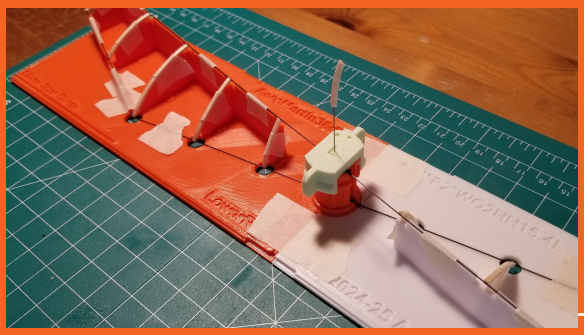
Science Olympiad Helicopter

WHERE ARE YOU NOW?

-A RoadMap for Your Helicopter Journey



Martin Chou Ph.D.
aka AeroMartin
12/20/2024

Hi everyone, Welcome! My name is Martin Chou, also known as AeroMartin on the Internet. Glad to be here.

From a very young age, I've been fascinated by the magic of flight. This lifelong passion for model airplanes ultimately led me to pursue a Ph.D. in Aerospace Engineering. In addition to Jet Turbine Engine, I've even had the privilege of working on the development of Unmanned Aerial Vehicles, otherwise known as drones!

My passion isn't just about building cool flying machines. For the past twelve years, I've been helping high school Science Olympiad teams, coaching them in a variety of events, including Wright Stuff, Flight, Helicopter, Glider, Bridge, Tower, Wind Power, Mousetrap Vehicle, and many more.

I don't just coach, I create! I've published numerous airplane designs and even developed 3D printable tools to share with the maker community. You can find my work on Thingiverse.com, HippocketAeronautics.com, RCGroups.com, and YouTube.com.

With this blend of experience in design, engineering, and coaching, I'm confident I can guide you through your helicopter journey. Let’s get started!

Helicopter Journey

STAGES:

1. Building
2. Flying
3. Custom Design & Iterating

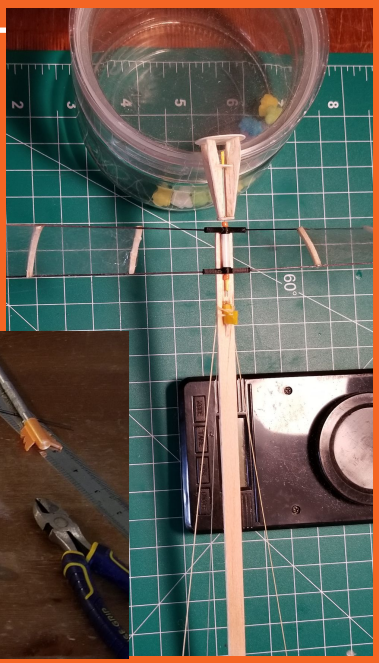




All students go through these stages: learn to build, learn to fly, and, if one is aiming high, learn to customize your own helicopter. Learning and perfecting is fun.

Start your journey soon.

Building Your First Helicopter





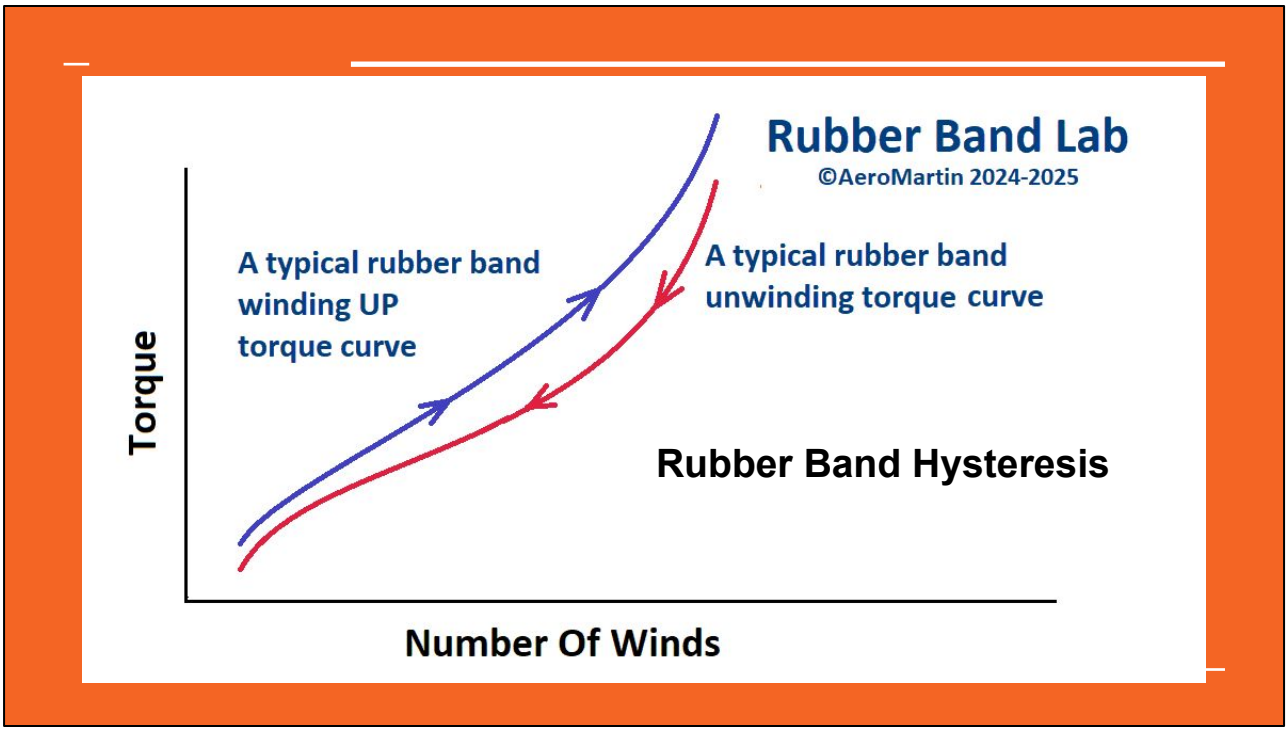
Building your first helicopter:

If you don't have any prior modeling experience, the best route is go buy the BEST kit on the market, learn most building tricks from it, and enjoy your successful maiden flights.

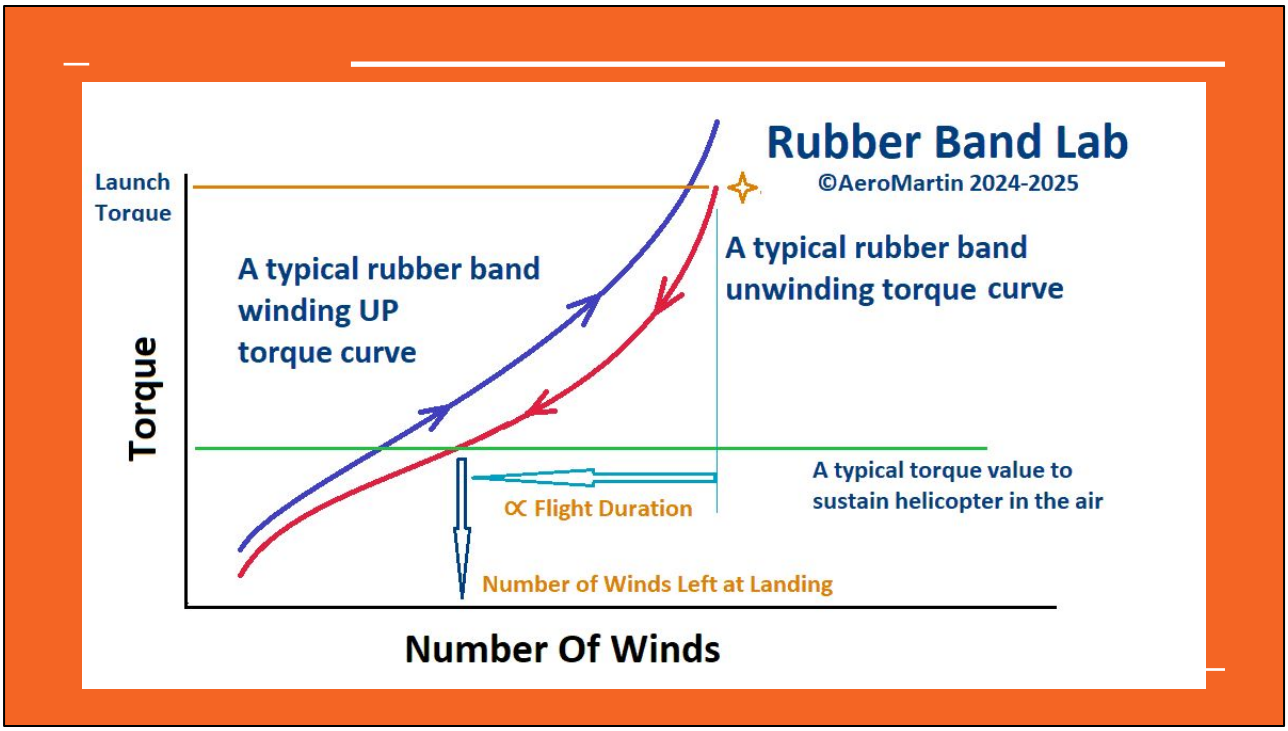
If budget is a constraint or you prefer a better challenge, find a good design (e.g. Viper25, https://www.thingiverse.com/thing:6858735). And, find a good local modeler/coach to help you learn those essential building skills. A good local coach is invaluable. You will avoid many pitfalls when a good coach is watching. This route actually is better than the above one. You will establish a better foundation for speedy advancing later.

Buy or 3d print essential tools like torque meter, pitch gauge, and rubber band winder NOW. E.g. https://www.thingiverse.com/aeromartin/designs Basic DIY version of these tools will do just fine. No need to spend excessive $$$ on these tools for now. (Read to the last slide to see if you are at a stage for such expensive tools.)

Weight is everything. For 2025 SO Helicopter, the minimum bare weight of the helicopter is 4.0g. Try to complete your first helicopter as light as possible, below 4.0g, at the same time, as strong as possible. Add clay at the lower end of motor stick to bring your helicopter to the minimum 4.0g. If it is overweight, rebuild your helicopter!

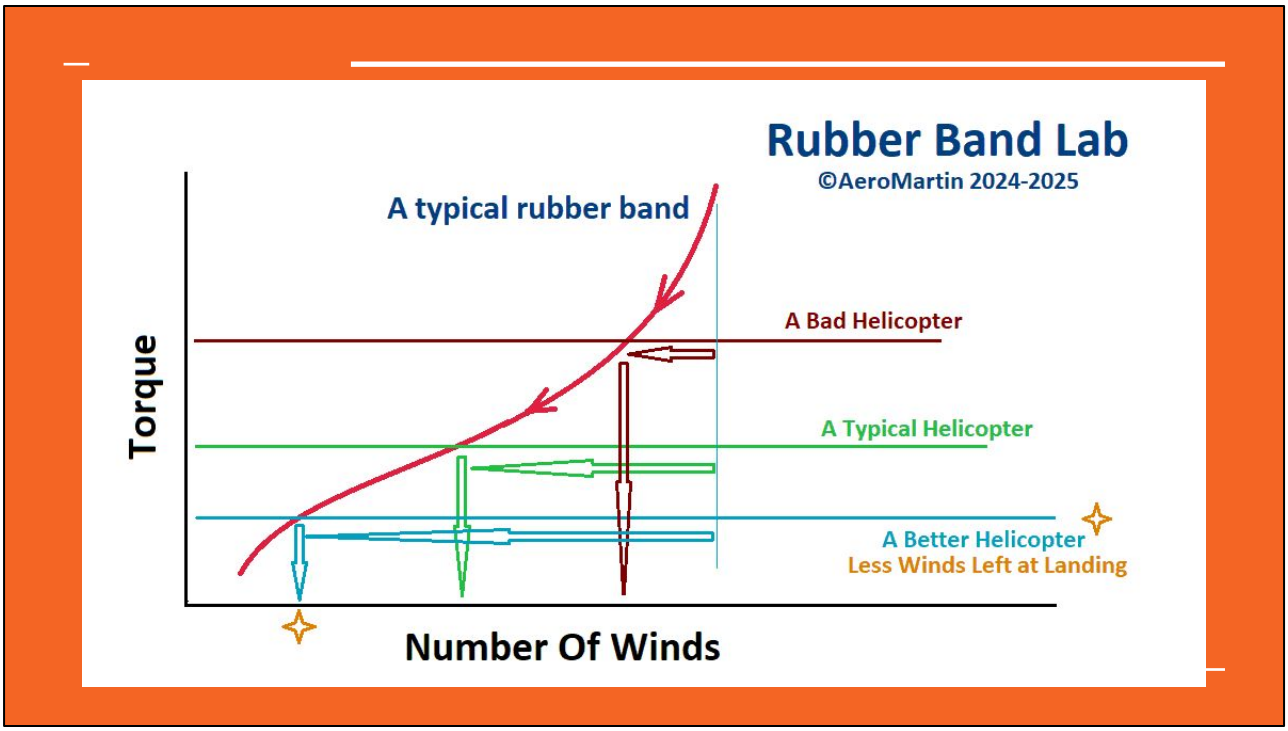


Other than the rotors, a very critical component on a SO helicopter is the rubber band. Before your first flight, spend time on learning how to stretch your rubber band. An invaluable exercise on recording down number of winds vs. torque would yield a set of curves like this. Note that the torque value is higher at any given number of winds when winding in. On the unwinding curve, the torque value is lower. This uneven condition is called **rubber band hysteresis.**



Once you have good understanding of this rubber band hysteresis, and are confident to put in ~80% or more maximum number of winds every time, go fly your first helicopter. Low ceiling is preferred for the first few flights. Record down how many winds left when it lands. This is a good indicator on how well your helicopter was built. We will see how to make use of it in the next slide.

FLIGHT LOG: Total number of winds, Initial launch torque, Number of winds left, as well as Rubber band size and weight, Bare Helicopter weight, Total weight, etc. are valuable parameters. Write them down in a flight log. Flight log is essential for improving your helicopter.

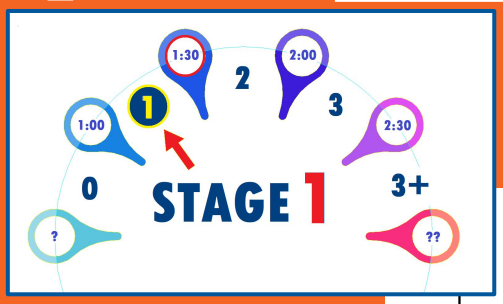


STAGE 1:

Use a rubber band (a specific size and weight) that is called out in the design plan. Test fly your first helicopter several times with the best stretching and max winds you can put in.

Fixing up helicopter:
A badly built/damaged helicopter won't fly well. As shown here, the number of winds at landing will show how good your helicopter is. True-up, Fix up, and Fine-Tune your helicopter. A better helicopter needs less torque to fly and will have least number of winds left at landing. (Assuming the same rubber band.)

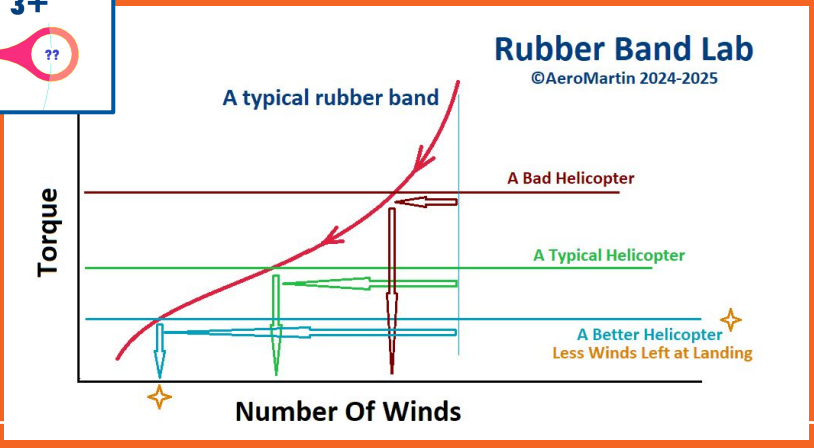
If the helicopter is badly damaged, or did not get built up correctly, rebuild it. The second build will take much less time than the first build.



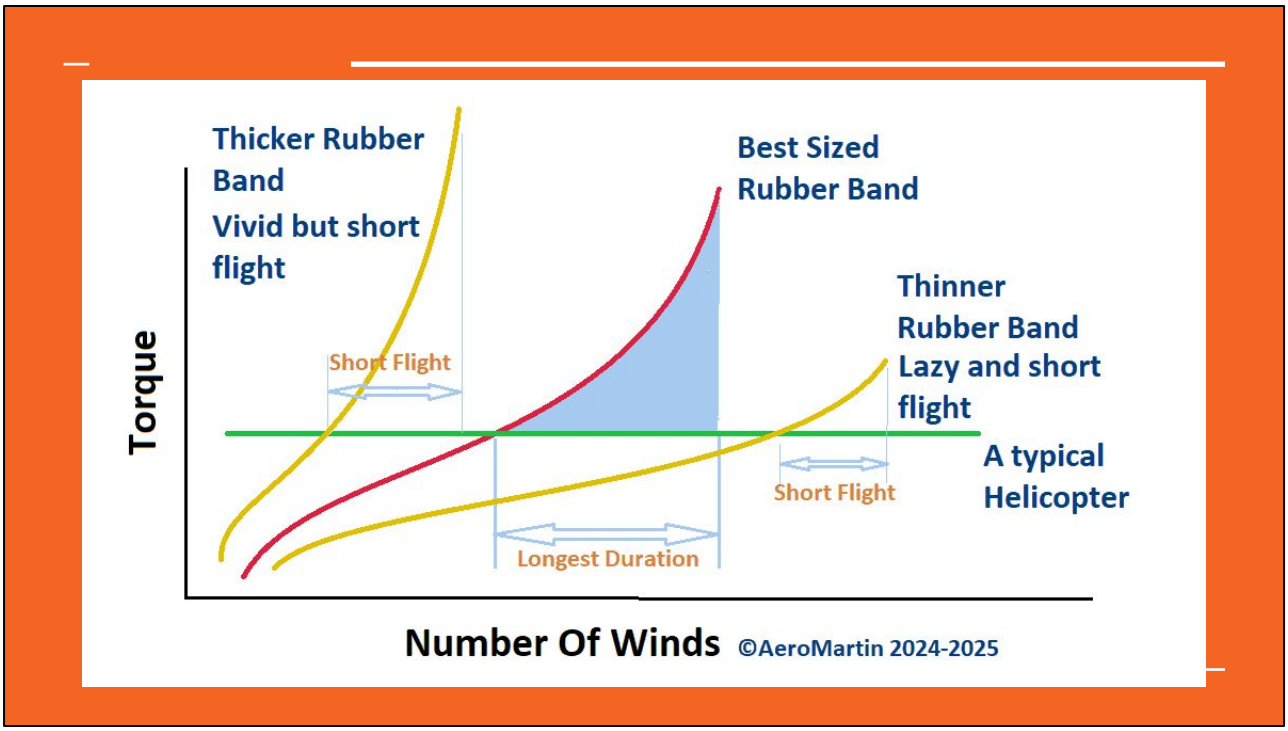
STAGE 1 Focus: Fix Up Build Problems

Milestone: ~1:30

2025 Rough Estimate



Assuming you fix up most build problems, e.g. loose Joints, slack covering, bad alignments, overweight, etc., a typical 2025 helicopter can fly to 1min and 30 seconds or more. Your hard work paid off. Congratulations! You have gone through the most difficult stage of this journey.



STAGE 2B (different length/weight rubber band):

Once you have a reasonably well-built helicopter, start experimenting with different weight rubber bands (i.e. cut the same size rubber band in different length). Don't worry about size (width or density) yet. We want to change one and only one variable at a time.

The goal is to have the longest duration. Start with a few different length (i.e. weight) rubber bands, (say, 2.0g, 2.5g, 3.0g) of the same size (say, 0.125" width). Fly your helicopter many times to find the best length/weight rubber band.

STAGE 2C: (different size/width or density rubber band):

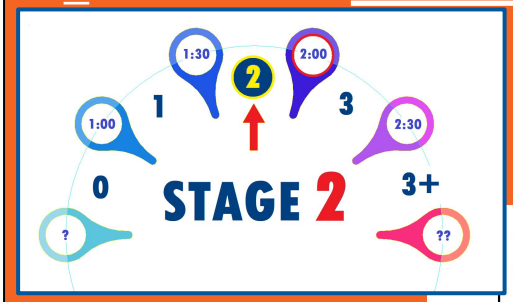
Order (or cut, if you have the tool,) different size (i.e. width or density) (say, 0.13", 0.125", and 0.12") rubber bands, with the same weight as the best rubber band obtained in 2B. Then, fly many more times to find the best size.

Iterate 2B: With the best sized rubber band (say, 0.125) found at the best weight, cut two more rubber bands. One is slightly heavier (i.e. longer.) One is slightly lighter/shorter, say, 2.4g, 2.5g, and 2.6g. Fly the same configuration (either 0.125"x2.4g, 0.125"x2.5g, or 0.125"x2.6g) at least three times to get the best result.. Do your best to be consistent with the winding and launching process.

Re-iterate Stage 2C one more time to nail down the best. You may iterate more if

improvement can still be observed.

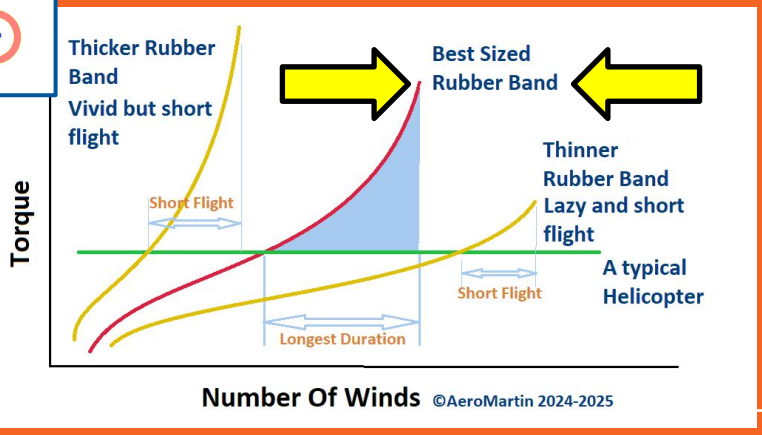
In short, fly your helicopter many times to find the best length (i.e. weight) and size (i.e. width or density) rubber band. "**One variable at a time."** *Timer is your guide.*



STAGE 2 Focus: Better Flying Techniques

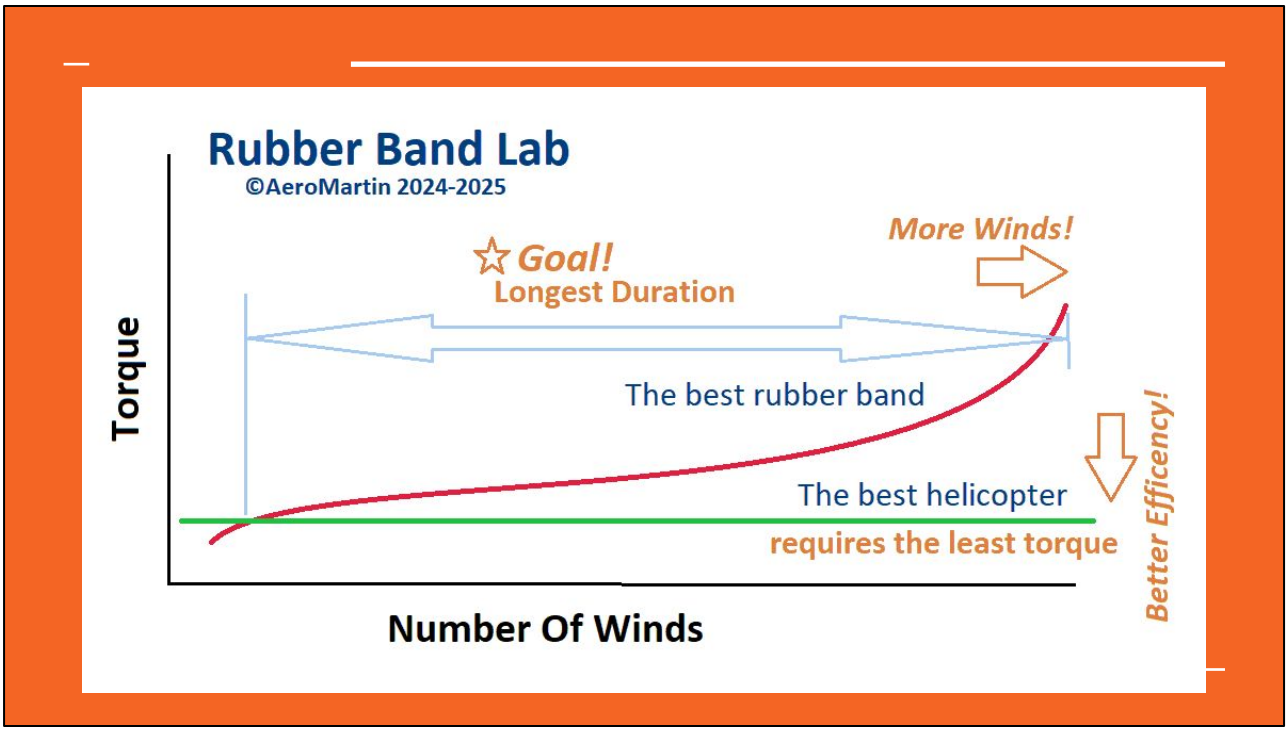
Milestone: ~2:00

2025 Rough Estimate



To recap, for STAGE 2, the focus is on bettering your flying techniques. This includes stretching and matching rubber band. In addition, smooth and consistent launching procedure is important, especially when working as a team..

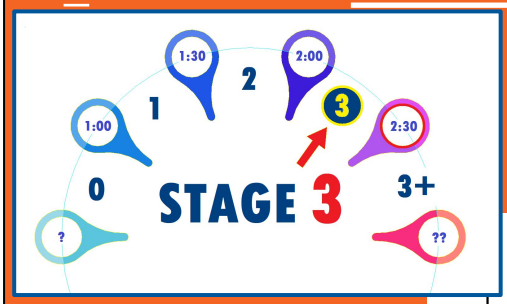
If all goes well, 2 min. or more duration should be possible. Cheers!



STAGE 3:

Now, try to alter or true up the original design of your first (or second, or third) helicopter. Say, decrease the upper rotor's pitch (i.e. P/D) and see if the flight time improves. Pitch on the lower rotor is another variable to change. Decrease it and see. **Everytime a change happens, you may have to iterate through prior stages, to get the best duration. In other words, your best rubber band may have a different weight/length, and the size might be thinner.**

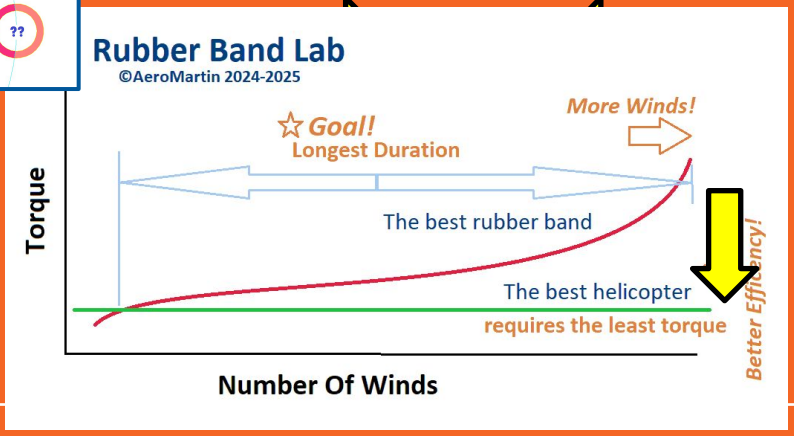
Fly many more times with your design changes. Rebuild if necessary. The goal is to **have a helicopter that requires the least torque to fly.** See the graph above. Again, for each change, same as described in STAGE 2 slide, we need several iterations to find a moderate length/weight and **a thin but not too thin** rubber band that yields the longest duration.



STAGE 3 Focus: Better Design

Milestone: ~2:30

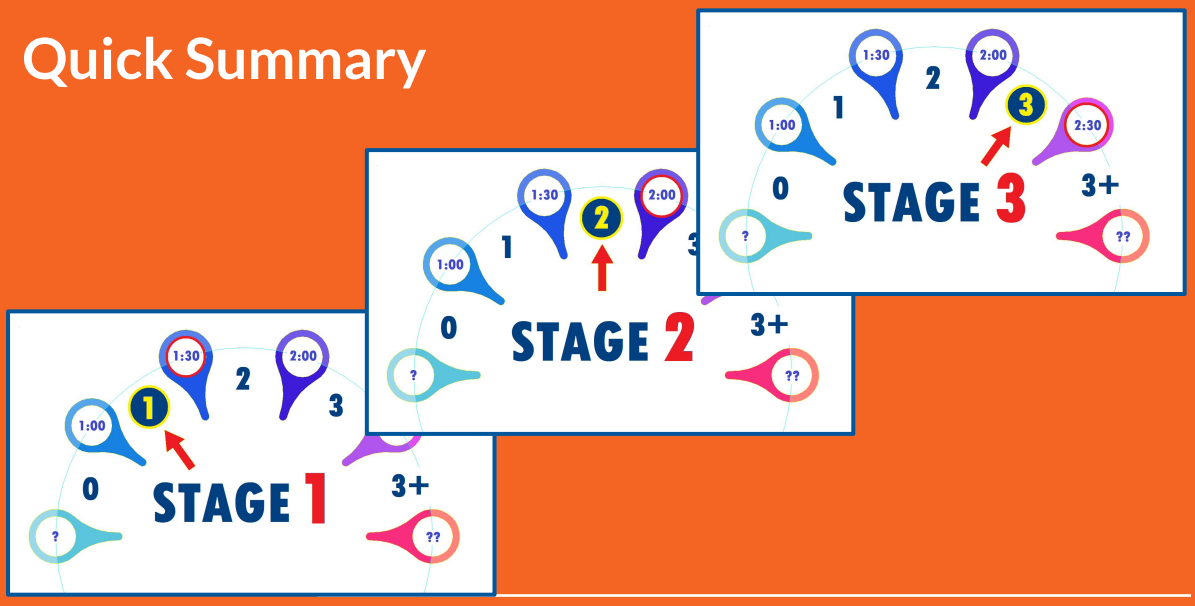
2025 Rough Estimate



Stage 3's milestone is around 2:30. Experiment with some crucial design variables, such as Pitch and rotor Diameter (i.e. P/D), number of blades, etc., to fine-tune and surpass the original design. Studying physics and general aerodynamics, e.g. propeller theory, thin airfoil polar diagrams, low Reynolds effect, etc., will help.

Iterate and Iterate more! If you come this far, you will place well at any competition.

Quick Summary



One quick summary here... Each stage on your helicopter journey has an unique set of problems. Most, if not all, building problems (e.g. loose covering, bad joints, misalignment, etc.) would make flying problems (e.g. dynamic balancing, rubber band stretching and matching, etc.) insignificant. I.e. if a helicopter was not built correctly, correcting flying problems may not yield any improvement... Furthermore, most flying problems would make design issues (e.g. not-so-perfect P/D, washout, etc.) less obvious. In other words, *unless you have **built** and **fly** your first helicopter **"perfectly"** to 2+min **consistently**, altering **design** variables like P/D, washout, even if the change is correct, the improvement might not show up.*

In short, if you started with a reasonably good kit (or a good design), focus on resolving building problems first, improving flying skills next, and then focus on improving design. *DO NOT, and no need to, jump stage*. (This is also a practice of “One (Set of) Things at A Time!” approach.)

Wait! I want more!

How do I build a helicopter from scratch that is better than any kits out there?!

Cannot push flight time

Wash-out or wash in?

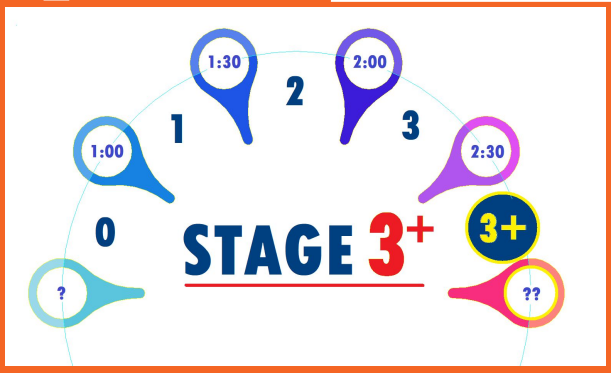
Ouch flight time?

Is helical pitch going to be 2.xx?!

How about camber? Is it important?

Set P/D >1.5? Or <1.0?

Now, you have worked hard and iterated through all three stages several times. You have achieved a lot. You are sure to place well in SO competition. BUT, you want more…



Design Your Own Helicopter!

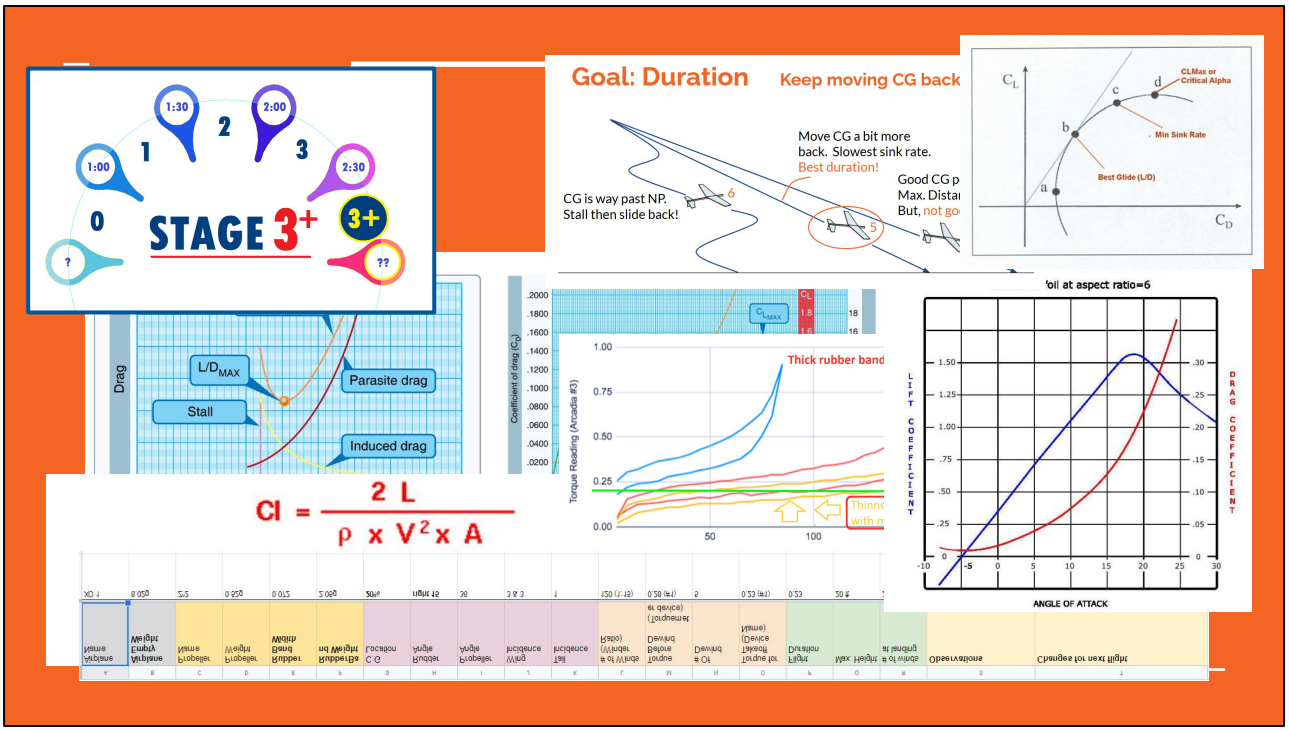
STAGE 3: Go Above and Beyond!

Iterate & Iterate More:

Best Design, Best Flying, Best Everything! Best Yourself!

You want to build a helicopter that is better than all kit helicopters! You want to **be proud of yourself!**

Design your own helicopter!



There are many resources on the Internet. Do your research, or ask around, to learn better airfoil, better blade shape, better pitch angle distribution, better P/D, better rubber band, better lubricant, better stretching, **better everything!**

Iterate and optimize them all!

Study more aerodynamics. Research, Rebuild, Re-design, and Fly even more! Do it with a systematic approach. Don't be afraid of failures. Don't always follow conventional wisdom. Question everything. Be adventurous. **Design your own**, or, try out something completely **new** and **unorthodox! You will be surprised!**

Good Luck!

Life is either a daring adventure, or nothing. -Helen Keller

Good Luck!

-AeroMartin 12/23/2024

Life is either a daring adventure, or nothing. -Helen Keller

Embrace challenges and step outside of one's comfort zone. Just do it!

-AeroMartin 12/31/2024
3d Designs: https://www.thingiverse.com/aeromartin/designs
Viper25 Jig https://www.thingiverse.com/thing:6858735
YouTube Channel: https://www.youtube.com/@aeromartin1533
Helicopter RoadMap Short: https://youtube.com/shorts/RO4Efl9ntb0
Viper25 Helicopter Video: https://youtu.be/NiIQ-OcxPEA