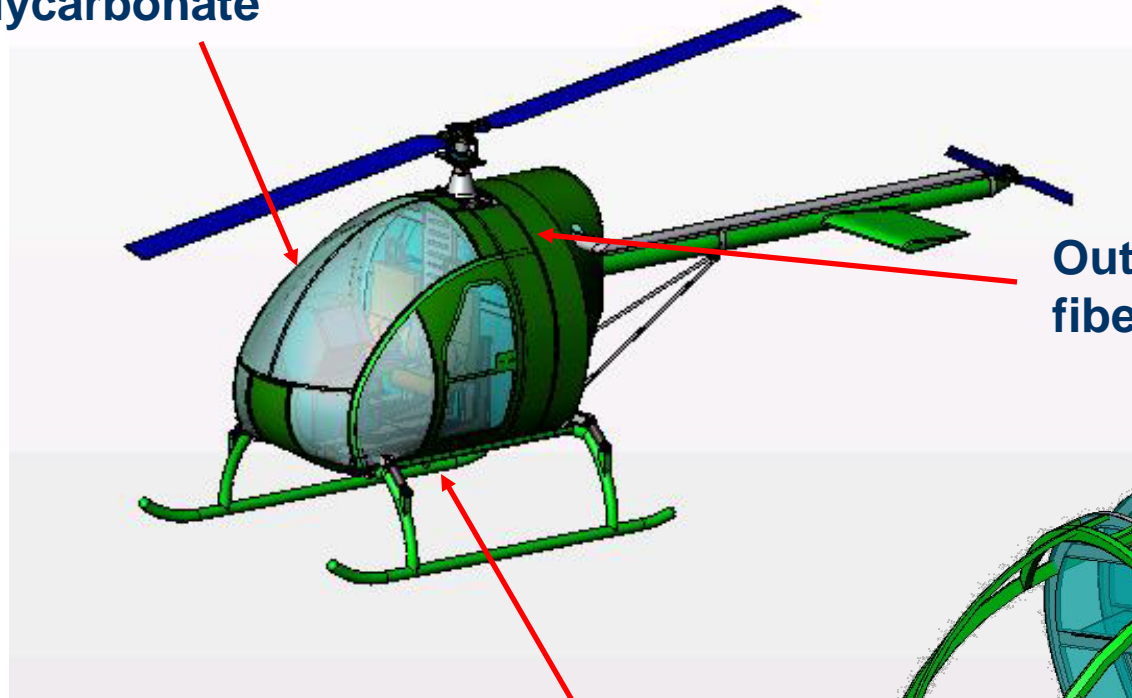
altimeter, magnetic compass, tachometer, VOR, vertical Speed , air speed, and attitude

Communications : UHF radio and internal communication panel



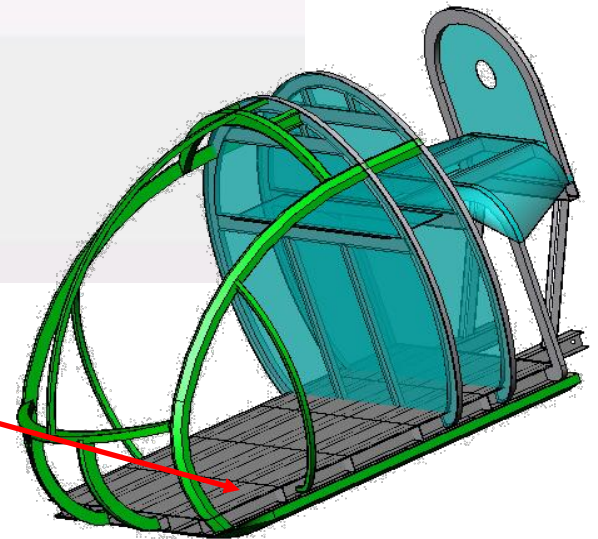
Skin Materials

Windows made of excellent total luminous transmittance polycarbonate



Outer skin made of fiberglass sheets.

Flooring made of nomex core (honeycomb) covered with graphite/epoxy laminates.

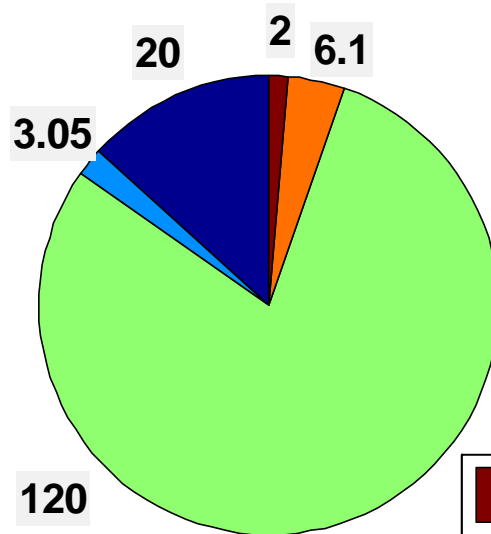


GrassChopper

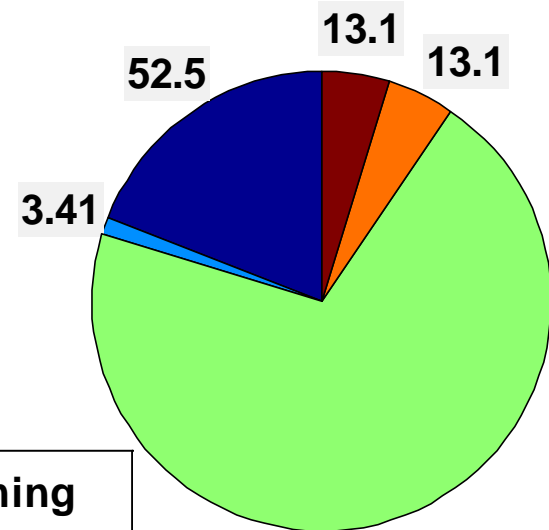
Performance

Max Velocity	Max Range	Max Endurance
115 knots	290 nmiles @ 89 kts	230 min @ 60 kts

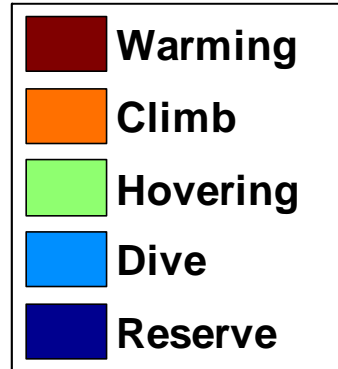
* Refers to an
ISA+20°C



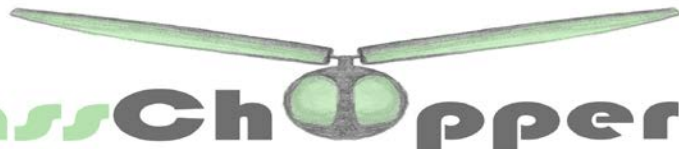
Total time = 151.2 [min]



Total fuel weight = 276.1 [lb]

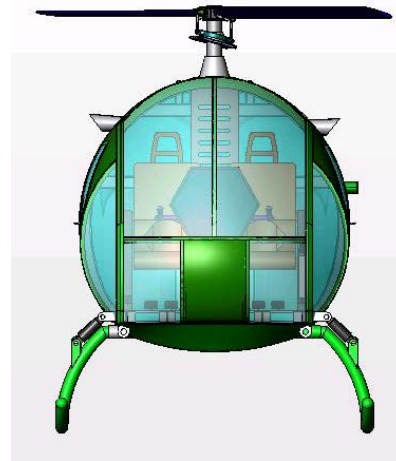


Large fuel capacity
allows for two hours
HOGE @ 6Kft.



GrassChopper

Manufacturing



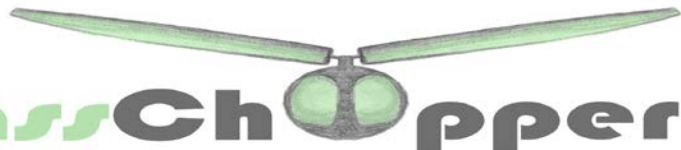
Studied new, emerging technologies that are currently being tested and validated

Goal was to decrease cost of production, while still maintaining standards of strength, stability, and reliability

- ✓ All-extrude aluminum rotor blades and tail boom
- ✓ Composite airframe
- ✓ Foam subfloor
- ✓ Integrated ceramic composite firewall

Summary of findings:

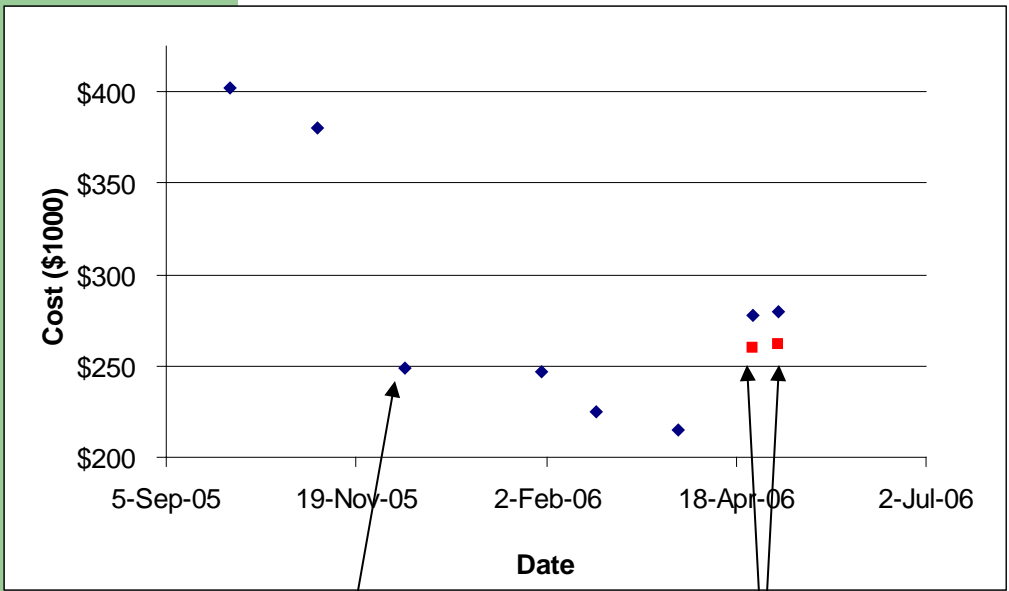
	Low Labor Time	Low Labor Cost	Low Part Count	Lightweight	Readiness (1-5, low-high)	Quality (↑,-,↓)
E-beam Curing	•	•	•	•	5	↑
Foam Sub-floor			•	•	5	-
Tool-less Assembly	•	•	•	•	3	↑
Ceramic Composite Firewall	•		•	•	5	-
Advanced Joints	•	•	•	•	4	↑
Paint-less Finish	•	•		•	4	-



Cost

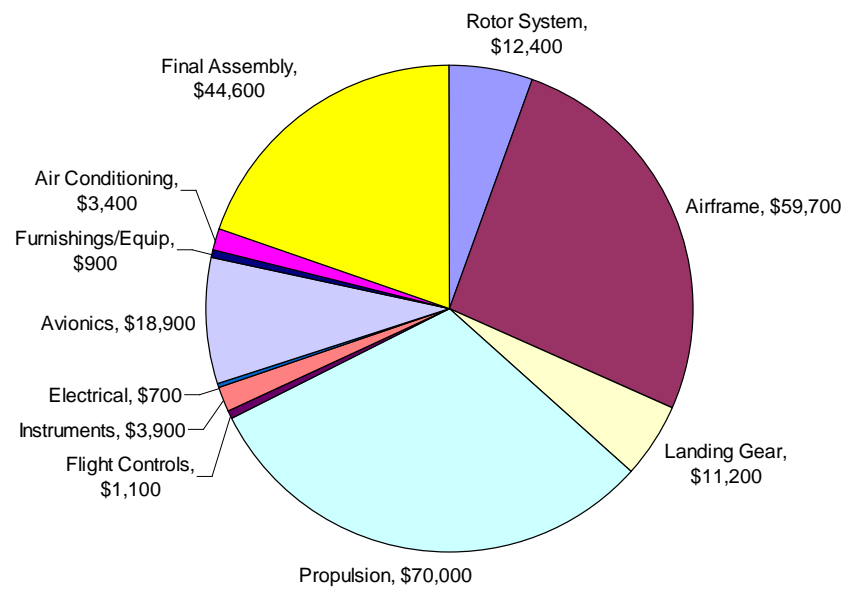
The GrassChopper is low cost through all stages of production and flight

The design team went through many iterations of cost estimation



PSU250

Use of composites



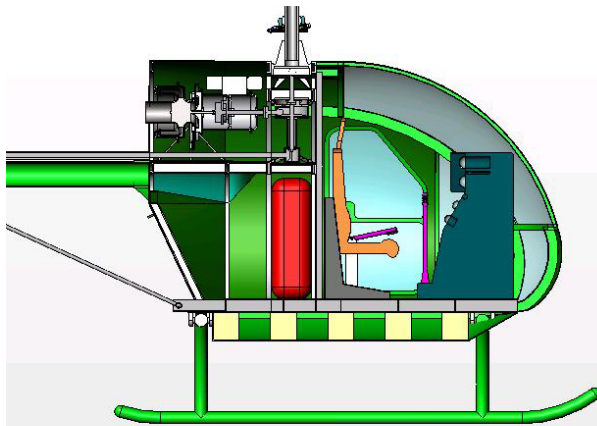
Story of Our Team

PSU and Technion worked very closely, almost daily, breaking down the 7 hour time barrier!

Our team was nervous about the international cooperation, but both schools communicated well and shared ideas



Penn State University



The helicopter was sent back and forth, many miles, many times until the team was happy with the resulting GrassChopper!



Story of Our Team

Methods of communication included

- ✓ e-mail
- ✓ Skype teleconferencing
- ✓ AOL Instant Messenger



PSU Personnel



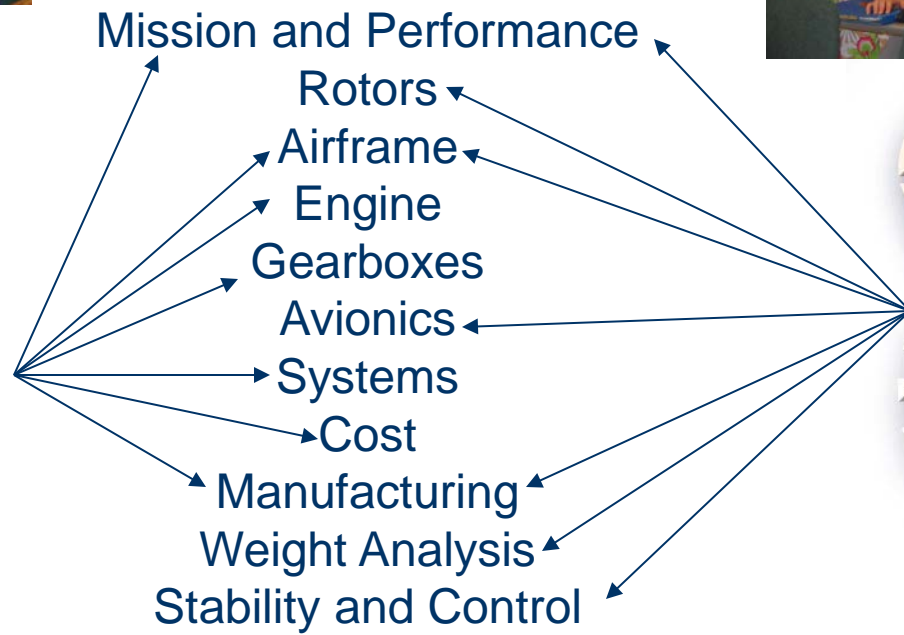
Technion Personnel



Story of Our Team



Task Breakdown



Acknowledgements

The GrassChopper team would like to extend special thanks to:

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Mr. Abdul H. Aziz – Penn State University
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