The Electric Helicopter Beginner's Guide v17

Toshiyasu Morita

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Preface

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The latest version of the EHBG is available from ehbg.rchomepage.com.

Many thanks to all the people on the Ezone forums and the Ikarus BBS who have posted many helpful messages - many of these tips were taken from these excellent discussion forums!

This was originally a "Heli FAQ" suggested by Fred Bronk, but it grew into much more than a FAQ - so now it's called the Electric Helicopter Beginner's Guide.

This guide assumes some prior R/C experience, such as R/C planes or cars. Therefore, it doesn't explain terms such as "servo" or the correct orientation for servo plugs, etc. If you need these questions answered, I recommend asking in the "Beginner Training Area" on RC Groups .

Be sure to check Chapter 31, *Glossary* if you encounter terms which you don't know, such as swashplate, collective pitch, etc.

Note

Use this information at your own risk! I make no guarantees as to the validity of any of this information! If in doubt, double-check!

Chapter 1. Things You Should Know

1.1. Helicopters require a *SIGNIFICANT TIME COMMITMENT*

R/C helicopters are not dynamically stable, and they require constant stick input. It's very similar to balancing a marble on a sheet of glass by radio control. In addition to this, the glass can be rotated which then rotates all the directions.

Therefore, it takes a lot of time to develop a good sense of balance and orientation. You will learn much faster if you can dedicate at least a half-hour a day to practicing on a flight simulator.

In addition, helicopters require significant amounts of time to build and isolate/fix various problems like vibration, tail wag, and other problems that will develop.

If you like building and tinkering with things for hours, and enjoy the challenge and satisfaction of learning difficult skills, then this is a great hobby for you.

If you don't like building and tinkering with things for hours and are easily frustrated by learning difficult skills, then you may want to consider another hobby.

1.2. Repairs are expensive

Helicopters crash, and they are somewhat expensive to fix

Some helicopters are more durable than others, and some are much cheaper to fix - these are good trainers. But, you cannot expect to learn to fly without spending some money for repairs. Be sure to allocate some money for repairs.

1.3. Hovering is difficult to learn

Eventually, something will "click" inside your head, and you will "get it". For some people, this occurs all of a sudden and everything makes sense. For other people it seems to be a more gradual process.

Basically, helicopters suck horribly. Then you get your first hover, and it's an incredible head-rush, and you're psyched for a whole week, and you're hooked. :)

1.4. Airplane experience may not help

Many people find that R/C airplane experience does not necessarily help when learning to fly R/C helicopters.

In particular, the normal airplane instinct to throttle down and pull back elevator when losing orientation will result in a crash when applied to a helicopter.

Also, airplanes do not need much rudder when turning, which is very different from a helicopter. A helicopter requires much more tail management than an airplane.

Chapter 2. Types of R/C Helicopters

There are four basic types of R/C helicopters:

1. Single rotor helicopters with fewer than four channels
2. Coaxial helicopters with two to four channels
3. Multirotor helicopters with four channels
4. Single rotor helicopters with four or more channels

2.1. Single rotor helicopters with fewer than four channels

This category includes helicopters such as the Nikko Skywatcher.

You cannot learn to hover properly on this type of helicopter, because it lacks the fore/aft cyclic control. Also, the forward flight skills you learn on this helicopter will not transfer over to other types of helicopters because you will not learn proper tail control.

2.2. Coaxial helicopters with two to four channels

This category includes such helicopters as the Hirobo XRB, the E-flight Blade CX, the Bladerunner II and the GPL Wild Wheels.

This type of helicopter has electronic stabilization circuitry, so you will not develop proper hovering skills. They also do not perform banked turns, so you will not develop forward flight turning skills. You can develop orientation skill with this type of helicopter, though.

2.3. Multirotor helicopters with four channels

This category includes helicopters such as the X-UFO and Draganflyer.

This type of helicopter is inherently stable, so you will not develop proper hovering skills. They also do not perform banked turns, so you will not develop forward flight turning skills. You can develop orientation skill with this type of helicopter, though.

2.4. Four to six channel single rotor

This type of helicopter has all of the basic controls, so you can learn hovering, orientation, and forward flight skills.

The information in the EHBG is mainly relevant to this category of R/C helicopters.

2.5. Summary of skills

Different types of R/C helicopters wil allow you to learn different skills.

Table 2.1. Helicopter types

	Visual orient-ation	Hovering skills	Forward flight skills
Single rotor with <4 channels	no	no	no
Coaxial with 2-4 channels	yes	no	no
Multirotor with 4 channels	yes	no	no
Single rotor with >4 channels	yes	yes	yes

Chapter 3. First Helicopter Selection Guide

3.1. Things to consider when selecting your first helicopter

- Durability
- Price of replacement parts
- Availability of replacement parts
- Size

The reason for this is: when you are learning to hover, you will crash. This is a given. Everyone crashes. When you crash, you do not want to spend a fortune repairing the helicopter, because everyone has limited funds. When you crash, you do not want to wait forever for replacement parts, because every day you spend waiting for a part is a day you are not flying the helicopter, and learning something.

Size is very important, because larger helis are more stable and easier to hover. They have more inertia, so they move slower and they give more warning of their intent. Micro helis are more difficult to hover because they are very skittish and wander off in a new direction with very little warning of their intent. Larger helis are not any easier to fly, though.

If you live in an area like Seattle where it rains almost continuously for nine months of each year, I would recommend a fixed-pitch Piccolo. Otherwise the Lite Machines Corona is the best electric trainer available today. The Corona is very stable and acts like a much larger helicopter, so it is nearly ideal for learning hovering.

To make a plane analogy, the Corona is basically the Slow Stick of R/C helicopters. It has a simple fixed-pitch rotor design which is very durable, and usually receives very little damage (if any) in most beginner crashes.

You may be tempted to buy an aerobatic 3D helicopter for your first helicopter. This is a bad idea, because aerobatic helicopters are usually much less stable. They are usually designed with a high center of gravity and very sensitive controls so they can roll and flip faster for aerobatic moves.

Think of this plane analogy: if your were an R/C airplane beginner, should you buy a hotliner for your first plane?

Be sure to purchase your helicopter from a shop that carries a full line of replacement parts and can ship replacement parts quickly. When you are learning to hover it's virtually guaranteed that you will crash a few times, and when you do you will want replacement parts ASAP. Any R/C helicopter for which you cannot buy replacement parts is not properly repairable, and is basically a paperweight.

Also, lithium-polymer batteries are fragile and easily damaged in helicopter crashes. For this reason, we do not recommend using lipo batteries on your first helicopter. Some helicopter are not flyable using NiCad and NiMH batteries, and require lipo batteries, and therefore these helicopters are not recommended for beginners.

Also, *GET A SIMULATOR*. Even a free simulator such as FMS will save you at least 100 dollars or so in replacement parts when learning hovering.

The Walkera helicopters are not recommended for beginner helicopters because the electronics are of very poor quality. Various problems which have been reported include:

- Transmitters and receivers have very short range and/or interference problems
- Servos jitter and/or have centering problems

These problems will make learning hovering much more difficult.

3.1.1. Recommended first heli choices

- Corona (very durable, easier to hover, inexpensive)
- Logo 10 (durable, easier to hover, expensive)
- ECO Piccolo / Piccolo Fun (very durable, hard to hover, inexpensive)
- Century Hummingbird, GWS Dragonfly, Skylark and exact clones (durable, hard to hover, inexpensive)
- Voyager E (durable, easier to hover, expensive)
- Hirobo XRB SR (durable, simple to hover, expensive, limited)

3.1.2. Recommended second heli choices

These are not recommended for your first helicopter, but would be good for your second helicopter.

- Hornet FP/CP (fragile)
- ECO Lite/8/16 (somewhat fragile)
- Logo 16/20 (expensive)
- Joker / Joker CX (expensive)
- Century Hummingbird Elite FP/CP (high headspeed)
- Century Hummingbird v3 (fragile)

3.2. Clones

Some of the helicopters today are either nearly exact copies of other helicopters, or have nearly exact copies of some major pieces.

Table 3.1. Helicopter size summary sorted by AUW

Original	Clone
Feda Dragonfly/GWS Dragonfly/Century Hummingbird V1/V2	Smartech Skylark, Smartech Aerohawk, Evoflight Sabre, Esky Honey Bee Mark 2, Venom Night Ranger II, Walkera Dragonfly #4
Hornet II	Eflight Blade CP (cloned head), E-sky Honey Bee CP (cloned head), E-sky Honey Bee King (cloned head), Venom

Original	Clone
	Night Ranger 3D (cloned head), Walkera Dragonfly 22D and 22E
Zoom 400/Zap 400/Shogun v1	Revo CP, Walkera Dragonfly 35
Zoom 400/Zap 400/Shogun v2	Walkera Dragonfly 36
T-rex 450XL	Walkera Dragonfly 39
Quick Japan EP8	Quick Worldwide Little Quickie 8
Quick Japan 16	Quick Worldwide Sweet 16

Many of the Chinese clones are attractive to beginners due to their low cost, however, they often have many problems. The problems most often seen in Chinese clones are:

3.2.1. Design problems

Some Chinese clones are direct or nearly-direct clones of other helicopters, but with a few changes (probably to avoid patent issues).

Sometimes these small changes cause serious problems, such as the Eflight Blade CP/Esky Honey Bee CP problems with abrupt bouncing problems in flight. Search the RCgroups Micro Helis forum for "sticky collective" or "yoyo" for more information.

3.2.2. Cheap plastic used for critical parts

The Chinese clones typically use cheap plastic for the main rotor hub, main blade grips, frames and other critical parts. The better helicopters use glass-reinforced plastic (GRP) for these parts which minimizes crash damage.

3.2.3. Low quality electronics

Many of the Chinese clones have problems with:

3.2.3.1. Transmitters and receivers

Transmitters and receivers which have limited range and/or severe interference problems (Walkera helicopters)

- www.rcgroups.com/forums/showthread.php?t=421883
- www.rcgroups.com/forums/showthread.php?t=389062
- www.rcgroups.com/forums/showthread.php?t=371046
- www.rcgroups.com/forums/showthread.php?t=359992
- www.rcgroups.com/forums/showthread.php?t=359402

3.2.3.2. Servos

Servos which jitter or have poor centering, or fail after the first few flights (Walkera helicopters)

- www.rcgroups.com/forums/showthread.php?t=437059
- www.rcgroups.com/forums/showthread.php?t=421680

- www.rcgroups.com/forums/showthread.php?t=412295
- www.rcgroups.com/forums/showthread.php?t=384344
- www.rcgroups.com/forums/showthread.php?t=381433
- www.rcgroups.com/forums/showthread.php?t=393943

3.2.3.3. Low quality transmitter joysticks

The potentiometers in many low quality transmitters are not accurate and will cause the heli to jump around.

- www.rcgroups.com/forums/showthread.php?t=459902

3.2.4. Nonstandard electronics

The Walkera transmitters and receivers are not compatible with standard negative and positive shift equipment from other manufacturer such as JR, Futaba, Hitec, Airtronics, etc.

3.2.5. Sloppy tolerances on molded and/or CNC milled parts

People have complained about Quick Heli kits (not to be confused with Quick Japan or Quick UK) having manufacturing problems.

- www.runryder.com/helicopter/t194374p1
- www.runryder.com/helicopter/t154779p1
- www.runryder.com/helicopter/t195107p1

Also seen on Walkera helicopters:

- www.rcgroups.com/forums/showthread.php?t=401657

3.3. Classification of helis used in this guide

- *Living room flyer:* These helis are flyable in small indoor areas and also outdoors when completely calm. They are typically fixed pitch helis using wide blades which are efficient at low headspeeds, and weigh up to about 350 grams.
- *Gym flyer:* These helis are flyable in larger indoor areas, and also outdoors when relatively calm. They are typically collective pitch helis up to about 600 grams.
- *Backyard flyer:* These helis reqire a small outdoor field and are flyable in mild winds up to about 8 km/h (5 mph). Not flyable indoors!
- *Large field flyer:* These helis require a larger outdoor field and are flyable in winds up to about 16 km/h (10 mph. Not flyable indoors!

3.4. Overview of selected machines

3.4.1. Lite Machines Corona

- A very good trainer
- Moderately inexpensive (retail about $180-$199)
- Very durable
- Manufacturer is in the US. Parts availability is very good.
- 1250-1500 grams AUW, 610mm rotor diameter, 6-8 cells
- large, moderate headspeed, easy to learn hovering - not indoors in small venues (gym ok)
- Backyard flyer, maybe in gyms

3.4.2. Ikarus Fixed Pitch Piccolos (Fun or ECO)

- Trainer, but harder to learn (probably 50% harder than Corona)
- Inexpensive (Fun retail ~$90, ECO retail ~$140)
- Fairly durable but landing gear is flimsy; requires reinforcement for beginners.
- Manufacturer in Germany. Parts availability is good.
- 280 grams AUW, 500mm main rotor diameter, 6-8 cells
- Small, low headspeed, hard to learn hovering, but can be flown indoors
- Living room/Gym flyer

The main differences between an ECO Piccolo and a Fun Piccolo are:

- The ECO Piccolo includes six ball bearings for the rotor head, the main shaft, and the tail shaft. The Fun Piccolo includes bushings instead.
- The ECO Piccolo has CF main and tail rotor shafts. The Fun Piccolo has steel main and tail rotor shafts. The steel shafts run smoother than the CF shafts but they are somewhat heavier.
- The ECO Piccolo includes tail motor connectors. The Fun Piccolo includes with no tail motor connectors, and the tail motor wires must be soldered directly to the Piccoboard or the ESC wires.
- The ECO Piccolo has a very lightweight tail boom. The Fun Piccolo has a slightly heavier tail boom

3.4.3. Ikarus Collective Pitch Piccolos (CP upgrade/Pro)

- Medium to advanced flyers
- Inexpensive (CP upgrade ~$99, Pro retail ~$199)
- Fairly durable except for balsa main rotor blades (68213) pitch arm base(68211) and landing gear.

- Manufacturer in Germany. Parts availability is good.
- 330 grams AUW,540mm rotor diameter, 8-9 AAA cells
- Small, high headspeed. hard to learn hovering
- Gym flyer

3.4.4. Ikarus ECO Lite

- Only for experienced pilots - only does forward flight
- Inexpensive (retail about $140)
- Somewhat fragile, same weakness as ECO 8.
- Manufacturer in Germany. Parts availability spotty,
- 1150 grams AUW, 760mm rotor diameter, 6-8 SubC cells
- Doesn't hover. Forward flight only.
- Backyard flyer.

3.4.5. Ikarus ECO 8

- Duration flying/slope soaring/moderate aerobatics capable
- Moderately inexpensive (retail about $180)
- Somewhat fragile - stock (non-hardened) main rotor shaft, feathering shaft and tail rotor shafts bend easily, frame and landing gear not very strong
- Manufacturer in Germany. Parts availability spotty, up to 4 weeks wait time for some parts.
- 1300-1500 grams AUW, 1060mm rotor diameter, 6-12 SubC cells
- Large, high headspeed, easy to learn hovering
- Backyard flyer

3.4.6. Ikarus ECO 16

- Moderate to serious aerobatics capable
- Moderately inexpensive(retail about $250)
- Somewhat fragile- a little more than ECO 8 because using the same parts for heavier helicopter
- Manufacturer in Germany. Parts availability spotty, up to 4 weeks wait time for some parts.
- 2000 grams AUW, 1200mm rotor diameter, 12-20 SubC cells
- Large,high headspeed, easy to learn hovering
- Large field flyer

3.4.7. Ikarus Viper 70/MS Composit Stinger 3

- Moderate to serious aerobatics capable
- Moderately inexpensive (retail ahout $250)
- About average durability
- Manufacturer in Germany
- 700-900 grams AUW, 750mm rotor diameter, 3-5s lipo
- Small, high headspeed, difficult to learn hovering
- Backyard flyer

3.4.8. Ikarus Viper 90/MS Composit Stinger 6

- Moderate to serious aerobatics capable
- Moderate (retail ahout $300)
- About average durability
- Manufacturer in Germany
- 1000-1200 grams AUW, 900mm rotor diameter, 3-5s lipo
- Medium, high headspeed, hard to learn hovering
- Backyard flyer

3.4.9. Feda Skylark/Century Hummingbird/GWS Dragonfly

- Trainer, but harder to learn (probably 50% harder than Corona)
- Inexpensive - $80 for bare heli kit
- Fairly durable, but rotor blades are stiffer? than Piccolo and are more easily destroyed.
- Manufacturer in Taiwan?. Parts availability is good.
- 280 grams AUW, 8 AAA cells
- Small, low headspeed, hard to learn hovering, but can be flown indoors
- Living room, Gym flyer

3.4.10. JR Voyager E

- Trainer/light aerobatics capable
- Expensive (retail about $400 incl. motor, cannot buy without motor)
- About average durability
- Manufacturer in Japan. Parts availability very good.

- 1500 grams AUW, 965mm rotor diameter, 7 SubC cells
- Large, high headspeed, easy to learn hovering
- Backyard flyer

3.4.11. Kyosho Concept EP - discontinued?

- Trainer/light aerobatics
- Expensive (retail about $380 incl motor, cannot buy without motor)
- About average durability
- Manufacturer in Japan. Parts availability ?
- 1500 grams AUW , 912mm rotor diameter, 7 SubC cells
- Large, high headspeed. Has weak power due to high disc loading. Flapping head version is very prone to boom strikes.
- Backyard flyer

3.4.12. Mikado Logo 10

- Trainer/moderate aerobatics capable
- Expensive (retail about $340)
- About average durability
- Manufacturer in Germany. Parts availability okay.
- ~2500 grams AUW, 1150mm rotor diameter, 10-14 SubC cells
- Large, high headspeed, easy to learn hovering. Outdoors only
- Large field flyer

3.4.13. Mikado Logo 20

- Serious aerobatics capable
- Expensive (retail about $470)
- About average durability
- Manufacturer in Germany. Parts availability okay.
- >3000 grams AUW, 1340mm rotor diameter, 20-24 SubC cells
- Large, high headspeed, easy to learn hovering. Outdoors only
- Large field flyer

3.4.14. MS Composit Hornet FP

- Moderate aerobatics capable
- Inexpensive (retail about $150)
- Fragile
- Manufacturer in Czech Republic. Parts availability okay.
- 280 grams AUW, 490mm rotor diameter, AAA 7-8 cells
- Small, low headspeed, hard to learn hovering,- but can be flown indoors
- Gym flyer

3.4.15. MS Composit Hornet CP

- Moderate to serious aerobatics capable
- Inexpensive (retail about $200)
- Fairly
- Manufacturer in Germany. Parts availability okay.
- 280 grams AUW, 490mm rotor diameter, 7-8 AAA cells
- Small, high headspeed, hard to learn hovering,- but can be flown indoors
- Gym flyer

3.4.16. MS Composit Hornet II

- Moderate to serious aerobatics capable
- Inexpensive (retail about $250)
- Fragile, but more durable than Hornet FP/CP
- Manufacturer in Germany. Parts availability okay.
- 330 grams AUW, 560mm rotor diameter, 7-8 AAA cells
- Small, high headspeed, hard to learn hovering,- but can be flown indoors
- Gym flyer

3.4.17. Maxir SE

- Moderate to serious aerobatics capable
- Inexpensive (retail about $240)
- About average durability
- Manufacturer in Czech Republic. Not many dealers.
- 350-420 grams AUW, 620mm rotor diameter, 3S LiPo
- Small, high headspeed, hard to learn hovering

- Gym flyer

3.4.18. Robbe Spirit L-8/Eolo R22

- Moderate aerobatics capable
- Expensive (retail about $300)
- About average durability
- Manufacturer in Germany?, parts availability okay
- 1280g AUW, 810mm rotor diameter, 8 SubC cells
- Large, high headspeed, easy to learn hovering, outdoors only
- Backyard flyer

3.4.19. Quick Quick EP 10

- Moderate aerobatics capable
- Inexpensive (retail about $250)
- About average durability
- Manufacturer in USA. Parts availability good?
- ??? grams AUW, 880-950mm rotor diameter, 10-14 SubC cells
- Large, high headspeed, easy to learn hovering, outdoors only
- Backyard flyer

3.4.20. Quick Quick EP 16

- Moderate to advanced aerobatics capable
- Expensive (retail about $400)
- About average durability.
- Manufacturer in USA. Parts availability good?.
- ??? grams AUW, 1060-1080mm rotor diameter, 16-24 SubC cells
- Large, high headspeed, easy to learn hovering, outdoors only.
- Backyard flyer

3.4.21. Zoom 400/Shogun 400/Zap 400

- Moderate to advanced aerobatics capable
- Inexpensive (retail about $200)

- About average durability.
- Manufacturer in Taiwan. Parts availability good.
- 500 grams AUW, 635mm rotor diameter, 3s1p lipos
- Small, high headspeed, moderate to learn hovering
- Gym flyer, Backyard flyer

3.4.22. Align T-Rex 450X

- Moderate to advanced aerobatics capable
- Inexpensive (retail about $160)
- About average durability.
- Manufacturer in Taiwan. Parts availability good.
- 650 grams AUW, 640mm rotor diameter, 3s1p lipos
- Small , high headspeed, moderate to learn hovering
- Gym flyer, Backyard flyer

3.4.23. Align T-Rex 450XL HDE/CDE

(Note: HDE version is mechanical mixing; CDE is eCCPM)

- Moderate to advanced aerobatics capable
- Inexpensive (retail about $200)
- About average durability, low priced replacement parts
- Manufacturer in Taiwan. Parts availability good
- 620-670 grams AUW, 640mm rotor diameter, 3s1p lipos
- Small , high headspeed, moderate to learn hovering
- Gym flyer, Backyard flyer

3.4.24. ARK X-400

- Moderate to advanced aerobatics capable
- Inexpensive (retail about $200)
- About average durability.
- Manufacturer in ?. Parts availability fair
- 580-620 grams AUW, 588mm rotor diameter, 3s1p lipos
- Small , high headspeed, moderate to learn hovering

- Gym flyer, Backyard flyer

3.4.25. Hirobo XRB SR (Sky Robo)

- A good trainer for beginners learning to hover
- Expensive (~$300)
- Fairly durable except for foam rotor blades. (Parts 0301001 and 0301002)
- Manufacturer in Japan. Parts availability is good.
- 195 grams AUW,350 mm rotor diameter, 2s LiPo cells
- Small, low headspeed. Perfect to learn hovering orientations. Not suitable to learn FFF.
- Living room flyer

3.5. Summary of helicopter sizes

This table summarizes the main size parameters of the helicopters in the preceeding section. AUW (All up weight) is in grams, Rotor Diameter is in mm and the Cell count indicates the "standard" configuration assumed by the manufacturer. Many people are using LiPo packs instead of the original NiCd or NiMh packs, but for the purposes of this table, the original recommendation has been retained.

Table 3.2. Helicopter size summary sorted by AUW

Name	AUW	Rotor Dia.	Cells
Hirobo XRB SR (Sky Robo)	195	350	2S Lipo
Ikarus Piccolo FP (Fun)	280	500	6-8 AAA
Century Hummingbird FP	280	508	7-8 SubC
MS Composit Hornet FP	280	490	7-8 AAA
MS Composit Hornet CP	280	490	7-8 AAA
MS Composit Hornet II	330	560	7-8 AAA
Ikarus Piccolo CP	330	540	8-9 AAA
Maxir SE	350-420	620	3S LiPo
Zoom 400/Shogun 400/Zap 400	500	635	3S Lipo
ARK X-400	580	588	3S Lipo
Align T-Rex 450X	650	640	3S Lipo
Align T-Rex 450XL HDE/CDE	620-670	640	3S Lipo
Ikarus Viper 70/MS Composit Stinger 3	~900	750	3S1P lipo
Ikarus Viper 90/MS Composit Stinger 6	~1000	900	3S2P lipo
Ikarus Eco Lite	1150	760	6-8 AAA
Robbe Eolo R22	1280	810	8 SubC
LiteMachines Corona	1250-1500	610	6-8 SubC
Ikarus Eco 8	1300-1500	1060	6-12 SubC

Name	AUW	Rotor Dia.	Cells
JR Voyager E	1500	965	7 SubC
Ikarus Eco 16	2000	1200	12-20 SubC
Century Swift	~2400	1160?	6S lipo
Mikado Logo 10	2500	1150	10-14 SubC
Mikado Logo 14	2700	1300	14-16cells/5-6S4P lipo
Mikado Logo 16	2700	1250	16-20cells/6S4P lipo
Mikado Logo 20	3000+	1340	20-24 SubC
Mikado Logo 24 Bionic	3800	1370-1500	24-28 cells/ 8S4P lipo
Quick Japan EP 10	???	880-950	10-14 SubC
Quick Japan EP 16	???	1060-1080	16-24 SubC

Chapter 4. Recommended Configurations

These are configurations for beginners, and therefore we tend to recommend inexpensive and mild setups rather than excessively "hot" 3-D setups.

Warning

Do not run R/C car-type "Speed 540" brushed motors (Atomic Force, Fusion 7, etc) on more than 8 cells. Most R/C car motors are not designed for more than 8 cells, and running them with more cells will kill the motor after only a few flights.

4.1. Beginner configurations

4.1.1. Corona - brushed configuration

- Kyosho Atomic Force brushed motor w/stock pinion
- Castle Creations Pegasus 35H or 35P main ESC (older Pegasus 35 has too high LVC)
- 2 Hitec HS-85MGs for cyclic
- 1 Hitec HS-81 for tail
- Futaba GY240 HH gyro
- 4 channel receiver
- 7 or 8 cell CP2400 or RC2400 battery pack

4.1.2. Corona - brushless configuration

- Mega Motors 16/15/3 brushless motor w/stock pinion
- Castle Creations Phoenix 45 main ESC
- 2 Hitec HS-85MGs for cyclic
- 1 Hitec HS-81 for tail
- Futaba GY240 HH gyro
- 4 channel receiver
- 7 or 8 cell CP2400 or RC2400 battery pack

4.1.3. FP Piccolo - brushed + Piccoboard

- Stock Speed 295/310 motor
- Piccoboard or Piccoboard Plus
- 2 HS-55s for cyclic
- GWS or Berg 4-channel receiver

- 7 cell NiCad or 8 cell NiMH battery pack

4.1.4. FP Piccolo - brushed - separates

- Stock Speed 295/310 motor
- 1 Castle Creations Pixie-7P main ESC
- High frequency tail ESC
- 2 HS-55s for cyclic
- Futaba GY240 or CSM LW200 HH gyro
- GWS or Berg 4-channel receiver
- 7 cell NiCad or 8 cell NiMH battery pack

4.1.5. FP Piccolo - brushless - separates

- Hacker B20-36S brushless motor w/8 tooth pinion
- Castle Creations Phoenix 10 main ESC
- High frequency tail ESC
- 2 HS-55s for cyclic
- Futaba GY240 or CSM LW200 HH gyro
- GWS or Berg 4-channel receiver
- 7 cell NiCad or 8 cell NiMH battery pack

4.1.6. GWS Dragonfly - brushed - separates

- Stock motor
- GWS ICS-100E main motor ESC
- High frequency tail ESC
- 2 HS-55s for cyclic
- Futaba GY240 HH gyro
- GWS 4-channel receiver
- 8 cell NiMH battery pack

4.2. Intermediate configurations

4.2.1. CP Piccolo or Pro - brushless - separates

- Hacker B20-31S brushless motor w/8 tooth pinion (for power) or

- Hacker B20-36S brushless motor w/10 tooth pinion (for duration)
- Castle Creations Phoenix 10 main ESC
- Pixie-7P or ICS-50E tail ESC
- 2 HS-50s (or HS-55s) for cyclic
- Futaba GY401 or CSM LW200 HH gyro
- GWS 6-channel receiver
- 8 cell NiCad or NiMH battery pack

4.2.2. T-Rex 450XL

- Mega Motors ACn 16/15/3 w/13 tooth pinion
- Castle Creations Phoenix 35 main ESC
- 3 HS-56s or HS-65s for cyclic
- 1 Futaba HS9650 for tail
- Futaba GY-240 or GY-401 gyro
- Hitec Electron 6 receiver
- 3S1P 2100 maH battery pack

4.2.3. Zoom 400

- Hacker B20-18L with 8T pinion
- Castle Creations Phoenix 35 main ESC
- 3 HS-55s or HS-56s for cyclic
- 1 HS-55 for tail
- Futaba GY-240 or GY-401 gyro
- Hitec Electron 6 receiver
- 3S1P 1320 maH battery pack

4.2.4. Logo 10 - brushless

- Kontronik FUN 600-18 w/15 tooth pinion
- Schulze Future 18.46K + UBEC or SBEC
- 3 JR DS3421 or DS368 or DS3728 for cyclic
- HS-5245MG for tail
- Futaba GY240 or GY401 HH gyro
- 6 channel receiver

- 12 cell NiCad battery pack

4.2.5. ECO 8 - brushed

- Kyosho Magnetic Mayhem Reverse brushed motor
- Castle Creations Pegasus 35
- 3 HS-85MGs for cyclic
- HS-81 for tail
- Futaba GY240 or GY401 HH gyro
- 6 channel receiver
- 8 cell NiCad battery pack (The MMR can run with 10 cells also)

4.2.6. ECO 8 - brushless

- Hacker B50-18S or Mega Motor 22/20/3H motor
- Schulze Future 12.46e (8 cells)
- Schulze Future 18.46K + UBEC or SBEC (10 cells)
- 3 HS-85MGs for cyclic
- HS-81 for tail
- Futaba GY240 or GY401 HH gyro
- 6 channel receiver
- 10 cell NiCad battery pack (will fly on 8 cells brushless, but much better with 10 cells)

Chapter 5. Brushless Motor Upgrade Paths

You may want to choose a brushless motor which is usable in both your first fixed pitch helicopter and your second collective pitch helicopter. This is a little tricky but definitely possible if you plan wisely.

In the following section, 10-12T means 10 tooth to 12 tooth pinion. The lower tooth pinions are for duration, and the higher ones are for power.

5.1. Corona upgrade paths

There are three possible upgrade paths from the Corona: the ECO 8, the Eolo, and the Voyager E. All of these helicopters can use 3.17mm shaft motors in approximately the same Kv range as the Corona.

5.1.1. Corona motors usable in an ECO 8

This requires choosing a 3.17mm shaft motor with a Kv of about 2400-2600. This results in a mild motor for the Corona, which becomes a power motor when moved to the ECO 8 on 10 cells. If you desire to use a Corona motor which will become a duration ECO 8 motor, then you will need a motor with a lower Kv (about 2200-2400) and use a larger tooth pinion on the Corona.

A motor with 3000 Kv is usable on an ECO 8 with 8 cells, but not really recommended for 10 cells.

5.1.1.1. Hacker C40-10L, Kv = 3000 rpm/V (powerful, but runs hot)

- Corona: 11-12T/8 cells
- ECO 8 : 10T/8 cells

5.1.1.2. Hacker C40-12L, Kv = 2500 rpm/V (powerful, but runs hot)

- Corona: 12-13T/8 cells
- ECO 8 : 12-14T/8 cells, 10-12T/10 cells)

5.1.1.3. Mega Motor 16/25/3, Kv = 1700 rpm/V (mild)

- Corona: 18T/8 cells
- ECO 8: 17T/8 cells, 14T/10 cells

5.1.1.4. Mega Motor 22/20/3HTDS, Kv = 1850 rpm/V (powerful)

- Corona: 15T/8 cells
- ECO 8 : 13-15T/10 cells

5.1.2. Corona motors usable in a Eolo

This requires choosing a 3.17mm shaft motor with a Kv of about 3300. This results in a power motor for both the Corona and the Eolo. The Mega 16/15/3 is fairly mild for both Corona and the Eolo.

5.1.2.1. Mega 16/15/3, Kv = 3000 rpm/V

- Corona: 10T
- Eolo : ?

5.1.2.2. Hacker C40-12S, Kv = 3500 rpm/V

- Corona: 10T
- Eolo : stock pinion

5.1.2.3. Hacker C40-9L, Kv = 3333 rpm/V

- Corona: 10T
- Eolo : stock pinion

The Hacker C40-12S is a little small for the Eolo and is probably not suitable for the Eolo in warmer weather.

5.1.3. Corona motor usable in a Voyager E

This requires choosing a 3.17mm shaft motor with a Kv of about 3700. This results in a power motor for both the Corona and the Voyager. You must be careful to limit the throttle on the Corona because the maximum headspeed of 2000 will be exceeded if the throttle is not limited.

5.1.3.1. Hacker C40-8L, Kv = 3750

- Corona : 10T
- Voyager: stock pinion

5.2. Piccolo upgrade paths

The FP Piccolo requires a motor with a Kv of about 2500. There are two upgrade paths available: the Piccolo CP kit or the Piccolo Pro, which both require a motor with a Kv of about 3000.

The B20-31S and B20-18L have a Kv that's a little too high for an FP Piccolo so the flight time will be short, but they will be powerful later in a CP Piccolo.

Table 5.1. Piccolo Upgrade Motors

Motor	Kv	FP Pinion	CP Pinion
B20-36S	2500	8T	10T
B20-31S	3000	8T	10T
B20-18L	3000	8T	8T

Chapter 6. Helicopter Parts Selection

6.1. Control system

6.1.1. Receiver

If you are using a gyro without remote sensitivity (like the GY240) on a fixed pitch heli, then you only need a four channel receiver (channels 1-4).

If you are using a gyro with remote sensitivity (like the GY401) on a fixed pitch heli, then you need a receiver which can receive channels 1-5.

If you are using a gyro without remote sensitivity (like the GY240) on a collective pitch heli, then you need a receiver which can receive channels 1-4 and channel 6.

If you are using a gyro with remote sensitivity (like the GY401) on a collective pitch heli, then you need a receiver which can receive channels 1-6.

See Section 11.1, “Channel assignments” for individual channel assignments for Futaba/JR etc. transmitters.)

For a Piccolo you can use a Piccoboard instead. The Piccoboard is a tiny board with a yaw-rate gyro and two brushed ESCs, one for the main motor and one for the tail motor. The Piccoboard Plus is the same except it can be upgraded to heading hold with a heading hold module. I haven't tried this, but people have mentioned the GY240 works better than the HH module.

Single conversion receivers will work fine for indoor microhelis, but are not recommended for larger outdoor helis. The larger motors in larger helis will generate much more electrical interference which will overload a single conversion receiver and cause severe glitching. A large helicopter which is out of control is very dangerous! Therefore, use a good quality dual conversion or PCM receiver for larger helis.

There have been many reports of some Berg 4/5/6 channel receivers manufactured after November 2004 having serious range issues. If you purchase one of these, please be sure to throughly test it before flying it in a heli.

6.1.2. Antenna

For indoor micro helis on 72 Mhz, the Azarr M72-I works well. This is a 0.3 gram antenna which is designed for indoor use.

For outdoor helis, the Deans one-piece antenna works well. The two-piece is not recommended because the threaded coupler can vibrate loose and cause glitching during flight.

6.1.3. Gyros

See Chapter 31, *Glossary* for a definition of Yaw-Rate Gyro and Heading Hold Gyro .

See Section 30.1.7, “How gyros work” in Chapter 30, *Technical Appendix* for more information on gyros.

The first question people invariably ask is: "Can I fly a helicopter without a gyro?" The answer is basically no. The helicopter's tail would be too sensitive to random air currents. Before helicopter gyros were invented, the world endurance record for flying a model helicopter was 5.65 seconds by John Burkham in 1969 in the "Super Susie" model.

A heading hold gyro is highly recommended for beginners. There are four reasons for this:

- A heading hold gyro is much easier to configure than a yaw rate gyro. The yaw rate gyro requires the revo mix curve to be set up correctly before learning hovering, and this is tricky to set up for beginners.
- The heading hold gyro will "lock" the tail at one heading rather than just dampening random tail movement. This is very good because you only need to learn two joystick axes initally instead of three. This means you can learn the right joystick first, then learn the left joystick later(for mode 2) instead of trying to learn both joysticks simultaneously. This makes learning hovering much, much, easier.
- The revo mix (required for a yaw rate gyro) will not compensate for the battery voltage dropping as the battery discharges. So, near the end of a flight, you will need to hold some rudder to keep the heli from turning. This makes learning hovering more difficult.
- A yaw rate gyro will require the revo mix to be changed every time the weight or headspeed changes.
    - If you install a modification which changes the heli weight, you will need to readjust the revo mix.
    - If you change the pinion to a different tooth count, you will need to adjust the revo mix.
    - If you have battery packs which are different weights, you will need to adjust the revo mix between packs.

The differences between the GY240 and GY401 are:

- The GY401 has a DS mode switch to enable a high-speed (200 hz) update for digital servos. The GY240 does not have a DS mode switch, but will still work with digital servos using the normal update rate (50 hz).
- The GY401 has a limit adjustment so the tail servo travel can be electronically limited as well as mechanically limited. The GY240 does not have a limit adjustment so the tail servo travel can only be mechnically limited.
- The GY401 has a remote gain lead (which plugs into a receiver channel) so the gyro gain can be set from the transmitter. This lead MUST receive a valid transmitter signal and cannot be left unplugged. The GY240 has a gain adjustment on the gyro and does not support remote gain.
- The GY401 has a very fast pirouette rate. The GY240 has a very low pirouette rate.

Futaba GY240 gyro

The GY401 is a more advanced gyro with many adjustment options. It requires a dedicated channel for sensitivity adjustment so it requires a radio with at least five channels. Also, the sensitivity is a little tricky to set up properly.

I would recommend purchasing a GY401 unless you have a four-channel radio, in which case you can only use the GY240.The GY240 also works slightly better than the GY401 on micro helis with tail motors, such as the FP Piccolo and clone because the GY240 seems to handle slow tail response better than the GY401.

Most heading hold gyros (other than the Futaba GY series) seem to have drifting problems. This is caused by the gyro's expectation of the rudder "center stick" position being different from the transmitter's center stick position. This can be very frustrating because the one click of the subtrim can be the difference between the heli slowly turning left and the heli slowly turning right.

The Futaba GY series seems to calibrate the center stick position at power-up which eliminates the need to use rudder subtrim. Therefore I highly recommend the GY240 or GY401 for beginners.

The inexpensive Hobbico gyro is NOT recommended for beginners. It is a yaw rate gyro, which makes hovering difficult for beginners. Also, it is very fragile and there are many reports of it breaking on the first heli crash from only 1.5 feet of altitude.

The Piccoboard used on the Piccolo is a single board with the following items:

- Yaw rate gyro (expandable to heading hold on the Plus or Pro)
- Revo mixer
- Main motor ESC (brushed
- Tail motor ESC (brushed)
- BEC

The older versions of the Piccoboard had extremely fragile gyro sensors and are not recommended for beginners. Supposedly the recent ones are more durable. For more detailed information on the various versions of the Piccoboard, consult Paul Goelz's Piccolo site.

The newer Piccoboards can be upgraded to a Plus by installing a four pin header into the four holes on the PCB.

Piccoboard Plus

The difference between the Piccoboard/Piccoboard Plus and the Pro is the Pro can handle a larger main motor and the BEC capacity is doubled. My guess is the Piccoboard has about a ~7 amp ESC for the main motor, and the Piccoboard Plus has about a ~10 amp ESC for the main motor.

The Piccoboard is not necessary for the Piccolo, and can be replaced by either:

- A yaw rate gyro + two ESCs (w/BEC) (requires revo mixing on transmitter)
- A yaw rate gyro + one ESC (w/BEC) + one TREC ESC w/mixing option (no revo mix required on transmitter for this configuration)
- A heading hold gyro + two ESCs (w/BEC) + transmitter (no revo mix required on transmitter for this configuration)

TREC ESC by Dionysus Designs

The TREC ESC by Dionysus Designs is a special ESC with built-in mixing options. It is a tail motor ESC that can read the throttle signal and do its own revo mixing. It also has many other features such as a 17 point throttle curve, low voltage monitor, etc. and weighs only six grams.

If you use two separate ESCs with their own BECs, don't forget to disable one of the BECs on one of the ESCs otherwise they may "fight" each other and overheat causing a BEC failure. To check for this, power up both ESCs (without motors attached) and see if the BECs of the ESCs run hot.

The GWS PHA-01 mixer board is similar to the Piccoboard, except it is not upgradable to a heading hold gyro. It is not really recommended for microhelis because it is very prone to overheating and will shut down abruptly when it overheats. It will also not re-arm until it cools down which can take 10-15 minutes. If you must use one, be sure to mount it where it will get airflow (NOT inside the cabinet on the side of the heli).

The Century CN2000-4 gyro+mixer board is also similar to the Piccoboard and is also not upgradable to a heading hold gyro.

The Century CNE052 mixer board is similar to a Piccoboard without a gyro (i.e. mixer + dual ESC). You must use a separate gyro with this board.

All of these combo units (Piccoboards, PHA-01, CN2000-4, CNE052) are only usable on submicro and microhelis. They will not work on larger helis such as the Corona, ECO 8, Logo 10, etc.

6.1.4. FMA Copilot

Some people have used the FMA copilot on their Corona heli. This is a device which will "level" the helicopter for you if you release (center) the cyclic control. It will not work indoors because it needs to see the horizon to work properly. It does not replace a gyro, so you will still need a gyro.

The FMA copilot is nice, but really isn't really necessary unless you are having problems learning hovering. If you have a limited budget, then it is more important to buy a good heading hold gyro than the FMA copilot.

Also, you will likely outgrow the FMA copilot after a few months and remove it whereas you will not outgrow a good heading hold gyro. Therefore I recommend buying a good heading hold gyro first, and purchasing an FMA copilot later if you become frustrated with learning hovering.

6.1.5. Revo mixing

If a transmitter without revo mixing capability is used with a yaw rate gyro, then some sort of revo mixing capability is required on the heli. Some heli motor controllers such as the Piccoboard, TREC, and 3-in-1 boards include revo mixing capability.

Dionysus Designs also manufactures a separate revo mixing board which allows the use of both brushed and brushless main and tail motor ESCs.

6.2. Servos

6.2.1. Swashplate (cyclic) servos

Torque, speed, and precision should be considered for swashplate servos.

Note

All servos controlling the swashplate MUST be the same type. Do not mix servo types otherwise cyclic control will be erratic.

6.2.1.1. Corona/ECO 8/16 choices

The servo generally recommended for the Corona is the HS-85MG because these last longer then the HS-81MG when abused by beginners.

The ECO 8/16 require a servo no taller than 1.1 inches, so this limits servo choices considerably.

- JR 341 (0.22 secs/60 degrees, 32 oz-in)
- JR 351 (0.22 secs/60 degrees, 32 oz-in)
- HS-81 (0.11 secs/60 degrees, 36 oz-in)
- HS-85MG/BB+ (0.16 secs/60 degrees, 42 oz-in)
- GWS Micro 2BBMG (0.17 secs/60 degrees, 75 oz-in)
- Futaba S3102 (0.22 secs/60 degrees, 63 oz-in)
- Volz Micro-Maxx (0.16 secs/60 degrees, 55 oz-in)
- Volz Micro-Maxx XP (0.16 secs/60 degrees, 66 oz-in)
- JR DS368
- Multiplex Mini Polo Digi 4 (0.10 sec/60 degrees, 39 oz/in)

6.2.1.2. Logo 10 choices

The Logo 10 uses servos from 1.1 inches to 1.3 inches tall, so it can use all the servos used in the ECO 8/16 except the servos with less torque are not suitable. Probably 42 oz-in of torque is a reasonable minimum requirement for a Logo 10.

- HS-85MG/BB+ (0.16 secs/60 degrees, 42 oz-in)
- JR 341 (0.23 secs/60 degrees, 42 oz-in)
- JR DS368
- Multiplex Micro BB?

6.2.1.3. Summary

I've been told the Volz servos are too deep to fit into the Logo 10 frame, so they are supposedly not usable for the Logo 10.

For the Piccolos, the most popular choices seem to be the Hitec HS-50 and the HS-55.

If you use ANY digital servos, see the BEC section for more info.

The HS-81s and HS-85BBs can be upgraded HS-81MGs and HS-85MGs by replacing the plastic gears with the metal gears from the MG version, which are available at many places (Servocity, etc).

6.2.2. Tail (rudder) servo

The tail servo for a helicopter needs to be very fast to respond quickly to small random tail movements. The tail servo should have a specification of 0.12 sec / 60 degrees of travel or better.

For the Corona, Logo 10, and ECO 8/16, some usable tail servos are:

- Hitec HS-81
- JR DS368 (do not use in DS mode, will burn out)
- Volz Speed-Maxx XP (DS mode compat, will be released about Oct 2003)
- Multiplex Micro BB Speed (DS mode compat)
- Hitec HS-5245MG (DS mode compat)
- Hobby Electonics HDS-577 (DS mode compat)
- Multiplex Mini Polo digi 4 (DS mode compat)

The Multiplex Micro BB Speed is slightly larger than the HS-81/DS368 so some modification may be required to use it.

For the Logo 10 or larger, the Futaba S9253 is very popular used with the GY401, although the S9253 is rather heavy for the Logo 10.

Some servo mounts will allow you to use high-speed micro servos for the tail pitch servo, such as the Precision Model Products tail servo mount for the ECO 8/16.

For micro helis such as the Hornet, Shogun, and T-rex which use tail servos, some usable tail servos are:

- Hitec HS-55
- Hitec HS-56
- Hobby Electronics HDS-877 (DS mode compat)

The Hitec HS-50 is not recommended for a tail servo because it has excessive slop in the gears and may cause tail wag when used with a heading hold gyro.

The metal gear servos are not recommended for the tail because the metal gear servos wear faster and have more backlash than plastic gear servos, which will result in less precise tail control (with the exception of the Volz Speed-Maxx XP which is specifically designed for tail pitch control)

The slower digital servos (such as the JR DS368, 0.21 sec/60 degrees) do not work well as a tail servo unless the stock servo arms are replaced by extra-long servo arms (Du-bro, Servo City, etc). This sacrifices some precision for extra speed.

JR does not recommend the DS3421 for tail gyros because the servo motor is too small to handle the frequent movement required.

Gyros are sensitive to temperature changes. If you car is warm, the weather is cold and you take your heli out of the car and immediately try to fly, the gyro will not work well. You should allow a few minutes for the gyro temperature to settle before flying.

6.3. Batteries and related items

6.3.1. Batteries

Helicopters need batteries that can deliver high current. If you use cheap batteries, your helicopter will probably not fly well. The Sanyo CP2400 and RC2400s are the best choices for beginners on nonmicro helis because they are reasonably priced and can discharge at high rates. NiMH batteries are usually higher capacity but deliver less current than Nicad batteries, so they are better suited for duration flying.

One exception is the Sanyo HR-SC which is a NiMH battery specially built for high current drain which performs slightly better than the CP2400/RC2400 (HR-SCs must be used immediately after charging for best results).

NiMH batteries require about 5 charge/discharge cycles to reach full capacity. They work best immediately after charging - if you allow them to sit and cool off they will not work as well. Both Nicad and NiMH battery packs should be slow-charged on the first charge to ensure all cells in the pack will reach a full charge.

If this is not done, the cells in the pack may be at different states of a charge and the pack may never fully charge properly. If you notice a big drop in capacity in your battery packs after a few months of use, this is probably due to the cells in the pack having different states of charge. If this happens, you should try to "rebalance" the cells in the pack by slow charging them at a constant current of C/20 for 24 hours. This will usually restore the pack to full capacity. This should only be done for Nicad and NiMH packs, and not for other battery types such as Li-ion or LiPoly. Your batteries will last much longer if you do not allow them to become too hot, because the primary cause of battery failure is the deterioration of the separator which is accelerated by higher temperatures. Therefore, you should allow your battery packs to cool a little after use before charging them again.

The batteries known to work well are:

Corona / Logo 10/16/20 / ECO 8/16:

- Sanyo CP1700SCR (NiCad 1700 maH, 5.5 milliohms)
- Sanyo CP2400 (NiCad 2400 maH, 4.5 milliohms)
- Sanyo RC2400 (NiCad 2400 maH, 3.2 milliohms)
- Panasonic HHR300SCU (NiMH 3000 maH)
- Panasonic RC-3300HV (NiMH 3300 maH, 5.0 milliohms)
- Sanyo HR-SC (NiMH 2600 maH, 4.0 milliohms)
- Gold Peak 3300 (NiMH 3300 maH)
- Gold Peak 3700 (NiMH 3700 maH)
- Thunder Power lithium-polymer batteries
- FlightPower lithium-polymer batteries
- Common Sense RC lithium-polymer batteries

Micro helis (Piccolo and clones, Hornet, etc but not T-rex or Zoom):

- Sanyo HR-AAAU (NiMH 720 maH, 35 milliohms)
- PowerEx AAA NiMH
- HECELL AAA NiMH
- Thunder Power lithium-polymer batteries

- FlightPower lithium-polymer batteries
- Common Sense RC lithium-polymer batteries

(milliohms is a measure of internal resistance; LOWER IS BETTER)

If you are buying batteries not on this list, then you should ask the manufacturer for the internal resistance of the cells. If the batteries do not have an internal resistance as low as the cells on this list, then it is probably not suitable for helicopter use.

If you intend to fly aerobatics, do NOT use commercial battery packs. Most of these packs use a flat springy metal to connect the battery terminals and the springy metal will melt at high (50-60+) currents. Be sure to use your own inline-soldered battery packs if you intend to do hard aerobatics with your helicopter.

Lithium-polymer batteries are NOT recommended for helicopter beginners. They are fragile and incur damage easily, and when they are damaged they can IGNITE up to ten minutes later.

There was a story posted on RC Groups about a guy who crashed his plane powered by Li-Pos, and he put it in his SUV. Several minutes later someone told him his SUV was on fire. He posted pictures of the totaled SUV, and the interior was completely burned.

NOTE: The 17mm-long N20 motor used on some micro helicopter tails (some Piccolo models, all Hummingbirds, etc) will burn out quickly (5-20 mins) if the motor is run on 8 cells. Be sure to use only 7 cell battery packs to extend the tail motor life.

6.3.2. Battery connectors

Heavy-duty battery connectors are recommended to minimize power loss.

The following connectors work well for the Corona/ECO/Logo:

- 4mm gold-plated Corally "bullet" connectors
- Astroflight "Zero-Loss" 50 amp connectors
- W.S. Deans Ultra connectors
- W.S. Deans micro connectors (micro helis)
- JST BEC connectors (micro helis)

If you use the 4mm bullet connectors, you may want to use one male and one female plug on the battery otherwise you may plug in the ESC backwards, which will definitely damage it.

The Astroflight connectors are expensive but they are polarized and of extremely high quality and highly recommended.

These connectors may have some problems:

- Anderson's PowerPoles
- Sermos Connectors
- Tamiya connectors

The Tamiya connectors do not handle high current well. They will become very, very hot when conducting large amounts of current. Unfortunately,these connectors are supplied with Corona kits. It is highly recommended to replace these connectors.

JST connectors are only good up to about 6 amps burst, and should only be used for micro helis under 400 grams. If used for larger helis such as a Zoom or T-rex, they will become very hot.

Some people do use Powerpoles or Sermos with helis, but evidently some ESC manufacturers are claiming these connectors have problems.

There has been a report of Schulze refusing to honor a controller warranty due to the usage of Powerpole connectors.

Also, Rumrunner Hobbies' webpage states:

> "Lehner/BK warrantee does NOT Warranty (and is not limited to):... If Sermos, Powerpole, or Tamyia style connectors are used in the application."

Also mentioned:

> "When connecting your new LMT controller to your batteries be sure to use Deans style connectors or 4mm Gold connectors (gold connectors are for racers only). Other connectors such as Sermos, Powerpole, and Tamiya connectors can NOT be used and WILL VOID your warrantee.
>
> These style connectors have a tendency to arch (sic) and or spark as your vehicle is in motion. They also have a much higher resistance factor. If the connector does arch (sic) during operation of your vehicle it will short out the motherboard and render your controller useless!"

6.3.3. BEC (battery eliminator circuit)

(See Chapter 31, *Glossary* for a definition of BEC)

If your heli uses up to 8 cells and uses only analog servos, then you can use the BEC which is included on many ESCs such as the Schulze Future 12.46k and the Castle Creations Phoenix 35.

Some controllers can handle up to 10 cells with four servos, but 10 cells is very marginal for most linear BECs, and the BEC will run very hot. I recommend using an external switching BEC when running battery packs over 10 volts (more than 8 cells NiCD/NIMH, or more than 2s LiPo).

If you are using any digital servos, then you will need to check the ESC's onboard BEC amperage rating. Most ESC BECs are rated for only 1 or 1.5 amps which is insufficient to run a digital servo + 3 analog servos. One digital servo with three regular servos can easily draw well over one amp, so if your ESC's built-in BEC is rated for only one amp, you will definitely need to use an external BEC. If you overload the ESC's BEC in flight, it will overheat and shut down. You will then lose control of the helicopter and it will crash.

To use an external BEC, you will need either a free servo/battery position on your receiver or a Y-lead for the BEC's output power plug.

Currently there are several popular BECs. The first is the Kool Flight Systems Ultimate BEC, also called the UBEC. This is a large 20 gram BEC which can deliver 3 amps continuous.

There are two models for 5 volt use, one for up to 29 cells and other for up to 36 cells.

The second is the Firmtronics SBEC. This is a very small and light (8 grams w/o switch) BEC which can deliver up to 2.5 amps continuous and can work with up to 40 cells. Some people have reported interference problems with the SBEC on 35 Mhz radio systems, however.

There are now two more choices, which are the Medusa Research "Potencia" 2 amp/6-25 cell and 3.5 amp/10-33 cell BECs (12 grams). I have not seen any reports from people using these on helicopters, however.

Dimension Engineering manufactures two BECs which are usable for helicopters: the ParkBEC and the DE-SW050. The ParkBEC is rated for 1.25 amps and 33 volts of input and includes a built-in Y-lead. The DE-SW050 is rated for 1 amp and 30 volts of input and requires some extra soldering to use. Both the ParkBECs and the DE-SW050s can be wired in parallel to increase the current capacity of the units.

The highest output BEC currently available is the R/C Model Works UberBEC. This BEC is rated for 3.5 amps of otuput on 3S to 13S lipo. There have been no reports of this used in helicopters, however.

General recommendation

- Helis using micro servos (HS-55/56 size): ParkBEC
- Helis using mini servos (HS-81/85 size): SBEC
- Helis using full-sized servos: UBEC

To use the ParkBEC with an ESC with a built-in BEC, the throttle wire should be plugged into the ParkBEC header and not the receiver. This will automatically disable the ESC's built-in BEC.

To use the ParkBEC with an ESC without a built-in BEC, then both the ParkBEC and ESC must be plugged into the receiver (using a Y-lead if necessary). If the ESC is plugged into the ParkBEC, then the ESC will not receiver 5 volt power and will not initialize.

To use an (non-ParkBEC) external BEC with an ESC which already has a BEC, then you will need to disable the built-in BEC of the ESC. To do this, check if the ESC has one or two plugs which plug into the receiver. If the ESC has two plugs (like the Schulze Future 12.46e), then one of the plugs will have three wires and the other will have only two wires. The plug with only two wires is the BEC plug. If you do not connect this plug to the receiver, then the ESC's onboard BEC will be disabled. If the ESC has only one plug (like the Castle Creations Phoenix series) then the plug will have three wires and the middle wire should be red or orange.

Either pull this red wire out of the connector and tape it with electrical tape to prevent it from touching other wires or use a servo extension with the red wire pulled out and taped. This will disable the onboard BEC of this type of ESC.

Some people have reported the SBEC causes interference with 35 Mhz R/C systems. If you have a 35 Mhz system, you should be careful of the SBEC.

As a beginner, you should use a 5 volt BEC and not a 6 volt BEC. The 6 volt BEC will provide better holding power for the servos, but this will not be very noticeable unless you are performing extreme 3D aerobatics. Also, the 6 volt BEC will increase the wear on your servos and decrease the servo life.

6.3.4. Wire

(The Corona kit does not need extra wire if using the Fusion 35, Pegasus 35, or Phoenix 35 controller)

The motor and battery wires are especially important on an electric helicopter. If the ESC to battery wire is too thin, then you may experience ESC shutdown problems when the motor is spooling up or the wire may become very hot.

If the ESC to motor wire is too thin, then the motor may stutter while the helicopter is in flight.

The following table lists the recommended wire sizes for various currents:

Table 6.1. Wire size recommended by current capacity

Size	Current
12 gauge	41 amps
13 gauge	35 amps
14 gauge	32 amps
16 gauge	22 amps
18 gauge	16 amps
20 gauge	11 amps
22 gauge	7 amps

For an Corona, ECOs, and Logos, you will need good quality 12-14 gauge wire for the motor and battery leads. This wire will work well:

- Castle Creations W13RB (13 gauge)
- Astroflight wire (13 gauge)
- W.S. Dean's Ultra Wire (12 gauge)
- Team Orion (12 gauge)

The 12 gauge is very heavy and only recommended for extreme flying and/or larger helicopters with high current draw (>30 amps). The 13 gauge wire should suffice for most types of flying.

For the Piccolos and Hornets, you will need good quality 20-22 gauge wire for the motor and battery leads. This wire will work well:

- Castle Creations W20RB (20 gauge)

Sometimes wire is sold as "square mm cross-section" instead of AWG. Here is a quick table for conversion:

- 1.5 sq. mm 15 AWG
- 2.5 sq. mm 13 AWG
- 4.0 sq. mm 11 AWG

6.3.5. LiPo battery monitor

If you are using a LiPo battery pack, you may want to use a LiPo battery monitor to avoid over-discharging and damaging your expensive battery.

There are several LiPo battery monitors:

- The BattSignal by Jim Bourke Model Products weighs 4 grams and protects 2s to 6s LiPo battery packs. It autodetects the number of cells in series and will provide an audible indication of the capacity left as the battery is discharged.
- The HRPoly-X by Custom Idea weighs 3.9 grams and protects 2s to 4s LiPo battery packs. It works similarly to the BattSignal and can also log the battery voltage for 42 minutes, and the data can later be downloaded to a PC.
- The Li-saver by New Creations R/C is not suitable for electric helicopters because it pulses the main motor to indicate a low voltage condition.
- The MicroScream is a $5 DIY low voltage monitor for 2s or 3s which was posted to the RCgroups DIY electronics forum. Search the forum for more info.

6.3.6. Battery mounting strap

Some helicopters may need a velcro strap to hold the battery to the frame.

For micro helis, the 1/2 inch Velcro Get-A-Grip strap can be used, which is available in 8, 12, and 18 inch sizes. The 8 inch size is most often used for micro helis, and is Office Depot item #369220.

For larger helis such as the Logo 10, the 3/4 inch Velcro Get-A-Grip strap (also called One-wrap strap) works well. The 3/4" x 9' strap is Office Depot item #193464.

6.4. Motors and related items

6.4.1. Motor

For more details see Section 30.2, “Motor selection guide” and Section 30.3, “Motor selection table” in the Chapter 30, *Technical Appendix*

6.4.1.1. Corona motors

Ideal Kv: 2700-3000 rpm/V - Main gear: 102T, 32 pitch

- Graupner Speed 500 Race #6307 (brushed) mild
- Kyosho Atomic Force (brushed) mild
- Mega Motor ACn16/15/4 (brushless) mild
- Mega Motor ACn16/15/3 (brushless) mild
- Hacker C40-12S (brushless) powerful
- Mega Motor ACn22/20/3HTDS (brushless, 8 cells/15T)

  Note: The Mega Motor motors are very good for duration flights in the Corona. 10+ minute flights are possible with some moderate wind.

Note: The Astroflight 020 has a high failure rate when used in the Corona.

6.4.1.2. FP Piccolo motors

Ideal Kv: 1800-2000 rpm/V - Main gear: 100T, 0.5 module

- Astro Flight Astro 010 (brushless) mild
- Team Orion Modified Elite (brushed) powerful
- Hacker B20-36S (brushless) (8T pinion) powerful
- Model Motors ACn1215/20 (brushless) powerful

Note: The Astro 010 is very good for long flights.

6.4.1.3. CP Piccolo main motors

Ideal Kv: 2700-3000 rpm/V - Main gear: 100T, 0.5 module

- Hacker B20-36S (brushless) (10T pinion) mild
- Astro Flight Astro 010/14T (brushless) mild
- Team Orion Modified Elite (brushed) powerful
- Astro Flight Astro 010/10T (brushless) powerful?
- Hacker B20-31S (brushless) (8T pinion) powerful
- Model Motors ACn1215/20 (brushless) powerful
- Hacker B20-20L (brushless)
- Hacker B20-18L (brushless) (8T pinion) powerful

Note: The B20-36S is good for duration flights.

The B20-18L is good for aerobatics.

6.4.1.4. Hummingbird FP/CP, GWS Dragonfly main motors

Century Hummingbird: 140T, 0.5 module

GWS Dragonfly: 120T, 0.5 module

Others: 0.5 module

- HiMaxx 2015-4100
- Model Motors ACn1215/16 (brushless)

The CP Piccolo is a similar weight and size, so all motors in the CP Piccolo section can be used also. Multiply the recommended pinion size by the difference in gear ratio to compensate (1.4 for the Hummingbird, 1.2 for the Dragonfly)

6.4.1.5. Piccolo, Dragonfly, Hummingbird tail motors

Main gear: 0.5 module

- GWS EDF50-2 motor (brushed, can draw >2 amps)
- Feigao 1208436L (brushless)(direct drive or geared use)
- Feigao 1208430S (brushless)(geared use only!)

6.4.1.6. Hornet CP motors

Main gear: 135T, 0.4 module

- HiMaxx HA3026-3600 (brushless)
- Hacker B20-26S (brushless)
- Model Motors ACn1215/16 (brushless)
- Razor Micro Heli V2 (brushless)

6.4.1.7. Maxir SE motors

Main gear: ?T, 0.4 module

6.4.1.8. Zoom 400 motors

Main gear: 132T, 0.5 module

- Himaxx HA2025-4200 (brushless)
- Hacker B20-15L (brushless, 9-10T, 3S LiPo)
- MiniAC 1215/20 (10T, 3S LiPo)
- Eflight Park 400 4200 (8T, 3S LiPo)
- Motor Max Motors 400DH (9T, 3S LiPo)
- NeuMotors 1105/3Y (10T, 3S LiPo)
- Do not use the Chili Pepper 3600 - it burns out

6.4.1.9. Align T-Rex 450X/450XL motors

Main gear: 150T, 0.5 module

- Himax 2025-4200 (8T, 3S LiPo
- Astro 020 4T (11-12T, 3S Lipo)
- Mega 16/15/3 (13T, 3S Lipo)
- Neumotor 1105/3Y (9T, ?S LiPo)

- Lehner 1020/17 (11T, 3S LiPo)
- Medusa Products MR-028-040-3400 (11T, 3S LiPo)

(Best low-cost choice is currently the Mega 16/15/3)

6.4.1.10. ARK X-400 motors

Main gear: 138T, 0.5 module

- Mega 16/15/3 (?)

6.4.1.11. Voyager E motors

Pinion: ?

- Hacker C40-10T (brushless)
- Hacker C40-8L (brushless)

Note: The Astroflight 020 has a high failure rate when used in the Voyager E.

6.4.1.12. Robbe Eolo motors

Ideal Kv:

3.17mm shaft motors: 3000-3300 rpm/V

5.00mm shaft motors: 2700-3000 rpm/V

Pinion: 0.7 module

The available pinions are 14-18T for 3.17mm, shafts, and 19-22T for 5mm shafts.

- Hacker C40-9L (brushless) (8 cells/18T)
- Hacker C40-8L (brushless)
- Mega 22/20/2 (brushless)
- Kontronik Twist 3700 (brushless)
- Aveox 27/39/1.5 (brushless)
- Lehner 1930/6 (brushless)

6.4.1.13. ECO 8 motors

Aerobatic flight - ideal Kv:

3.17 mm shaft motors: 2300-2600 rpm/V

5.00 mm shaft motors: 1800-2000 rpm/V

Duration flight - ideal Kv:

3.17 mm shaft motors: 2100-2300 rpm/V

5.00 mm shaft motors: 1500-1800 rpm/V

Main gear: 180T 0.5 module

The ECO 8 has a 180T main gear, and the available pinions are 10T-17T for 3.17mm shafts, and 13-24T for 5mm shafts

- Magnetic Mayhem (brushed) mild
- Mega 16/25/3 (brushless, 10 cells/13T) mild
- Hacker C40-13L (brushless) mild, good for duration
- Aveox 27/30/1.5 (brushless) ???
- Mega 22/20/4 (brushless, 10 cells/19T) mild
- Aveox 36/15/1.5 (brushless) ???
- Ikarus X-250-4H (brushless) mild, discontinued
- Hacker C40-14S (brushless, 8 cells/9-10T) mild
- Hacker C40-12L (brushless, 8 cells/12-13T, 10 cells/10-11T)
- Aveox 27/39/1.5 (brushless, 10 cells)
- Aveox 36/15/1.5 (brushless, 10 cells)
- Ikarus H8 (brushless, 8 cells 22-24T, 10 cells 21-24T, 12 cells 20-24T) ???
- Hacker B50-22S (brushless, 10 cells/16T, 12 cells/13T)
- Hacker B50-18S (brushless, 8 cells/14-19T, 10 cells/13-15T) powerful
- Hacker B50-15L (brushless) powerful
- Hacker C40-10L (brushless) powerful
- Mega Motor ACn22/20/3H (brushless) powerful
- Kontronik 500-19 (brushless) (8-10 cells, 13-15T) powerful
- Hacker B50-13L (brushless) very powerful
- Plettenberg Orbit 15-14 (brushless, 10 cells/24T) powerful
- Lehner Basic 2400 XL (brushless) ???
- Lehner Basic 2800 XL (brushless) ???
- Hacker B50-11L (brushless) insanely powerful(requires very good matched batteries)

6.4.1.13.1. Best inexpensive motor for ECO 8

Mega Motor ACn22/20/3H

6.4.1.13.2. Best overall motors for ECO 8

Hacker B50-15L

Plettenberg Orbit 15-14 (10 cells/23-24T)

Note: The C50 motors will NOT fit in an ECO frame.

The smaller motors (C40, etc) may overheat in warm weather (70+F) so be careful.

6.4.1.14. ECO 16 motors

The ECO 16 has the same main gear and pinions as the ECO 8.

- Mega 22/30/4 (brushless, 16 cells, 17-20T)
- Ikarus H16 (brushless, 16 cells, 20-24T)
- Plettenberg Orbit 20-16 (brushless, 16 cells, 22T)
- Mega 22/30/3 (brushless, 16 cells, 13-15T)

6.4.1.15. Viper 70 motors

The ECO 16 has the same main gear and pinions as the ECO 8.

- Mega RCn 400/15/5 (brushless, 3s lipo, 17T)
- Mega ACn 16/15/4 (brushless, 3s lipo, 10-12T

6.4.1.16. Logo 10 motors

5.00 mm shaft motors: 1800-2000 rpm/V

Pinion: old models: 0.5 module, newer models: 0.7 module

The main gear is 200T, and the available pinions are 13-23T for 5mm shafts.

Pinion:0.5 module

- Aveox 36/24/2 (brushless) ???
- Kontronik Fun 600-15 (brushless) powerful
- Hacker C50-15L (5s3p, 13T)(brushless) powerful
- Mega ACn 22/30/3 (brushless) (5s3p, 13T)
- Astro 040 (brushless) ???
- Kontronik Fun 600-15 (brushless) (12 cells, 14-16T)
- Aveox 36/24/2 (brushless)
- Hacker C50-14L (brushless) (5s3p, 13T)
- Hacker C50-13L (brushless) (12 cells, 14T, 14 cells, 13T)
- Kontronik Fun 600-17 (brushless) (12 cells, 15-19T)
- Kontronik Fun 600-18 (brushless) (12 cells, 14-18T)

- Plettenberg Orbit 15-16 (brushless, 1070 rpm/V) ???
- Plettenberg Orbit 15-14 (brushless, 12 cells, 17T) ???
- Mega ACn 22/30/2 TDS (brushless) (6s3p, 10T)
- Hacker B/C50-11L (brushless) super powerful (requires very good matched batteries)

Recommended:

- Plettenberg Orbit 15-14 (12 cells/17-21T)
- Plettenberg Orbit 15-16 (14 cells/17-21T)
- Hacker C50-13L (12 cells/13-17T)

6.4.1.17. Logo 14 motors

5.00 mm shaft motors: ?

There are two main gears included with the Logo 14: 200T/0.5 module and 140T/0.7 module.

- Hacker C50-13XL (5s4p, 11-13T)
- Hacker C50-14XL (6s3p, 10-12T)
- Hacker C50-15XL (7s3p, 10-11T)
- Hacker C50-16XL (8s3p, 10T)
- Hacker C50-17XL (8s3p, 10-11T)
- Hacker C50-18XL (8s3p, 10-11T)
- Hacker C50-19XL (8s2p, 10-11T)
- Hacker C50-12XL (6s3P, 13T)
- Hacker C50-11XL (5s4p, 13-14T)
- Hacker C50-10XL (5s4p, 13T)
- Plettenberg HP 300/30/A2 Heli (5s4p/15T)

6.4.1.18. Logo 20 motors

5.00 mm shaft motors: ?

138T main gear for the older model, 98T main gear for the newer model

6.4.1.19. Quick EP 10 motors

The main gear is 120T, and the available pinions are 10-14T for 5mm shafts.

- Aveox 36/20/2 (brushless, 12 cells, 11-12T)

6.4.1.20. Quick Sweet 16 EP motors

The main gear is 120T, and the available pinions are 10-14T for 5mm shafts.

- Aveox 36/38/3 (brushless, 20 cells, 12-13T)

6.4.1.21. Summary

If you choose a brushless motor, then an autorotation gear is highly recommended. Most brushless motors have extremely high torque so when the motor spools down, the "braking" effect will be very strong. This will very likely break the main gear teeth if you do not have an autorotation gear. The only exception to this is the Corona; the main gear on it is very tough and can handle a brushless motor without an autorotation gear.

The older sensored Aveox motors (12xx and 14xx series) are only rated to 20,000 rpm, and the JETI motors are only rated to 15,000 rpm. You must be careful not to exceed these rotational speeds otherwise the rotor may eject a magnet (i.e. "throw a magnet"). Therefore, I do not recommend these motors for helicopter use. The better motors such as the newer Aveox, MEGAs, Hackers are typically rated for 50k-70k rpm, which makes them a better choice for helicopter applications.

The Model Motors 2814/10 is not recommended for an ECO 8. The motor seems to have problems with the rotor wobbling and touching the stator windings which burns out both the motor and the ESC. There are also some reports that the magnets are not epoxied very well to the rotor and may shift position. Also, these motors are not very efficient, and run very, very hot when used in a helicopter.

Most of the HiMaxx motors are not very efficient and therefore are not very good for larger helicopters because they generate large amounts of heat. There was one report of an HB 3615-2100 used in an ECO 8, and it became "too hot to touch". The HiMaxx seems to work okay in microhelis such as the Hornet CP and Zoom. The choice of a motor with a proper Kv for a collective pitch helicopter is very important, because most motor ESCs are not efficient when running at much less than 90% throttle. If you run an ESC continuously at low throttle, the ESC will probably overheat. Therefore, you should select a motor + pinion combination that will allow the motor ESC to run at 90-95% throttle for best efficiency.

Pole counts for motors are unfortunately difficult to find, and are necessary to program some ESCs correctly. Here are the pole counts that I have managed to find:

- 2 pole: Hacker, Kontronik, Lehner, some Plettenberg
- 4 pole: Aveox, Neumotor, some Plettenberg
- 6 pole: Mega 16 and 22 series, some Plettenberg

Also see Tohru Shimizu's helicopter brushless motor page at: www.dokidoki.ne.jp/home2/tohrus/motorindexE.html

Note

Check the length of your motor mounting screws before mounting!

If they go too deep into the motor they will short out a winding which will damage the motor. Even worse, if you try to run a motor with a shorted winding, it will burn out the ESC. So test the screw length by screwing it into the motor with your fingers before mounting in the frame.

6.4.2. Pinion

For more details see Section 30.4, “Pinion selection guide” in Chapter 31, *Glossary*

Most helicopter manufacturers supply a range of pinions for their helicopters. You may require pinions with more teeth for some reason. The most common reason is for running outrunner motors which usually have a fairly low Kv and therefore require a pinion with a higher tooth count.

Some helicopters use metric pinions, and some use English pinions.

The smaller brass press-on pinions (1 and 1.5mm) can be very difficult to remove from motors. I do not recommend the GWS pinion puller for these - I have personally destroyed two GWS pinion pullers trying to remove this type of pinion. The Maxx products pinion puller (ACC650) is much sturdier than the GWS pinion puller. Also, many brass pinions can be pulled off motor shafts by using heat since brass has a high coefficient of thermal expansion.

The best way to remove these brass pinions is to clamp the motor in a vise, then press a hot blunt tip soldering iron on the end of the pinion (for maximum heat transfer), wait about four seconds to allow the pinion to become hot and expand, then pry off the pinion using needle nose pliers. Do not skip the soldering iron step, because otherwise you will pull the shaft out of the motor.

The best way to install a brass pinion on a motor is to use a vise. Put the motor and pinion between the jaws, and screw the vise shut to push the pinion onto the shaft. Be sure the back end of the shaft is pressed against the jaw otherwise you may damage the motor bearings.

When selecting pinions, be sure to check your helicopter manufacturer's pinions first. The pinions from the helicopter manufacturer usually work best for most models.

6.4.3. Motor connectors

The standard connector for nonmicro helis is the 3.5mm bullet-style connector. These work well for up to 70 amps and are supplied with Schulze controllers.

For the main motor of FP micro helicopters and for tail rotors of micro helicopters, the most commonly used connector is the crimp pin from a D-sub connector. These are good up to about 4 amps and are available from Jameco Electronics; the female pins are part #43369 and the males are part #43377

For the main motor of CP micro helicopters there really is no standard. I personally use the MP Jet 1.8mm gold connectors, which are available from Aircraft World.

6.4.4. Main motor ESC

(See Chapter 31, *Glossary* for a definition of ESC)

If you plan to use a brushed motor, you will need a brushed motor ESC. If you plan to use a sensored brushless motor (like the X-250-4H) then you can use either a sensorless or sensored brushless motor controller. For the sensorless brushless motor controller, the sensor wires (connector) from the motor will not be connected to anything because the sensors are not required by the controller.

The sensored brushless motors may need to be sent back to the motor factory to reverse the motor direction if your rotor head is spinning in the wrong direction. Therefore, I recommend avoiding sensored brushless motors unless you already know the timing is for the desired direction of rotation.

If you plan to use a sensorless brushless motor, you will need a sensorless brushless motor controller. This motor type is not usable with a sensored brushless motor controller (such as the older Schulze Booster-40b).

An ESC used for main motor control must have the following characteristics are required (or must be programmable):

- No brake. If the ESC has a brake, then the motor may strip the main gear when the throttle is reduced.
- No reverse. A helicopter rotor should never spin in reverse.
- Slow start-up. If the ESC does not have a slow startup, the heli may spin when throttle is applied, tip over, or strip the main gear.
- No low voltage cutoff or programmable very low voltage cutoff. (As low as possible, must be less than 0.7 volts/cell for Nicad/NiMH or less than 2.5 volts cell for LiPo.

Most airplane ESCs are not suitable for helicopters because they have low throttle resolution, include a brake and have a fairly high low-voltage cutoff.

For the micro helis, the following are poular as main motor ESCs:

- Pixie-7P (brushed ESC, 7 amp)
- Schulze Future 11.20e (brushless, rather heavy)
- Castle Creations Phoenix 10 (brushless, very light)
- Piccoboard/Piccoboard Plus/Piccoboard Pro
- GWS ICS-100E (brushed main motor ESC, 5 amp)
- Cool Running H-12 (brushless, 12 amp)
- Cool Running H-25 (brushless, 25 amp)

For the Corona, the following work:

- Castle Creations Pegasus 35 (brushed)
- Castle Creations Phoenix 35 (brushless)
- Hacker Master 40-3P (brushless, do not use the BEC on this ESC because the ESC will overheat on 3 servos?)

For the ECO 8/16, the following work:

- Schulze Future 12.46k
- Schulze Future 18.46k
- Hacker Master 40-3P Heli

- Kontronik Jazz 55-6-18

For the Logo 10, the following work:

- Schulze Future 18.46K
- Kontronik Jazz 55-6-18

Do not use the SMILE 40-6-18 in the Logo 10 - it tends to burn out!!!

The Hacker Masters seem to burn out in the Logo 10 as well due to ESD problems.

The JETI Micoprocessor (red label series) is not suitable for helis because the throttle control is not smooth and is rather "steppy". The Advance (blue label series) is supposedly better, but nobody I know has tried this.

Some ESCs have an optocoupler (usually called OPTO) instead of a BEC. The optocoupler electrically isolates the ESC from the control signal which reduces the possibility of interference from the external BEC.

The Kontronik ESCs have a good soft start and governor mode for use on helicopters. However, they do not have thermal overload protection.

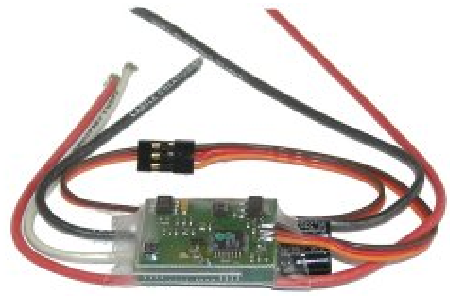
The Schulze ESCs also have a good soft start and governor mode, and they do have thermal overload protection.

The Castle Creations Phoenix works fine in the Piccolos and the Corona but does not work well in the ECO 8/Logo 10 and larger helis. The current version of the firmware has a problem in three areas:

- The soft start doesn't work properly. It may kick your heli around 180 degrees and/or tip your heli over.
- The governor mode doesn't work properly with a heading hold gyro. The RPMs will go up and down even when hovering, which makes the tail wag back and forth.
- The controller seems to have less glitch filtering than other ESCs. When the Phoenix is used in a heli, it requires a receiver which has a fail-safe mode or glitch filtering, such as a PCM receiver or a Berg DSP receiver.

Therefore, the Phoenix is not suitable for larger helicopters until these firmware bugs are fixed.

If you are mounting the Phoenix ESC with double-stick tape, be sure to put the tape on the BEC side and not the FET side. The FET side generates the most heat, so it needs to be exposed to free air.



Phoenix 35 ESC showing the BEC side

The FET side is the side with the regular pattern of identical chips. The BEC side has a random collection of chips. Do NOT use a switch between the battery and ESC. Most switches will not handle the current and will become very hot. Also, if the battery is plugged into the helicopter, you should consider it live for basic safety reasons anyway.

6.4.5. Tail motor ESC

(See Chapter 31, *Glossary* for a definition of ESC)

You will only need a tail motor ESC if the heli has a tail motor, obviously.

For the tail motor ESC, two characteristics are important:

- High throttle resolution (256 steps or more)

  Many airplane ESCs have very low throttle resolution (typically 32 steps) because airplane radios typically have a ratchet on the throttle stick which limits the throttle resolution anyway.

  If a heading hold gyro is used with an ESC with low throttle resolution, the tail will "wag" as the gyro tries to find the correct throttle position to hold the tail still.

  If a yaw rate gyro is used with an ESC with low throttle resolution then the tail will creep left or right because you will be unable to set the tail throttle to the perfect value with the revo mix.

  The GWS ICS-50E and probably other GWS ESCs are known to have only 16 steps of throttle resolution

- High switching rate (>50 khz) (for brushed motors)

  Many micro helis use metal brushed tail motors. Theses are easily recognizable because there are two types:

  - The popular "N20" style motors all use metal brushes.
  - The IPS-style motors with grey endbells use metal brushes.

  These metal brushes are very fragile and are easily destroyed by the high current surges generated by low switching rate ESCs. Therefore it is desirable to use a high switching frequency ESC to extend the operating life of the expensive tail motors.

  The IPS-style motors with black endbells use carbon brushes which are less fragile, but they will still last longer with a high switching frequency ESC. IPS motors (both grey and black endbell) are rated for about 2 amps max current.

The GWS ESCs are described as "high frequency" but they're only 2.8 khz. It's high frequency compared to the 50 hz control signal but it is not high frequency compared to the the TREC and other high frequency ESCs.

Some people are using the Feigao 1208436L brushless motor + Phoenix 10 ESC for tail control, but this combination has wagging problems and does not work as well as a standard brushed motor + high frequency ESC. See also Section 30.1.7, “How gyros work” for more info on tail motor ESCs and mixing options.

The following ESCs are usable as tail motor ESCs

- JMP HF100 (brushed 100khz switching, 256 steps, 1.5 amp)
- Schulze Slim-105He (brushed, 100 khz switching, 256 steps, 5 amp)
- Dionysus Design TREC ESC (brushed, 78 khz switching, 256 steps, 5 amps, low voltage LED)
- Castle Creations Phoenix 10 (brushless, 10 amp, ? steps)

6.5. Other

6.5.1. Modifications

You should avoid adding any aftermarket modifications to the helicopter when are are learning to hover. The reason for this is:

- If you crash the helicopter, you may destroy your expensive aftermarket modifications
- You will be distracted by trying to avoid destroying your expensive mods and therefore learn slower

The modifications to avoid when learning to hover are:

- Carbon Fiber frames/crutches/tailbooms (cracks)
- Aluminum frame upgrades (bends, increases radio glitches)
- Carbon fiber frame upgrades (cracks, increases radio glitches)
- Aluminum head upgrades (bends)
- Fuselage (cracks)

Some mods are recommended because they improve control and are less likely to be damaged in a crash, such as:

- Aluminum swashplate
- Tail servo mount
- Carbon fiber pushrod (only costs ~$3 to replace anyway)
- Autorotation gear (REQUIRED for most brushless motors)

- Ball-in-swash modification (improves control)

but in general, a stock helicopter is recommended.

Chapter 7. Support Equipment

7.1. Hand tools

7.1.1. Screw/hex/nut drivers

The best screw/hex/nut drivers for helicopter assembly and repair are probably the ones made by Wiha in Germany. The tool tips are made of hardened tool steel and the handles are made of very high quality plastic.

www.wihatools.com stocks the entire line of inch and metric tools, and they stock both sets and individual tools.

7.1.2. Ball link pliers

Ball link pliers are highly recommended for non-micro helicopters because ball links are very difficult to remove properly without ball link pliers. You do not need a ball link plier for micro helicopters.

Ball Link Pliers

Both JR and Century make nice ball link pliers.

Be very careful when removing ball links on plastic balls (such as the ECO 8/16 stock swashplate) with ball link pliers. You can scratch deep grooves in the plastic balls if you fail to center the ball in the jaws before squeezing.

7.1.3. Submini needle nose pliers

You need an extremely small pair of needle nose pliers to properly loosen the ball links on micro helicopters.

Xcelite makes a very good 4" sub-mini needle nose pliers, and it costs about $15. It's available from Jameco. www.jameco.com part #217891

Needle-nose Pliers

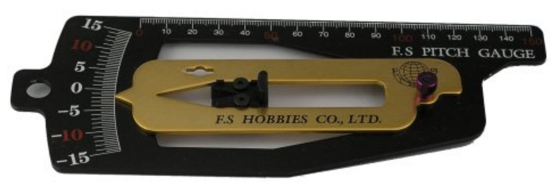
7.2. Helicopter tools

7.2.1. Pitch gauge

A pitch gauge is an absolute must for collective pitch helicopters. It is unlikely you will be able to properly setup your non-micro CP heli to hover without using a pitch gauge.

For microhelis, MJP Carbon makes a microheli main blade pitch gauge. It is available from DeeTee Enterprises.

Ikarus makes a pitch gauge specifically for the ECO 8. For other non-micro helis, Century Helicopter Products makes a decent pitch gauge.



Pitch Gauge

7.2.2. Blade balancer (optional)

If you don't buy a blade balancer, it is still possible to balance the blades using a dowel or other method, but a good blade balancer makes the job much easier.

The KSJ-528 blade balancer works well. The Koll Rotor Pro is better than the KSJ-528 but is overkill unless you're doing advanced flying.

I highly recommend CAing the tip of a sewing pin to the pointer of the KSJ-528 to make the scale easier to read.

Kyosho Blade Balance

7.2.3. Paddle pitch gauge (optional)

This is very handy for ensuring your paddles are completely flat relative to each other. For non-micro helicopters, the KSJ-624 paddle gauge works well.

KSJ paddle pitch gauge set

7.2.4. Prop balancer (optional)

In order to balance the rotor head, you need a prop balancer. The Du-bro "Tru-spin prop balancer" works well because you can hang the rotor head over the edge of a table when balancing he rotor head.

7.2.5. Tachometer

There are about three tachometers in wide use for helicopters.

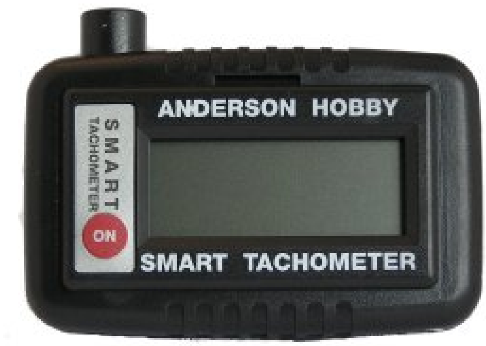
The first is the Anderson Hobby tachometer. This is fairly cheap about $35) and works well on the ECO/Logo, but it does NOT work on micro helis such as the Piccolo CP! It also drains batteries quickly even when not turned on, so I recommend removing the battery when not in use.

The second is the X-cell optical tachometer. This is expensive(about $150) but works with almost any helicopter. It only reads to 1990 rpm, so it may not be suitable for micro helicopters which typically need 2000+ rpm of headspeed.

The third is the Tera tachometer distributed by Thunder Tiger. This is a very nice digital tachometer specifically for helicopters which will clip onto the tail boom for hands-free measuring of the headspeed.

There are other tachometers, including:

- Magnum mini-tach. Price is about $35.
- Hangar 9 micro digital tach
- Thunder Tiger 2642 mini tachometer



Tachometer

For some reason, Quantum Models www.quantummodels.com stocks more tachometers than any other online store I've seen.

The shadow of the rotor blade should fall on the tachometer sensor for best results. Therefore, the tachometer should be under the rotating plane of blades.

It is a good idea to build a stand for the tachometer or to tie it to a tent stake so you can stand a safe distance away from the rotor blades and read the tachometer display.

Tachometers will not work indoors with fluorescent lighting, because fluorescent lights flicker at 50 or 60 Hz which interferes with detecting the main rotor blade shadow. You must use either incandescent lighting or natural sunlight.

7.3. Adhesives

7.3.1. CA Glue

CA glue is Cyanoacrylyte glue, which is a type of instant glue. There are usually three different types of CA glue: thin, medium, and thick viscosity.

CA glue works best when fresh, and gradually loses its adhesive properties as it ages. It is best to either discard old CA after a few months or store it in refrigeration to preserve its adhesive properties.

7.3.2. CA accelerator

CA accelerator will instantly harden CA glue, and is recommended when extremely strong structural repairs are required.

7.3.3. CA debonder

CA debonder is usually acetone with a jelling agent so it will cling to surfaces.

Some types of fingernail polish remover contain acetone, and sometimes a fluid works better because you can soak the entire part in acetone.

CA debonder usually does not work instantly, and requires at least a few minutes to weaken the CA sufficiently to allow the parts to be separated.

7.3.4. Epoxy

Two-part epoxies are often useful for making repairs.

There are many different types of expoxies, with many different curing times. As a general rule, the fastest setting epoxies are the weakest, and the slowest setting epoxies are the strongest. For example, J-B Weld requires 4-6 hours to set and is one of the strongest epoxies.

You should avoid creating bubbles in the epoxy when mixing the resin and the hardener, because the bubbles will weaken the epoxy significantly. A *stirring* motion to mix the epoxy is very bad because it tends to produce bubbles. A *smoothing* motion (similar to the motion used to level cement with a trowel) works much better.

7.4. Charging equipment

7.4.1. Battery chargers

See also Section 30.9, “Battery care and maintenance” for important information about batteries.

There are many nice chargers on the market.

Here are the features I recommend you look for:

- For micros: able to charge at 500 ma - 1.5 amps
- For nonmicros: Able to charge at 3.5 to 5 amps
- Delta-peak charge termination (for NiCad/NiMH)
- Some type of false peak rejection capability (Sometimes called soft-start, peak delay, etc.) (for NiCad/NiMH)

The soft-start/false peak rejection capability is especially important for Nicad and NiMH charging. Helicopters tend to discharge cells rather deeply, and when these cells are charged, the charger may often "false peak detect". This occurs because the cell chemistry is unstable when deeply discharged and the cell voltage will fluctuate randomly until the cell chemistry stabilizes.

A charger with soft-start or false peak rejection will not require restarting the charging cycle multiple times in the first 5-10 minutes of charging a deeply discharged battery pack.

The chargers which are known to fit these criteria are:

- Maha MH-C777 Plus II (surface charge, Nicad, NiMH, Li-ion)
- Great Planes Triton (peak delay, NiCad, NiMH, Li-ion, Pb)

- Great Planes Triton Jr (peak delay, NiCad, NiMH, Li-ion, Pb)
- Great Planes Triton 2 (peak delay, NiCad, NiMH, Li-ion, Pb)
- Hitec CG-330 (false peak reject, NiCad)
- Hitec CG-335 (false peak reject, NiCad)
- Hitec CG-335 Pro (false peak reject, NiCad, NiMH)
- Hitec CG-340 (false peak reject, NiCad, NiMH)
- Robbe Infinity II (false peak reject, NiCad, NiMH)
- Schulze ISL 6-330d (false peak reject, NiCad, NiMH, Li-ion,Pb)
- Orbit Microlader (soft-start, NiCad, NiMH, Li-ion, Pb)
- Orbit Microlader Pro (soft-start, NiCad, NiMH, Li-ion, Pb)
- Orbit Pocketlader (soft-start, NiCad, NiMH, Li-ion, Pb)

The best value in chargers in this list is the Great Planes Triton. It has almost the same features as the high-end Orbit Microlader at about 1/3rd of the price.

Before buying a charger, make sure it can charge the number of cells in your pack! Some chargers can only handle up to 10 or 12 cells, which is insufficient for a Logo 16/20 or ECO 16.

This may be important if you're planning on buying a larger helicopter eventually.

Lipo batteries can ignite if overcharged, or become bloated and damaged if overdischarged. Therefore, it is highly recommended to equalize or "balance" the charge in the cells in the pack either before charging or during charging.

Standalone lipo balancers work in different ways. Some willd discharge all cells to a preset voltage, such as 2.75 volts. Some will equalize the cells in the pack by slightly discharging the cells with extra charge. Some balancers work by working with a non-balancing charger to provide a balanced charge. Some balancers support two or more of the above methods of balancing.

Some lipo balancers currently available are:

- Orbit LiPoChecker (1s to 5s packs)
- Orbit LiPoChecker pro (1s to 5s packs)
- Schulze LiPoBal 8 (1s to 8s packs)
- Schulze LiPoBal 14 (1s to 14s packs)
- Astro "Blinky" battery balancer (1s to 6s packs)
- Thunder Power Smart Balancer TP205 (2s to 5s packs)
- Thunder Power Lipo Balancer TP210 (2s to 10s packs)
- Electrifly Equinox lipo cell balancer (2s to 5s packs)

A lipo balance charger will individually charge the cells in a lipo pack to insure no cells are overcharged.

Some balance chargers currently available are:

- Schulze LiPoCard (1s to 4s packs, 3.85 amps max)
- Thunder Power High Power Charger (1s to 10s packs, ? amps max, requires optional balancer for balance charging)
- Commonsense R/C balancing charger PB-14 (1s to 4s packs cells, 2 amps max)

Note

There is no standard connector for lipo balancing, so you will need to buy balance connectors which are compatible with your balancer or balance charger, and solder these connectors onto your lipo packs.

7.4.2. Battery charging containers

LiPo batteries can ignite and/or explode while charging. Therefore, you should charge LiPo batteries in a metal container (such as a military surplus ammo box) or ceramic container (such as a Battery Bunker).

7.4.3. Power supplies

Most battery charges will require a 12 volt power supply for use at home. Here are some 12 volt power supplies which are suitable:

- Samlex America SPS-1206 12 volt 5.5 amp power supply
- Samlex America SEC-1212 12 volt 10 amp power supply
- Samlex America SEC-1223 12 volt 23 amp power supply
- Alinco DM-330MVT 12 volt 30 amp power supply
- Maplin XM22Y 13.8 volt 5 amp power supply
- Maplin XM21X 13.8 volt 7 amp power supply
- Maplin XM19V 13.8 volt 10 amp power supply
- Pro Peak 20 amp power supply

A 5 amp power supply is suitable for charging most micro heli batteries. The 12 to 30 amp power supplies are suitable for charging most larger batteries.

A fully charged car battery at rest has a voltage of about 12.6 volts but when the car is running the battery voltage rises to 13.8v because the generator/alternator is running. So therefore all battery chargers designed to work off a car battery will handle 12v to 13.8v of input without problems.

This type of power supply is available from Ham radio suppliers such as www.hamradiooutlet.com . The Pro Peak power supply is available from R/C model outlets such as www.hobbypeople.net

7.4.4. Field battery (optional)

If you must go to a flying field in order to fly, then you will probably need a field battery. It is not recommended to charge larger batteries from your car's battery because automotive batteries are not designed to be discharged on a regular basis.

7.4.4.1. Calculating field battery capacity

The steps to calculate the required field battery capacity are:

1. Calculate the number of watt-hours required per charge

   The number of watt-hours required per charge is the voltage of the battery multipled by the amp-hour capacity of the battery.

   For example, a ten-cell 2400 maH battery pack has:

   (1.2v per cell) x (10 cells) x (2.4 amp-hours) = 28.8 watt-hours of capacity

2. Multiply by the number of charges

   If you want to charge a battery of this size about six times every trip to this field, this will require:

   6 * 28.8 = 172.8 watt-hours of capacity

3. Add fudge factor for charger inefficiency

   Battery chargers are not perfect at charging batteries (due to switching power supply and other losses), so add about 20% to account for this.

   In this case, this would be:

   172.8 watt-hours * 1.2 = 207.36 watt-hours of capacity

4. Add extra capacity to avoid completely discharging field battery

   Lead-acid batteries will last longer if you do not completely discharge them at every use. Therefore I recommend adding at least 20% to your expected required capacity to avoid fully discharging the field battery.

   If you anticipate flying extremely frequently (more than twice a week) then you should add at least 50% to your required capacity.

   In this case, this would be:

   207.36 * 1.2 = 248 watt-hours of capacity

7.4.4.1. Choosing a field battery

The most common type of field battery is some type of deep-cycle lead-acid battery, due to its low cost and availability. For field battery capacities up to 240 watt-hours, a car "jumpstart" package is a very convenient source of power. One suitable package is the Vector Manufacturing VEC012 jumpstart system. This retails for $50 and includes a 12 volt 19 amp-hour sealed lead-acid battery and a built-in AC charger.

For field battery capacities up to 1440 watt-hours, a marine-style deep-cycle battery is a good solution. These typically cost between $50 and $120 and are available in sizes from 40 amp-hours to 120 amp-hours. Be sure to use a deep-cycle battery as regular lead-acid batteries are not designed for discharge on a regular basis. For field battery capacity up to 2880 watt-hours, the lowest cost solution is to use two 6 volt golf car batteries. These typically cost about $140 for a pair and are rated at 6 volts and 220 amp-hours. The Exide E3600 is one readily available battery of this type.

Note: the higher capacity batteries can weigh up to 70 pounds. For example, Exide E3600 weighs 62 pounds. If anticipate problems moving batteries of this weight, then you may choose to use multiple smaller batteries instead.

I do not recommend connecting field batteries in parallel. If you accidentally connect the batteries incorrectly, it can result in an explosion which will spray sulfuric acid over a wide area. It is safe to connect them in series, however, as a reversed battery will only result in less voltage at the output.

7.4.5. Field battery charger (optional)

Most high-end battery chargers will also charge a lead-acid battery. Some examples of this are the Great Planes Triton, the Schulzes, and the Orbits. The charge rate is usually limited to about 5 amps on these chargers, so they will take a long time to charge high-capacity field batteries.

A better choice is to use a dedicated lead-acid battery charger. Be sure to select a good quality battery charger which includes an automatic cutoff feature. These battery chargers will avoid overcharging and "boiling" your battery and subsequently causing early battery failure.

Vector Manufacturing makes good battery chargers for this purpose. They use switching power supplies, digital voltage readouts, and a multi-stage charging algorithm for faster charging. The VEC1088 will charge at up to 12 amps, and the VEC1092 will charge at up to 35 amps.

7.4.6. Portable generator (optional)

If you fly larger helis, you may want to use a portable generator instead of a field battery and a field battery charger.

Honda manufactures a line of very quiet generators which are ideal for use at flying fields. The Honda EU1000i uses a four-stroke engine, is rated for 1000 watts of AC output, has a noise level of only 53-59 dB and will run from 4-8 hours on a single tank. The older discontinued Honda EX350 and EX650 are also good choices for a portable generator if you can find one. These use two-stroke engines so oil will need to be mixed with the gasoline. These generators output a square wave instead of a sine wave, so some equipment may not work well with it. Be sure to test before you buy one.

Yamaha manufactures the EF1000iS which is rated for 1000 watts of output, and is also a very quiet (47-57db) generator.

The 12 volt output of most portable generators is very weak, so the AC output should always be used for charging batteries. Portable generators should be run at least 30 minutes a month to keep the generator properly lubricated internally.

7.5. Electronic instruments

7.5.1. Digital voltmeter

A DVM is very useful for monitoring the voltage of the battery packs. If you are having trouble lifting off, then the first thing you should check is the battery voltage while the heli is powered up.

Digital Multimeter

7.5.2. Wattmeter

A wattmeter is a device which is connected between the battery and ESC of a helicopter, and measures the voltage, current, the instantaneous watts used, the cumulative battery capacity used, and other parameters. This is very useful to check if the current draw is too high or the battery voltage is dropping too low.

The original wattmeter is the Astroflight Super Whattmeter. This device can handle up to 60 volts and 70 amps of discharge.

A recently released wattmeter is the Medusa Products Power Analyzer II. This is available in three different versions and is available with a USB interface for connection to a computer.

Another recent wattmeter is the RC Electronics "Watt's Up" power analyzer. This appears to be similar to the Astroflight Whattmeter.

Note that a Wattmeter only measures AVERAGE current. This is a slight problem because it does not measure the maximum current draw of a pulse-width modulated motor.

Chapter 8. Simulators

A simulator is highly recommended for helicopter beginners.

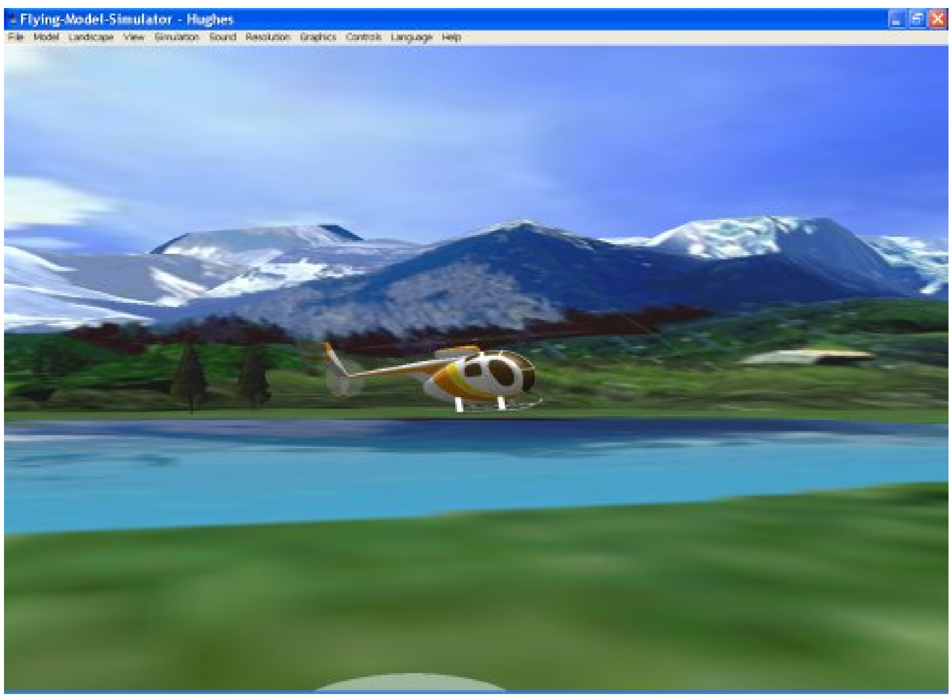
A typical well-trimmed helicopter will only hover in place for two or three seconds "hands-off" before it starts to drift in a random direction. Therefore, a helicopter requires constant correction to hover in one spot. In addition, a drifting helicopter will gain speed much like a ball rolling down a hill. If you are slow to move the stick to correct the drift, then you need more input to arrest the drift, so it is best to arrest the unwanted motion quickly before it gains speed.

The hardest part of flying a helicopter is developing the "reflexes" to move the stick in the correct direction regardless of helicopter orientation and the "delicate touch" required to adjust the helicopter movement without overcompensating. A simulator will help you develop these skills quickly without spending a lot of money on replacement parts.

Here is a quick subjective review of some simulators, with links to get additional information:

8.1. FMS

Free! (score: 3/10)



FMS

FMS is okay for learning hovering in all orientations. The models move extremely slowly so hovering is a little too easy. However, it does not seem to model forward flight correctly, so when you are ready to practice forward flight, I would recommend finding a better simulator.

Futher information available from n.ethz.ch/student/mmoeller/fms.

You need to buy, or build an interface lead. There are several different designs for serial, gamesport or USB connection. Many of the suppliers listed in Chapter 27, *Electric Helicopter and Parts Vendors* sell them and a search on the web will produce a lot of suppliers, but here are a few to give you an idea of what is available:

- (US) www.aero-model.com
- (UK) www.rcworld.co.uk
- (CA) www.rc-circuits.com
- (UK) www.rc-electronics.co.uk
- (US) www.milehighwings.com
- (NZ) www.acehobby.co.nz USB cable
- (US) www.heliguy.com has instructions on how to build your own cable.

8.2. Piccofly with Game Commander

~$80 (score: 7/10)

Piccofly - in the kitchen

Piccofly is excellent for learning to fly the FP Piccolo and clones. It doesn't model forward flight well, but it simulates the "squirreliness" of hovering the fixed pitch micro helis very well.

It has a very nice "slow time" function which allows you to slow down the movement of the Piccolo so you can build your reflexes without getting too frustrated.

I would recommend starting off at about 70% time and gradually increasing the time until you can hover at 100% time (real time).

Futher information available from www.ipacs.de.

8.3. Easyfly

~$80(score: 4/10)

Easyfly

The quality of Easyflight's helicopter flight model is a little better than FMS, but not by much. The helis move faster, which is good, but forward flight doesn't feel right because there isn't any translational lift. Okay for learning hovering, but not forward flight.

This is often bundled with Piccofly. Add-on aircraft and scenery packs are available.

Futher information is available from: www.ipacs.de.

8.4. Aerofly Professional

$130 to $200 (score: 5/10)

Aerofly Pro

The helicopter flight model is a little bit better than Easyfly but it still doesn't feel quite right. There's still not enough translational lift, but at least it won't let you loop the heli with 5ft of altitude without negative collective like Easyfly does. Good for learning hovering, but not forward flight.

Add-on aircraft and scenery packs are available.

Futher information is available from www.ipacs.de.

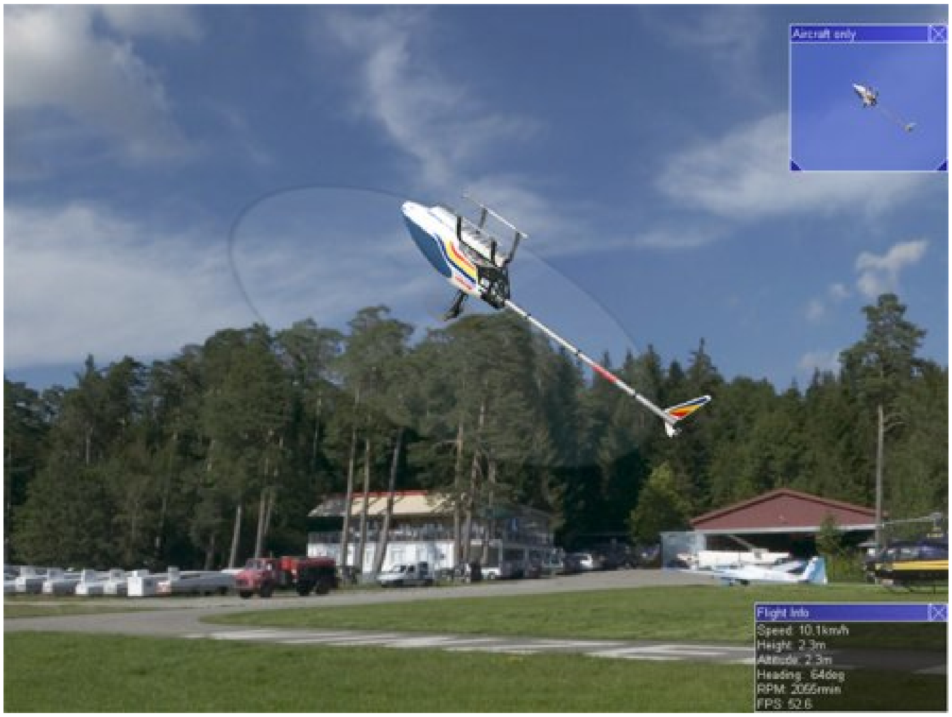
8.5. Aerofly Professional Deluxe

- $130 to $200 (score: 8/10)

This is a major update to the Aerofly engine. This version can handle photo-realistic scenery, and has very good lighting and shadow effects. However the underlying physics model for helicopters is not quite as good as that in Reflex XTR, and there are not so many adjustable parameters as in Reflex. This is a very competent simulator, but perhaps lacks the ultimate flexibility offered by Reflex XTR.

Add-on aircraft and scenery packs are available.

Aerofly Pro Deluxe (Screen capture by Dongle)



Aerofly Pro Deluxe (Screen capture by Dongle)

Futher information is available from www.aerofly.com/dehome.html.

8.6. Realflight G2 w/USB Interlink

~$200 (score: 8/10)

Realflight G2

Realflight G2 has a pretty good helicopter flight model, and is a good simulator for learning non-micro helicopter skills. The helicopter flight model is one of the best of all the flight sims mentioned here, and it will probably be good enough to practice 3D aerobatics.

I would recommend practicing hovering on the Impala model initially, then later when you acquire proficiency I would recommend buying the Add-ons 3 and practicing with the Raptor 30 model.

For some reason, many of the models in Realflight do NOT have the heading hold function enabled nor the revo mixing set up correctly. This means the helicopter will continually rotate and be difficult to hover. If you have this problem, you should select "Copy Model" and enable the heading hold gyro and also edit the radio to turn off the revo mixing. Add-on aircraft and scenery packs are available.

Futher information available from www.realflight.com.

8.7. Realflight G3 w/USB Interlink

~$200 (score: 8/10)

RealFlight G3 (Screen capture by LanternMaker)

Realflight G3 is recently released, the flight models have been improved even further, so this remains an excellent all-round simulator. The user can choose between computer-generated scenery or panoramic photographs. If you wish to move through the scenes you can use the computer-generated scenes. The existing G2 add-ons also work with G3.

This is an excellent all-round simulator, but it is expensive.

Futher information available from www.realflight.com.

8.8. Reflex XTR simulator w/USB interface

~$190 (score: 9/10)

Reflex XTR - Indoor flying Corona

Reflex XTR - Realistic Corona model

People have mentioned the physics model in Reflex seems better than RFG2; however I have not tested this. However, Reflex does not include a USB controller (only USB interface for a regular transmitter) and does not support network play.

The previous version of Reflex (version 4) is not as pretty as RFG2, but has a good reputation for accurate heli flying characteristics. However, the newer XTR version looks fantastic - much nicer than RFG2, and it has improved the physics model even more.

Although this is quite expensive, updates, upgrades and new models are available at no cost.

Futher information available from www.reflex-sim.de.

8.9. ClearView

$30 (score: 7/10)

ClearView photo-realistic scenery

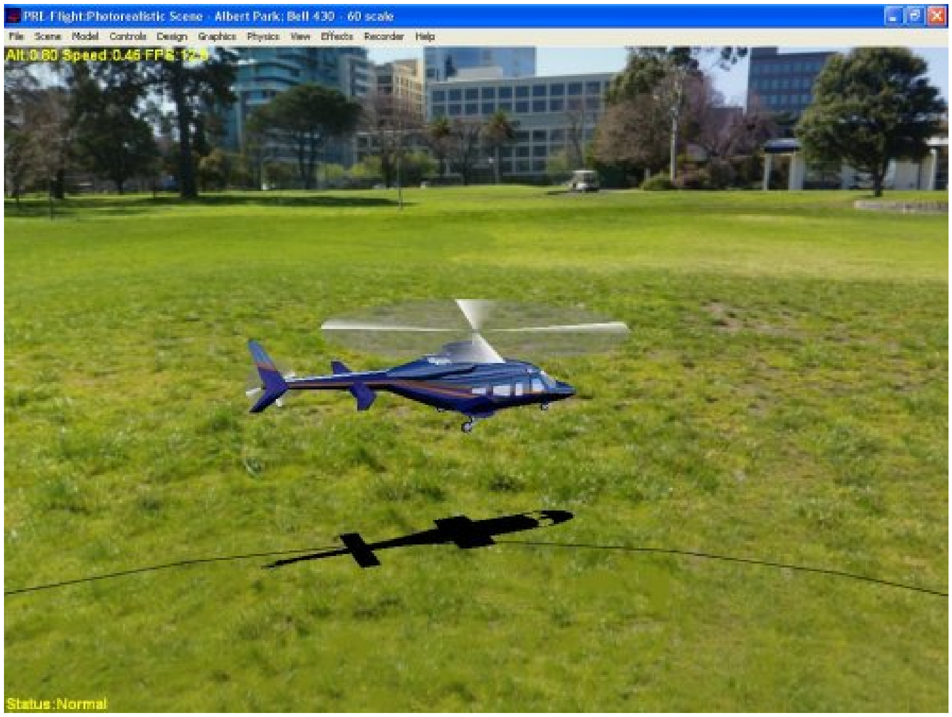
ClearView is available as a free evaluation download to allow you to evaluate performance on your own computer, and to check that your controller and/or Tx cable can work with it before buying. After the evaluation period expires, the software is disabled, but can be fully enabled by paying the $30 registration fee.

Although perhaps not quite as realistic as the "high-end" simulators it is much better than FMS and represents excellent value for money. It also offers a wide range of add-on models and scenery, and it can import scenery and models for several other formats. ClearView has an excellent reputation for responsive support.

Futher information available from www.rcflightsim.com.

8.10. PreFlight

~$70 (score: 5/10)



PreFlight with Albert Park photo-realistic scenery

Available directly from the maker Trancedental Technologies. This requires a unique transmitter lead, which plugs into the PC microphone socket.

The latest version includes photo-realistic scenery, an aircraft editor and a full scenery editor to allow you to create either your own photo scenery or your own cartoon scenery. There are a few helicopter models available from the supplier's site, but not really any independent sources.

This is a good budget simulator, with better physics that FMS, but less models are available. However you have the built-in capability to create your own aircraft and scenery. This sim is now often bundled as a model-specific simulator now (e.g. T-Rex) and these models seem to be quite accurate.

Futher information available from www.preflightsim.com.

8.11. PhoenixRC

~$140 (score: 9/10)

Phoenix RC simulator

This new simulator offers excellent physics and very impressive graphics. The models supplied have been configured with the help of recognised helicopter experts, and behave in a very realistic way.

The simulator comes with a proprietary USB dongle/transmitter lead, like most other high-end sims. This software is created in the UK, so the price is especially competitive for the UK and European markets.

Futher information available from www.phoenix-sim.com.

8.12. Helicopter simulator for the Mac

Almost all the simulators are available only for Windows, but this one is a helicopter simulator built specifically for Mac OS X.

Futher information available from www.alphamacsoftware.com.

8.13. Summary

Basically, Realflight G2/G3, Aerofly Pro Deluxe, Reflex XTR and PhoenixRC are the only one which seems to simulate helicopters properly. All other sims seem to model helicopters as a special type of airplane, which does not produce the correct flight characteristics.

The incorrect translational lift model actually affects hovering as well, because real (light) helicopters tend to bob up and down when there is a slight wind. This is because the wind has the same effect as forward flight - it makes the heli generate extra lift.

So, in Aerofly Professional, if you turn on wind, your heli doesn't bob up and down properly - it just slides around horizontally, which is incorrect. Realflight G2 and G3 models translational lift correctly, and the heli will gently bob up and down as the wind gusts. They also seems to model the "rotor wash" effect where the main rotor blades become less efficient when they enter their own rotor wash.

Therefore, if you learn to hover completely in FMS, Easyfly, or Piccofly, you will not learn how to properly use the collective to compensate for the effect of wind making your heli bob up and down. This can be learned later on a real heli, but it will require some adjustment time.

Most simulators have wind turned off by default, which makes hovering unrealistically easy. In order to accurately simulate being outside, you should turn on a little bit of gusty wind (maybe 3 mph or so).

When learning to hover, don't worry too much about finding a simulator which has (say) the Corona. Just learn to hover on the helicopter trainer model supplied with your flight simulator.

Imagine that you don't know how to drive a car and you plan to buy a Honda eventually. Do you really need to practice on a Honda so you can drive the Honda when you buy it? The basic driving skill is pretty much the same for all cars, with the exception of small driving differences and control placement.

Helicopters are pretty much the same way. Some helicopters are smaller and therefore more twitchy and difficult to fly, but the basic skill in flying a helicopter is the same across all models.

One nice feature of Realflight G2 & G3 is the network play, which allows you to fly and chat with other people using Realflight on the Internet. This helps to alleviate the tedium of hovering practice.(ClearView has recently added this feature too.)

Reflex seems to be more processor-intensive than RFG2. There is at least one report that RFG2 runs faster on a P3/500 than Reflex. If you have a machine under 1 Ghz then RFG2 may run better on your machine.

Both RFG2 and Reflex require fairly good video cards to run well. I would recommend at least a GeForce 3, although people have run RFG2 on as low as a Riva TNT (probably with most effects disabled).

The Simulators Forum on RC Groups is a great source of information, and will give you the latest information on new versions.

A huge number of additional aircraft, scenery and utilities for most of the main simulators can be found at www.rc-sim.de .

8.14. Simulator practice

You should practice on the simulator as though it were a real R/C helicopter. You should practice each hovering orientation in the simulator before trying it outside on a real R/C helicopter. This will greatly minimize your heli repair costs.

Many beginners do not consider the simulator to be a serious tool. They will play the simulator as though it were a videogame and try the latest aerobatic moves. These people often have very high heli repair costs because they do not understand the importance of a simulator as a serious training tool.

Chapter 9. Transmitters

9.1. Suitable helicopter transmitters

You can fly some helicopter with a simple four-channel radio, but you will be limited to the following helicopters:

- Piccolo FP and clone with any Piccoboard
- Hummingbird with onboard mixer board with any gyro
- Corona with heading hold gyro with no remote gain (e.g. GY240)
- ECO 8 with mechanical mixing with any gyro

  (deprecated - not recommended due to sluggish response)

Ideally, you want a better radio with at least six channels and some or all of the following features:

- No throttle detents ("notches")

  Most airplane versions of radios have "clickers" which will only allow a fixed number of throttle positions instead of a completely linear throttle position. This is very annoying when flying helis because the perfect throttle position for hovering is usually between two throttle click positions so you wind up fiddling with the throttle and bobbing up and down. Airplane-style radios can be converted to remove the notches by "flipping over" the metal arm which touches the joystick detents, but it's nicer if the radio is already configured for a helicopter.

- Exponential

  This will allow you to make the helicopter cyclic less sensitive around the center, which will help you learn hovering more quickly. After you develop a delicate touch, you may want to reduce the amount of exponential.

- 5 point throttle/pitch curves (or better)

  When flying a collective pitch helicopter, you will want a constant headspeed from a little below hovering up to full throttle. This is difficult to do with a three-point throttle pitch curve, and a five point curve is better.

- Throttle hold switch

  This is a basic safety feature. It will prevent the helicopter from spooling up if a gust of wind pushes your shirt over the throttle stick or you accidentally bump it with your hand.

- 90 and 120 CCPM swashplate support

  (See Chapter 31, *Glossary* for a definition of CCPM)

  Most helicopter nowadays use 90 or 120 CCPM swashplate modes. If your transmitter does not support these modes, then you will not be able to fly them.

- Idle-up support

  (See Chapter 31, *Glossary* for a definition of Idle-up Mode)

Idle-up allows you to change the throttle curve of the helicopter. This is highly desirable for collective pitch helicopters because it allows you to maintain a constant headspeed at all throttle positions in (idle-up mode) after spooling up (in normal mode). This makes a collective pitch helicopter more responsive to the throttle stick and nicer to fly.

Currently, the best price/performance in helicopter radios is the Futaba 7CH (FF7 in Europe). This radio has all of the above features except 5 point throttle/pitch curves and can be purchased for about $170 (without receiver/servos) at various vendors on the Internet (e.g. Servo City and Bruckner Hobbies).

"Futaba 6XHS is similar to the 7CH but has fewer model memories and fewer swashplate types, and will work fine for modelers on a tight budget. The older Futaba 6XH is not recommended because it does not support exponential, swashplate types, and swashplate mixing settings.

The Hitec Optic 6 can also be used, but this transmitter is only available in an airplane configuration, so the throttle will have detents and the idle-up and throttle hold switches will be in a nonstandard location.

The Futaba 9CH is also good. This radio can be purchased for about $300 (without receiver/servos) on the Internet.

Other good choices which are moderately priced (<$500) include:

- JR 9303 Heli
- JR XP6102 Heli
- JR XP8103 Heli (XP3810 in Europe)
- Hitec Eclipse 7 Heli (can do 90 CCPM with programmable mixes -explained in Section 9.2.1, “Hitec Eclipse 7 with 90 CCPM”)
- Airtronics RD6000 Super Heli (do not buy the SPORT model because the SPORT model has no swash mode)
- Airtronics RD8000 Heli
- Multiplex Cockpit MM
- Multiplex Royal EVO 9

These radios are very nice but are also very expensive:

- JR 10X Heli
- Futaba 9ZH
- Futaba 14MZ
- Multiplex EVO 9
- Multiplex EVO 12
- Multiplex Profi 4000

9.2. Special transmitter notes

9.2.1. Hitec Eclipse 7 with 90 CCPM

This is not supported directly by the transmitter, and must be done using programmable mixes. This was taken from the Ikarus Forums:

Quick guide on how to set up your Hitec Eclipse 7 for the ECO 8 using the stock 90 deg swash without the need for mechanical mixing.

First thing you need to do is set up your RX like this;

- Channel 1 - Aileron. Left servo on swashplate.
- Channel 2 - Elevator. Rear servo on swashplate.
- Channel 3 - Throttle. Goes to the ESC.
- Channel 4 - Rudder. Tail servo.
- Channel 6 - Pitch. Right servo on swashplate.

Now we move to the TX. Use the manual to set yourself up a 180 degree swashplate helicopter.

OK, here is where we actually get the swash to work correctly. If you turn you RX and TX on (engine disconnected please) and increase and decrease the throttle you will see that the swashplate tilts back and forth. This is not desired behavior. What we need to do is get those pitch movements working on the servo on the back (Channel 2).

To do this we are going to use one of the Programmable Mixers on the TX. To do this we have to enter "Programming Mode", it is done like this;-

1. Make sure your ECO's battery is disconnected and your TX is on (and your ECO is selected)
2. Hit the first two buttons at the same time on the bottom left (Edit up and down, not Engine lock cut). The TX should now have something like EPA 100% on it.
3. Hit the Edit up button (First button on the left) 6 times until you see PMX1 inh (stands for Programmable Mixer 1 Inhibit).
4. Hit the Active/Inhibit button (Last button on the Right) the display will change and have a lot of junk on it.
5. Select the Master Channel by hitting the Cursor Right button (4th button).
6. Set the Master Channel to 6 by hitting the Data Increase button 5 times (5th Button).
7. Select the Slave Channel by hitting the Cursor Right button (4th button).
8. Set the Slave Channel to 2 by hitting the Data Increase button once (5th Button).
9. Select the Mix Ratio by hitting the Cursor Right button (4th button).
10. Select the Mix Ratio to 70% by hitting the Data Decrease button 30 times (6th Button, and

you can just hold it down, you don't really need to do it 30 times).

11. Turn on the mixer by switching the top right switch toward you. The screen should now look like this;-

12. You're done!! Exit from Programming mode (first two buttons at the same time on the bottom left) hook up your ECO (engine disconnected still) and move the throttle, the swash should now move up and down smoothly.

    Some quick notes that may come in handy;-

    - You may need to reverse some servos.
    - Pitch and throttle curves must be setup now to complete the setup

9.2.2. Hitec Eclipse 7 and yaw rate gyros

The Eclipse 7 revo mixing seems to be based on the throttle curve, not the stick position. Therefore when flying a CP heli with a yaw rate gyro, you will need to configure a programmable mix to mix the pitch channel into the rudder channel.

9.2.3. Hitec Eclipse 7 bug

Some of the older Eclipse 7s have a firmware where if you pull the throttle down all the way, the throttle will go to 100% instead. This is very dangerous - if you are buying a used Eclipse 7 beware of this bug.

9.2.4. Hitec Optic 6 problems

Some people have reported problems with model memory 1 and/or random switching between mode 1 and mode 2 stick configurations. See this thread for more info: http://www.rcgroups.com/forums/showthread.php?t=492204

9.2.5. Futaba 7C bug

People have reported that setting the throttle timer to operate at part throttle will erase the channel 1 endpoint settings and set the right endpoint to zero.

9.2.6. JR 10X Airplane

The JR 10X Airplane does not support helicopter modes and is not recommended for flying helicopters.

9.3. Transmitter tray

A transmitter tray can help your helicopter flying skills. It holds the transmitter at a natural angle which allows better control of the joysticks. Petal Manufacturing makes nice transmitter tray which works with most transmitter models.

9.4. Transmitter hand position

There are two basic ways of controlling the transmitter joysticks: either thumb and forefinger (sometimes called "pinch"), or thumb only.

If you have no prior R/C aircraft experience, then the preferred way to control the joysticks is by the thumb and forefinger method. This method allows the most precise stick control and sensitivity.

For the thumb and forefinger method, make the letter "O" with your thumb and forefinger and lightly pinch the tip of the joystick with the thumb and forefinger. The ball of the thumb rests on the corner of the controller for support and the tip of the pinkie lightly touches the side of the controller. You will need to place the controller on a table (or use a transmitter tray) to use this method because it will be difficult to support the controller while moving the joysticks. It may help to lengthen the transmitter sticks for better sensitivity when using the thumb and forefinger method.

The alternate method of controlling the joysticks is the thumb-only method. This method may be easier for people who have videogame playing experience because the hand position is similar to a Playstation joystick. In this method. the pad of the thumb is placed on top of the tip of the joystick, and the other fingers curl under the controller and hold it.

9.5. Transmitter manuals

Many manuals are available for download:

- Futaba transmitter manuals are available at: www.futaba-rc.com
- JR Propo transmitter manuals are available at www.horizonhobby.com
- Hitec transmitter manuals are available www.hitecrcd.com
- Airtronics/Sanwa manuals are available at www.airtronics.net
- Multiplex transmitter manuals are available at www.multipexusa.com

Chapter 10. Helicopter Construction

10.1. General tips for all helicopters

10.1.1. Building

Do not rush building the helicopter. Take your time and be very careful with everything, and make sure everything moves smoothly. If all moving linkages do not move smoothly, then the helicopter may have vibration problems later which will make hovering very difficult. A few extra hours spent making sure linkages move smoothly will pay off later when you shorten your hovering learning time by a few months.

10.1.2. Threadlock

Only use threadlock on metal-to-metal areas. Do not use threadlock on:

- metal-to-plastic areas
- plastic-to-plastic areas
- setscrews (will become nearly impossible to remove)
- bearings

Blue threadlock is temporary, for stuff which may require disassembly later (after a crash, etc). Red threadlock is permanent, for stuff which will never be disassembled.

Example:

- Blue threadlock for the tail blade grip screw
- Red threadlock for the swashplate ball screws

To disassemble loctited parts, apply heat of over 100C/212F. This should soften the loctite enough to remove the parts.

10.1.3. Gear lubrication

Do not lubricate any exposed gears. This will only make the gears sticky and pick up grit, which will cause premature gear wear. It is okay to grease gears in enclosed gearboxes such as the Corona tail gears. When using lubrication, be sure to use a grease which will not soften plastic, such as a silicon or lithium grease. Tri-flow synthetic grease (available at most bike shops) also works very well.

10.1.4. Frame assembly

When assembling a plastic frame with metal screws (e.g. ECO 8/16 and Logo 10) be sure to use a jeweler's screwdriver or a Wiha with a small handle to assemble the frame. If you use a large-handled screwdriver you will not be able to feel when the screw is fully inserted and you will probably strip the hole in the plastic frame.

10.1.5. Stripped threads

If you strip a plastic screw or setscrew hole, then you can fix it by squirting a small bit of CA into the screw hole and letting it dry to give the screw additional friction. But, it's better not to strip it in the first place.

10.1.6. Breaking-in motors

If you are using a brushed motor with carbon brushes, then you should "break-in" the motor before your first flight. This break-in procedure allow maximum contact of the brushes with the commutator. This will allow the motor to run at maximum efficiency and extend motor life.

Break-in is not required for these motor type:

- Metal brushed motors. This includes motors such as the Team Orion Elite Micro Modified motor.
- Micro heli tail motors. This includes both the gray and black endbell GWS IPS-style motors, and the N20 style motors.
- Brushless motors. Brushless motors do not have brushes and therefore require no break-in.

There are at least two ways to do this:

- Dry method: Run the motor for two hours at 1/4 throttle.
- Wet method: Run the motor for 10-15 minutes in a glass of water.

Be sure to disassemble the motor afterwards and throughly dry everything, otherwise parts may rust. Don't use this method on motors which are assembled using bent metal tabs (such as the Piccolo motors) because the metal tab may break off when disassembling or reassembling the motor.

Be careful with the carbon dust. It can get into your lungs and cause severe breathing difficulty, especially if you're asthmatic.

Be sure to blow the carbon dust out OUTSIDE with some compressed air and don't get the carbon dust into your lungs.

10.1.7. Carbon dust

Beware of carbon fiber dust. It is classified as a hazardous material and can cause severe breathing difficulty, especially if you are asthmatic.

Warning

DO NOT CUT CARBON FIBER INDOORS. ALWAYS CUT CARBON FIBER OUTSIDE.

10.1.8. Capacitors

If you are using a brushed motor, be sure to solder three capacitors to the motor: one between the positive terminal and negative terminal, one between the postive terminal and case, and one between the negative terminal and case. This will reduce the amount of interference generated by the brushed motor.

10.1.9. Motor diode

If you are using a brushed motor, it may come with a diode which you may need to attach to the motor. The diode looks like a black barrel with a grey stripe on one side, and two leads coming out each end.

This diode prevents ESC damage by shunting the spikes of reverse current generated when the brushed motor rotates. So, you put the diode on the power terminals of the brushed motor. The end with the silver band goes on the postive terminal of the motor, and the end with no band goes on the negative terminal of the motor.

10.1.10. Ball links

Your ball links must move freely, but not be loose. If your ball links are too tight, you can put the ball link on the ball and gently squeeze around the edge of the ball link with a pair of slip-joint or ball-link pliers.

If your ball links are too loose, then they can be tightened by removing them from the ball then squeezing them gently across the face of the ball link with a pair of slip-join or ball-link pliers.

10.1.11. Motor shaft

For motors with 3.17mm shafts or larger: If your motor output shaft does not have a "flat" on the shaft, the pinion may spin around on the shaft because the setscrew can't grip the shaft. To put a flat on the shaft you need a Dremel with a diamond grinding tip, some masking tape, and a plastic bag.

- Cut off about eight pieces of masking tape about 3 inches long. Take four of the pieces and make a # pattern across the front of the motor so the # will slightly overlap the shaft. Take the remaining four pieces and make another # across the front about 45 degrees offset from the previous tape, making sure it slightly overlaps the shaft again. This should completely cover the front bearing and will prevent metal bits from falling in.
- Put the motor in the plastic bag, then punch a hole in the plastic with the motor shaft so the motor shaft sticks out the bottom. Tie the back end of the plastic bag. This will prevent metal shavings from falling into the motor and destroying it.
- Grind a flat on the shaft using a Dremel with a diamond bit. Hold the Dremel so the metal bits are ejected AWAY from the front bearing of the motor.
- Use some masking tape and wrap it around the shaft a few times to collect the loose metal bits sticking to the shaft.
- Remove motor from plastic bag, being careful not to get any metal shavings into the motor.
- Remove remaining masking tape from the motor.

10.1.12. Brushless motor wires

If the wires between the ESC and brushless motor are too long, then shorten the wires from the ESC, not the motor wires. The brushless motor wires are usually enamel-coated copper wires from the stator windings and are difficult to solder if cut.

10.1.13. Canopy painting

Do not paint the canopy a dark color. You will need to focus on the canopy while learning to hover, so be sure to paint it a bright color or leave it white.

Also, some kind of decals are recommended to make it easier to see the orientation of the canopy at long distances.

10.1.14. Tail servo

Do not use rubber servo grommets when mounting the tail servo because this will cause tail wag when used with a heading hold gyro.

10.1.15. Mounting component

For micro helis: you can mount a gyro or tail servo on the tailboom by using either a cable clip or cable tie mounting plate. If you use a cable tie mounting plate, you may need to use two tiewraps to secure the mounting plate to the tail boom and/or use some hot glue to prevent the mounting plate from sliding on the tail boom.

10.1.16. Ball in swashplate

For FP micro helicopters: many micro helicopters do not include a swiveling ball in the swashplate to minimize slop. This makes the helicopter very difficult to hover.

There are upgrade kits which allow you to install a ball-in-swash on most micro helicopters. These are highly recommended. Like90 sells one, so does Pierre Hollister. See links section for URLs.

For even better control, you should put a small piece of fuel tubing above and below the swashplate ball to prevent the swashplate from moving up and down.

10.1.17. Removing CA glued joints

If you need to weaken the CA glue to remove a part, you can use acetone. Most regular fingernail polish removers contains acetone but the odorless types do not contain acetone and will not work. You will need to soak the glue in acetone for a while which will weaken the glue, then you should be able to remove the part.

10.2. Specific tips for LMH Corona only

- Many Corona kits seem to have missing parts. If you are missing a part and you bought the kit directly from Lite Machines, call them and explain your situation. If you bought from a retailer and not Lite Machines, then talk to your retailer about the missing parts. You may want to finish most of the model before reporting missing parts so you don't need to call multiple times.
- The general consensus on the Ezone regarding the Fusion-7 motor is it's not very good. People have reported the motor dying after as few as 5-10 flights. The Kyosho Atomic Force seems to be the best alternative brushed motor. It is available from Tower Hobbies.
- Make sure there is enough room between the two cyclic servos for the servo arms to rotate freely without hitting the other servo. If the servo arm rubs against the other servo, your front/back cyclic control will be sluggish and hovering will be very difficult.
- The manual recommends using one 4 dot blade grip and one 6 dot blade grip, but the heli is more stable and easier to hover if you use two 4 dot blade grips because the headspeed

is higher. Later on if you want more lift you can switch one of the blade grips to a 6 dot blade grip.

- If you are at a high elevation, you may not get enough lift using two 4 dot blade grips, however. In this case, you should use the manual-recommended grips.
- The labels on the main rotor blades seem to be attached using the world's stickiest adhesive. The residue from the adhesive can be easily removed using WD-40 or Goo Gone.

Warning

DO NOT USE ACETONE. ACETONE WILL MAKE THE BLADES BRITTLE. THE BLADES MAY SHATTER WHEN THEY HIT AN OBJECT.

- The Fusion 35 controller on the LMH Corona is a relabeled Castle Creations Pegasus 35.
- The Fusion 35/Pegasus 35 seems to have trouble arming on many transmitters. If you turn on the transmitter, then turn on the Corona and do not hear two beeps, then you are having this problem. To fix this problem, you need to set a lower endpoint for the throttle channel on your transmitter. For a Futaba 9C, go to Menu->End Point->THR and set it to 125/125.
- Many people make "tail boom protector" for the Corona to protect the tail boom from boom strikes. This is usually foam wrapped around the tail boom or a strip of 1/4 thick balsa or 3/8 dowel tie wrapped to the tail to prevent the rotor blades from denting/bending the tail boom. Other people use a "rotor deflector" which is a piece of wood or angle aluminum mounted on the tail to deflect the rotor blade.
- The feathering plate should be parallel to the swashplate. If these are not parallel, then you may need to loosen the main shaft and slide the main shaft down a little bit until the two are properly parallel.
- The newer Corona tail gearboxes appear to be much more fragile than the older ones. One option is to use an aftermarket tail gearbox such as the Ballistic Technology or Chopper-1 gearbox.

10.3. Specific tips for all Piccolo (Fun/ECO/CP upgrade/Pro)

- The stock plastic motor pinion may slip on the motor shaft. We recommend using CA to glue the motor pinion onto the motor shaft to prevent this from occuring.
- Drill a hole through the landing skid (67361) so the struts (67378) will go all the way through the skid. This will make the landing skid much stronger. If you don't do this, then the nipple on the landing skid will probably break off in a hard landing.
- When building the landing skids (67361), use thick CA instead of the thin CA included in the kit. The thin CA runs all over the place and is difficult to get in the right place. Also, CA the rear skid struts into the frame FIRST. Then CA the front skids into the frame and make sure they almost align with the rear skid struts. If you don't do this the landing skids will probably be crooked.
- Do not use CA to glue in the tail boom. This usually works too well. When you crash, it will be almost impossible to remove all the tail boom bits and you will have to drill out the remaining pieces. It is much better to put a few layers of CA on the ends of the tail boom and let this dry thoroughly, then friction-fit the tailboom into the body and the tail rotor assembly.
- The landing skids may pop off the frame in even mild landings. You can reinforce the landing gear by CAing a length of CF rod across the front and rear landing gear skids about a

half-inch (1.25cm) below the chassis (67360). This absorbs most of the landing stress that would normally pop the landing skid struts off the frame.

- The Piccolo tends to lose the bearings on the hub (67566) on hard crashes. You may want to purchase an aftermarket aluminum hub or carefully thick CA the bearings to the stock hub to avoid losing the bearings. Beware when purchasing an aluminum hub; some of them appear to be made from soft aluminum and will bend easily. I do not recommend J's aluminum hubs for this reason. The Precision Model Products hubs are of much better quality.

10.4. Specific tips for fixed pitch Piccolo (ECO/Fun) only

- The stock Piccolo FP has excessive play in the control mechanism. Specifically, the swashplate wobbles around too much. There are two mods which are required to fix this: the ball-in-swash mod and the Chris Rigoleth antirotation strap. These will make your initial hover attempts somewhat easier.
- The older FP Piccolo kits had a anti-rotation link (67366) with only a single hinge rather than the newer double hinges. If you receive a one of these single hinge anti-rotation links, they do not work well, and I recommend you replace it with a newer double-hinge one.

10.5. Specific tips for collective pitch Piccolo (CP upgrade/ Pro) only

- The pitch case (68211) will usually be too tight on the main rotor shaft (68203). This will cause drag on the motor. To fix this, put a 3mm drill bit into Dremel, then put the pitch case onto the drill bit, then run the Dremel at low speed for about five minutes. Hold the pitch case very gently to prevent it from spinning around. After this, lubricate the inside of the pitch case with some graphite to further reduce friction.
- The M2x6 screw which holds in the pitch bellcranks (68212) will usually rub against the flybar control levers (68209). To fix this problem, put the M2x6 screws into a drill and hold the head of the screw against a metal file to shave down the screw head. This will prevent the screw head from rubbing against the flybar control lever.
- Some CP upgrade kits include an older style flybar (68208) which is not very good. The older style flybar is completely smooth and does not have the grooves stamped into the flybar to prevent the control arms (68209) and flybar paddle (67371) from slipping. If you have one of these flybars, you should replace it, because it will be almost impossible to prevent the control arms from slipping on the older flybar even if you roughen the flybar.
- The Piccolo CP/Pro head has some cyclic interaction. For example, when you apply forward cyclic, it tends to go forward and left, and back tends to go back and right. Therefore, you will need to use aileron/elevator and elevator/aileron mixing to compensate for this problem.

10.6. Specific tips for the MS Composit Hornet II

This is a very difficult kit to build. There are many tiny nearly invisible parts, so please be careful not to lose any parts! There are some parts which are too tight on the Hornet II. This is an explanation of the "enlarging the hole" trick used in many of the following Hornet II steps:

- Put a 2mm drill bit on a drill

- Slide the part onto the drill bit
- Hold the part with your fingers
- Turn on the drill at low speed
- Using your fingers, Move the part in a circular motion so the drill bit will touch the sides of the hole to widen it slightly.

There are a few steps which involve CAing together two smooth plastic parts or a plastic part and a carbon fiber part. The CA will not adhere well to smooth parts, so you should roughen the areas to be glued with 400 grit sandpaper for better adhesion.

Making CA joints

Step 1 - Main Body Assembly:

The joint between the frame base (E402) and the frame support (E403) will be much stronger if you use 400 grit sandpaper to roughen the area underneath the frame support so the CA will stick better.

Step 2 - Tail Rotor:

Do not force the bearings onto the tail drive shaft (E417). If you try to force the bearings onto the shaft, the shaft may split. It is much better to use some 400 grit sandpaper to sand down the shaft slightly so the bearings will slide on.

Step 2 - Tail Rotor:

The pinion (E118) and the gear (E028) which are supposed to fit on the ends of the tail drive shaft (E417) have holes which are too small and the gears will get stuck halfway onto the shaft. Please use the "enlarging hole" trick so the pinion can be slid onto the shaft without becoming stuck. If you widen the hole too much, then the gear/pinion may slip. You can fix this by smearing some thin CA into the crack between the pinion and shaft *AFTER* you have put the gear/pinion on the shaft.

Step 2 - Tail Rotor:

The bell crank (E026) will not pivot smoothly on the tail gearbox (E425). There are multiple problems which must be fixed for this bell crank to pivot smoothly:

- The bell crank is too tight on the tail gearbox. You will need to do three things to fix this problem:

  i. Polish the pivot pin with some extra-fine sandpaper (800 grit or better)

  ii. Use the "enlarging hole" trick on the bellcrank pivot hole to enlarge it slightly.

  iii. Use the "enlarging hole" trick on the bellcrank hole for the slider cage CP (E091). Be very careful enlarging this hole because it doesn't need to be enlarged much.

- There are bits of flashing left on the tail gearbox (E425) in two places which rub against the bellcrank. These look like small circles. Use some masking tape to protect the bearings from the plastic dust, then use a small needle file to remove the flashing so the bellcrank (E026) pivots smoothly.

- Use powdered graphite to lubricate the bellcrank pivot hole before using CA on the plastic retainer (E027).

Step 2 - Tail Rotor:

The holes in the tail hub (E431) are not tapped very well. Screw in a stainless steel M2 screw into both holes of the hub to clean up the threads before inserting the M2x8 bolts (E058).

Step 3 - Rotor Head Assembly:
At this point you will have six bearings: four 2x6x2.5 and two 2x6x2. Be sure to use the 2x6x2.5 for the main blade grips! The bearings look very similar!

Step 4 - Rotor Head Assembly:
Squirt some powdered graphite through the flybar hole in the stabilizer lever (E072) to reduce friction and allow the flybar to rotate smoothly.

Step 4 - Rotor Head Assembly:
Be sure to tighten the grub screw(E083) just enough so you can see a tiny gap between the stabilizer lever (E072) and the stabilizer bed (E073) on both sides. This will ensure the stabilizer lever pivots freely without rubbing against the stabilizer bed.

Step 5 - Rotor Head - Completion:
The ball link diagram labeled "2x" is incorrect. The diagram shows two short ball links connected by a bolt. The ball link labeled E021 should be a LONG ball link, not a short ball link.

Step 6 - Helicopter Construction:
There are two places in this step (4 and 14) where it calls the E419 the "Vertical Fin Holder". This is incorrect. It should read "Horizontal Fin Holder". There is no vertical fin holder.

Step 6 - Helicopter Construction:
If you glue the vertical fin to the tail boom, it will be difficult to remove when replacing the tail boom. I recommend drilling four 2mm holes in the vertical tail fin and using two nylon tiewraps to secure the tail fin to the tail boom without using CA.

Step 7 - RC Installation:
I recommend putting a piece of 1/8" or 3mm plywood underneath the front servo mount to give extra clearance to the servo arm. Additionally you should trim the same amount off the ball link to compensate for the raised servo.

10.7. Specific tips for Ikarus ECO 8/16 only

If the ECO 8/16 is built strictly by the manual, you will create a helicopter which has extremely tight linkages and will have severe vibration problems and will be difficult to hover. Please follow these tips so your ECO 8/16 will fly well.

- It is possible make the ECO more durable and crash-resistant by "doubling up" the sideframes. To do this, buy another set of sideframes, and epoxy each set together - don't forget to rough up the mating surfaces of the sideframes with 200 grit sandpaper first for better epoxy adhesion. You will need to replace the M2x8 with M2x10 screws, and also replace the M2x30 screws with two extra-long M2 bolts or two M2 threaded rods because the M2x30s will be too short to reach through the tail boom mounts. The double frames will add about 41 grams to your AUW and reduce your flight times by about 30 seconds, but the frame will be much stiffer for better control and also survive most crashes.
- The stock ECO 8 landing gear is a bit narrow and makes landing difficult for beginners. You may want to replace it with the ECO 16 landing gear (67916 + 67917) or the ECO 8/16 extra wide landing gear (67822).

  The ECO 16 landing gear is about 1 inch longer and two inches wider than the stock ECO 8 landing gear. This landing gear will need slight modifications to work on the ECO 8 because it is designed to hold two battery packs.

The ECO 8/16 training gear is about 1 inch longer and 3.25 inches wider than the stock ECO 8 landing gear. This can hold either one or two battery packs and requires no modification.

Both the ECO 16 landing gear and the ECO 8/16 training gear use the ECO 16 skids (67917) which are wider in diameter.

- The control balls on the plastic swashplate (67701) have been known to break off on extremely hard crashes. You may want to upgrade to the aluminum swashplate (67707) immediately. Also, the aluminum swashplate can be configured to support 120 CCPM which offers better control than 90 CCPM.
- The stock main rotor shaft (67535), the stock feathering shaft (67509), and the stock tail rotor shaft (67550) are very soft and bend easily in minor crashes.

  If this happens, I highly recommend replacing them with the hardened versions: 67940, 67942, and 67941 respectively.
- I don't recommend using the mechanical mixer, because electronic mixing works much better than the mechanical mixer. If you do choose to use the mechanical mixer anyway, you will need fairly strong servos because the mechanical mixer needs a lot of force to move it around. Probably HS-81s are not adequate for mechanical mixing - you need at least HS-85BBs.
- The stock wooden main rotor blades are fairly durable and are very good for beginners because they will survive minor crashes. I would recommend using the stock wooden main rotor blades for as long as possible - definitely while learning hovering in all orientations.
- Pg 6: The tail drive belt pulley (67702) may wobble because the hole is not drilled exactly in the center of the pulley. This usually does not cause problems, but in some cases the hole is very out of center, and the tail belt may slap against the tail boom as it spins up or while it's flying. In this case, it is advisable to replace the tail belt pulley with a new one that is hopefully better, or replace both pulleys with the Voyager E rear belt pulleys (060860), or replace both with aftermarket aluminum pulleys (PMP ATPS).
- Pg 6 and 13: It is best to prethread the setscrews (67574) into the plastic pulleys (67702) before mounting the pulley onto the shaft. This will reduce the chance of stripping the setscrew hole. You should use a small nutdriver (Wiha #263 or similar) to tighten the setscrews.

  If you accidentally strip the hole, you can repair the hole by using the CA trick mentioned in the general construction tips section.
- Pg 8: If the aluminum skids (67563) are difficult to fit into the undercarriage cross member (67562) try using a hairdryer to heat the cross member until it softens slightly, then slide in the aluminum skids.
- Pg 9: When building the pitch compensator, the manual does not mention the arm (67591) has a *TAPERED* hole for the pin. If you try to force the pin through the narrow hole instead of the wide one, this may cause damage to the arm.
- Pg 9: The two collective pitch compensator arms (67591) will rub against each other on a stock ECO, which is bad. You should put an M2 washer between each arm (67591) and the hub (67590) to increase the spacing between the arms.
- Pg 10: The flybar seesaw (67610) usually does not seesaw smoothly on the rotor center unit (67639). This flybar seesaw needs to move very smoothly on its pivots otherwise this will cause vibrations when hovering.

To fix this problem, take some extra-fine steel wool (#000) and spread it with your fingers to make a very thin mesh. This mesh should be about 1 inch by 1 inch and be mostly air with about 50 or 60 strands of steel wool running through it.

Remove the flybar seesaw, then put the steel wool mesh on top of the pivot, then mash the seesaw on top of it so the steel wool is trapped between the pivot and the seesaw. The seesaw should snap on with moderate pressure; if you need too much pressure then your steel wool mesh is too thick.

Now wiggle the seesaw up and down about 10 times, then remove the steel wool and check if the seesaw pivots smoothly. If it still does not pivot smoothly, then repeat this process. Do not repeat more than twice because this will wear out the pivot. For the final finish, apply some powdered graphite onto the pivot. After this, the seesaw should move very smoothly.

- Pg 10: The flybar (67609) usually does not rotate smoothly in the flybar seesaw (67610). You MUST make the flybar seesaw rotate smoothly in the flybar seesaw otherwise the heli will be very difficult to hover. You will need to push the flybar through the flybar seesaw repeatedly (like playing a violin) for about 5 minutes until the rod slides smoothly through the flybar seesaw. This will make the heli much more stable and easier to hover.
- Pg 11/update: (Advanced) You can give make a free tail pitch slider upgrade by installing a brass ball on the outer slide ring (67643). You must do this modification BEFORE the needle bearing (67644) is installed inside the outer slide ring. Cut off the plastic ball from the outer slide ring, then drill a 1.5 mm hole where it was. Take an M2x8 screw and a brass ball, and screw it into the 1.5 mm hole. Look inside the outer slide ring and check how much of the screw protrudes inside. Remove the screw and trim it to size, then CA the screw and brass ball into the outer slide ring.
- Pg 12: The diagram does not show this, but you will need to bend the top of the 93mm ball link very slightly (maybe 5-10 degrees) to ensure it does not rub against the flybar when the swashplate is at the bottom of its travel. Check to make sure the ball link does not rub against the flybar seesaw (67610) when the swashplate is moved up and down. If the ball link rubs against the flybar seesaw, then reduce the angle of the bend. This bend slightly increases the usable negative pitch range.
- Pg 13: The tail rotor shaft (67550) is asymmetrical and one notch is closer to one end than the other. The shaft end with the notch FARTHER from the end should slide into the pulley (67702), not the blade grip hub (67549).
- Pg 13: The tail blade grips (67542) should controlled by the leading edge of the blade, and not the trailing edge. If the tail blade pitch is controlled by the trailing edge, the tail may wag. Double-check and make sure the Ikarus logo on the tail blades is visible from the right side of the heli, and the control ball for the tail blade grips is on the leading edge of the blade.
- Pg 13: There is a serious problem on this page. In some versions of the English manual, the instructions do not mention using threadlock on the screw holding the tail blade grip (67603) to the tail hub (67549). The German version of the manual correctly tells you to use threadlock on this screw. If you fail to do this your tail rotor grip may fall apart in flight causing the heli to pirouette out of control. Do not skip the threadlock on this screw! Also, if you disassemble and reassemble the tail rotor later, don't forget to reapply fresh threadlock on this screw!!
- Also, be sure the screw tail blade grip is left slightly loose so it can rotate freely on the ball bearing and screw. If the tail blade grip is screwed too tightly to the tail rotor hub, then the tail may "wag" because the mechanics may bind and gyro will have trouble controlling the tail blade pitch.

You should check the play in the tail blade after installing the tail blades. There should be approximately 12 mm (half inch) of play in the tail blades. If you have significantly less or more play, then you should remove the tail blade and readjust this screw.

- Pg 13: The M2x6 screw (67561) should not be screwed too tightly into the short ballend (67564) on the tail. If the screws are too tight,then the tail pitch lever will not move smoothly around the middle of its range because the ballends will not be free to flex outwards. To adjust this screw properly, screw it in completely, then reverse it approximately one-eighth turn. This should be about right but you should check the pitch lever movement to verify it moves smoothly.

- Pg 13: The pitch lever (67541) must move VERY freely on the tail housing (67548). On an unmodified ECO this is very sticky, which will make the tail "wag" with a heading hold gyro!

  To fix the stickiness problem, rub the post where the pitch lever mounts with some extra fine steel wool to remove the grooves left from the molding process. Next, apply some powdered graphite to the post and to the inside of the pitch lever and mount the pitch lever. Wiggle the pitch lever a few dozen times to spread the graphite. The pitch lever should now move very smoothly.

- Pp 16-21: Don't use servo grommets to mount the servos to the frame. Instead, cut a 4mm length of very small fuel tubing and slide this onto the M2 screw. When this tubing is compressed, it will fatten out and fill the gap between the servo and screw.

- Pp 16-21: If you are using the aluminum swashplate with 120 CCPM, mount one servo in front and two in the back at the 12 o'clock, 4 o'clock, and 8 o'clock positions. This is easier to mount than two servos in front and one in back. You will need to fiddle with the transmitter swashplate setting to swap the front and back with this servo configuration (SWASH AFR on the Futaba 9C).

  Note: This servo arrangement will not work with a frame brace (because the front servo will hit the frame brace) nor will it work with a stock Hacker B50 heatsink (because the heatsink will hit the frame brace). The Hacker B50 heatsink will require about a 1.25" section of it removed so it doesn't interfere with the front servo.

- Pg 22: The suggested component placement will work if your gyro requires mounting on a vertical surface but does not work well if using a gyro which requires mounting on a horizontal surface such as a Futaba GY240 or GY401. If using these gyros, then mount the gyro on top of the tail boom support behind the shaft (instead of the receiver) and mount the receiver upside down under the tail boom support (where the frame is angled). This component placement keeps the ESC far away from the receiver and gyro and prevents radio glitching problems.

10.8. Specific tips for Logo 10 only

- See www.logoheli.com for excellent construction tips

- Some Logo 10 kits are missing parts and/or including the wrong sized ball links. If your kit has this problem, you should contact the retailer who sold you the kit and explain your problem.

- Many Logo 10 owners have reported the tail belt builds up static electricity in the tail boom. This can cause glitching and/or ESC failure. Extreme care must be taken with component placement.

- The Logo 10 stock plastic swashplate has been known to separate in flight. This leads to loss of control and probably a crash. You may want to immediately upgrade to the aluminum swashplate to avoid this situation.

- The Logo 10 tail wire guides are not very good. They are not adjustable and the pushrod tends to bind in them. I recommend replacing these guides with an adjustable set, such as the K&S 529 "Special Control Rod Guide Set".

Chapter 11. Helicopter Electronics Mounting/Wiring

11.1. Channel assignments

Note

The channel assignments are determined by the transmitter, not the receiver. For example, when using a Futaba transmitter with a JR negative shift receiver, you must use the Futaba channel assignments.

11.1.1. Futaba/Hitec transmitters

If you have only two servos controlling your swashplate (with either non-CCPM or any CCPM) then the channel assignments are:

- channel 1: left/right (roll) servo
- channel 2: front/back (pitch) servo
- channel 3: throttle (ESC)
- channel 4: gyro control (tail servo or tail ESC plugs into gyro)
- channel 5: gyro sensitivity (optional)
- channel 6: collective pitch servo (for CP helicopters such as Shogun)

If you have three servos controlling your swashplate (either non-CCPM or any CCPM) then the channel assignments are:

- channel 1: right (roll) servo
- channel 2: front/back (pitch) servo
- channel 3: throttle (ESC)
- channel 4: gyro control (tail servo or tail ESC plugs into gyro)
- channel 5: gyro sensitivity (optional)
- channel 6: left (roll) servo

11.1.2. JR transmitters

If you have two servos controlling your swashplate (either non-CCPM or any CCPM) then the channel assignments are:

- channel 1: throttle (ESC)
- channel 2: left/right (roll) servo
- channel 3: front/back (pitch) servo
- channel 4: gyro control (tail servo or tail ESC plugs into gyro)

- channel 5: gyro sensitivity (optional)
- channel 6: collective pitch servo (for CP helicopters such as Shogun)

If you have three servos controlling your swashplate (either non-CCPM or any CCPM) then the channel assignments are:

- channel 1: throttle (ESC)
- channel 2: right (roll) servo
- channel 3: front/back (pitch) servo
- channel 4: gyro control (tail servo or tail ESC plugs into gyro)
- channel 5: gyro sensitivity (optional)
- channel 6: left (roll) servo

11.1.3. Multiplex transmitters

The Multiplex Evo transmitters can also use the Futaba or JR channel assignments instead of the Multiplex channel assignments.

If you have three servos controlling your swashplate (must be CCPM) then the channel assignments are:

- channel 1: right (roll) servo
- channel 2: front/back (pitch) servo
- channel 3: gyro control (tail servo or tail ESC plugs into gyro)
- channel 4: left (roll) servo
- channel 5: throttle
- channel 6: gyro sensitivity (optional)

11.1.4. Airtronics/Sanwa transmitters

If you have only two servos controlling your swashplate (either non-CCPM or any CCPM) then the channel assignments are:

- channel 1: front/back (pitch) servo
- channel 2: left/right (roll) servo
- channel 3: throttle
- channel 4: gyro control (tail servo or tail ESC plugs into gyro)
- channel 5: gyro sensitivity
- channel 6: collective pitch servo (for CP helis such as a Shogun)

If you have three servos controlling your swashplate (must be CCPM) then the channel assignments are:

- channel 1: front/back (pitch) servo
- channel 2: right (roll) servo
- channel 3: throttle
- channel 4: gyro control (tail servo or tail ESC plugs into gyro)
- channel 5: gyro sensitivity
- channel 6: left (roll) servo

11.2. Component placement

- Mount the ESC close to the main motor and the battery. The battery-to-ESC and ESC-to-motor wires carry high power switched current and will radiate interference, so keep these wires as short as possible. Do not shorten the wires from the motor, because motor wires are difficult to solder after cutting. Shorten the wires from the ESC which go to the motor instead.
- If you are using a brushed motor, the motor itself will be the main source of RFI. Pragmatically speaking, you want to keep your radio and gyro as far away from the brushed motor as possible. This will eliminate and/or reduce the number of radio glitches.
- If you are using a brushless motor, the ESC for the motor will be the main source of RFI. So, it is desirable to locate the radio and gyro as far away from the ESC as possible. On a Corona/ECO 8/Logo 10, I would recommend at least two inches of spacing between the ESC and the gyro/receiver.
- Switching BECs are also a source of electrical noise. A switching BEC should be placed close to the ESC and away from the gyro and receiver.
- Most gyros (GY240/GY401) require mounting on a horizontal surface, but some gyros (Ikarus Profi, CSM LW200, GWS PG-03) require mounting on a vertical surface. Be sure to check your gyro's documentation to see how it should be mounted on your heli!
- Make sure your gyro is mounted firmly to the frame and/or to a gyro mount which is firmly attached to the frame. Be sure to use the manufacturer-supplied double-sided foam tape or equivalent to attach the gyro to the frame or gyro mount. The double-sided foam absorbs high-frequency vibration which will cause a heading hold gyro to drift, so the tape is VERY important. DO NOT USE VELCRO to mount the gyro! Do not put a nylon tiewrap, velcro wrap, or other strap around the gyro and frame. This strap will transmit vibrations from the frame to the gyro case. Also, the strap will compress the mounting foam, which will prevent the foam from absorbing vibration.

  If a heading hold gyro is not FIRMLY mounted, then this problem will cause tail wag. This will occur because the gyro will be wobbling and will not sense the correct angular position, and will overshoot when trying to return the tail to the "correct" position.
- Do not shorten any radio/servo/gyro wires until you have flown a flight or two and have checked for glitching. You may need to move some components farther apart on the frame to eliminate glitching, and if you have shortened the wires this will be difficult.

11.3. Wire routing

- Ensure all electronic components which are sensitive to electrical noise (gyro and receiver) are placed away from the components which generate electrical noise (motor and speed controller).
- Try to route wires to/from electrically noisy components (ESC power, motor, and control wires, also all switching BEC wires) away from other wires. A good strategy is to route the noisy wires on either the left or right side of the heli, and all other wires on the other side. Do not coil excess wire. These coils of wire will act as an antenna and will amplify the generated or received electrical noise. Bundle the wire in an S-pattern instead.
- Do not cut the receiver antenna wire to shorten it, because this will detune the antenna and significantly shorten the receiver range. If you need a shorter antenna, use the proper Dean's antenna, Azarr antenna, or other antenna tuned to your frequency band instead.
- Place the antenna or antenna wire at least 1 inch (2.54 cm) away from any carbon fiber or metal frame parts.
- Ensure the expensive electronic components (such as the gyro and speed control) are located where they will not be easily damaged in a crash.
- Ensure all wires are securely fastened, especially the wires from the gyro. Dangling wires may cause tail wag problems.
- Put a strip of tape over the receiver crystal to ensure it will not vibrate in flight (which may cause glitching) or fall out of the receiver.

11.4. Soldering technique

Good solder joints are extremely important for an electric helicopter. Electric helicopters require extremely large amounts of current for even simple acts such as basic hovering.

If the battery and motor connections are not soldered correctly, then the motor may not receive enough current and the helicopter may lack power to fly properly.

The basic steps to forming a good solder joint are:

- Select the correct size soldering iron for the application

  If you are soldering small wires (about 20 gauge) then you should use about a 20 watt soldering iron. If you are soldering battery packs or larger (12-18 gauge) wires then you need at least a 40 watt soldering iron with a thick tip to have sufficient heat to solder properly. The Weller SP40L costs less than 20 dollars and is a very good soldering iron for soldering thicker wires.

- Use the correct solder

  You need ROSIN core solder for soldering electrical connections. Do not use acid core solder, because this solder is for applications such as plumbing and the acid will cause corrode the wires and connectors.

- Use the correct size heat shrink tubing (if necessary)

  Heat shrink tubing generally shrinks by 50%, so you will need tubing which is no larger than twice the size of the wire and/or connector in order to ensure a snug fit.

- Allow the soldering iron/gun to warm up

It requires approximately 750 degrees Fahrenheit to melt solder. If you try to solder before the iron/gun is fully heated, then the solder will not melt properly. If the soldering gun does not heat up properly and/or takes too long to heat, then the screws holding the tip have probably loosened, so not enough current is flowing to the tip. Disconnect the soldering iron, wait for it to cool, then tighten the tip.

- Slide heatshrink tubing onto the wire (if required)

  In some circumstances you cannot slide the heatshink onto the wire(s) after soldering, so you should slide the heatshink tubing onto the wire first.

  Make sure that you slide the heatshink tubing far enough away from the soldering area so it will not shrink prematurely from the soldering heat.

- Clean the surfaces to be soldered if necessary

  If you are soldering batteries together you will need to clean the surfaces with some sandpaper before soldering. This is not required for gold- or zinc-plated connectors or circuit boards which are already coated with solder, or for wires which have recently been stripped.

- Twist the wire conductors tightly together

  If they conductors of the wire are loosely twisted then they will not heat properly and it will be very difficult to solder them. If you apply a little extra twist just before soldering, they will be much easier to solder.

- Coat ("tin") the mating surfaces with solder (do not solder them together yet). If soldering wire to a gold-plated bullet connector or an Astroflight Zero-Loss connector, then do not tin the connector.

  This involves three steps:

  1. Touch the soldering iron to the surface to heat it
  2. Wait a few seconds to allow the surface to become hot
  3. Touch the solder to the surface and let the solder melt

  A common mistake is to apply the solder directly to the soldering iron/gun tip. This is not the correct way to solder and will create a hole in the soldering iron/gun tip after a while. The solder should be touched to the surface to be tinned. If it does not melt, then the surface is not hot enough.

- Touch the parts together then heat with a soldering iron

  This step is much easier if you clamp one of the parts with a small table vise to keep it from moving, and hold the other part with a wooden clothespin to avoid burning your fingers.

  Alternatively, you can drill a hole in a block of wood to hold bullet or Zero Loss connectors while soldering.

  When the the soldering iron is touched to the solder it should melt and merge with the solder on the other surface. After the solder has completely melted, remove the soldering iron tip and let the solder cool. Be sure not to move the parts while the solder is cooling.

- Visually inspect the soldering joint

  The solder joint should be smooth and shiny after the solder cools. If the solder joint looks dull and grainy, then the solder joint is bad and it should be reheated to let the solder flow properly. You may need to apply a little fresh solder so the fresh rosin will allow the solder to flow freely.

- Shrink the heatshrink tubing

  Heatshink tubing is best shrunk with a hairdryer on a high heat setting. Allow the hairdryer to warm up, then hold the heatshrink tubing in the hot air stream., Be sure to rotate the tubing so it heats evenly and shrinks without creasing.

- Be sure to WASH YOUR HANDS after soldering

  Most commercial solder is 60% tin and 40% lead. Lead is harmful to your body and causes lead poisoning which prevents calcium, iron, zinc and other minerals from being properly used by your body. Be sure to wash your hands after soldering before eating!!!

  Lead-free solder is becoming much more widely available. If you have the choice you should use this type.

Chapter 12. Post-Construction/ARF Checklist

These items should be double-checked before you attempt to fly your new helicopter. These items should be checked for both helicopters you have built yourself, and also for prebuilt ARF kits.

1. The main rotor blades should be mounted for the correct rotor head rotation. For most helicopters this is clockwise. For the Corona this is counterclockwise.

2. The tail rotor blades should be mounted for the correct rotation. Turn the main gear by hand so the main rotor blades are rotating in the correct direction, and the tail rotor blades should be rotating in the correct direction also. If the tail rotor blades are rotating in the wrong direction:

   i. Make sure the tail blades are not mounted backwards.

   ii. If the heli uses a belt-driven tail, then ensure the tail belt is twisted in the correct direction.

   iii. If the heli uses a gear driven tail, then ensure the the tail drive gears is meshing at the correct point on the main gear.

3. Check the meshing of all gears, and ensure they are not too tight. If your gears (including bevel gears and motor pinions) are meshing together too tightly, you will lose a lot of power and your flights will be very short.

   Make sure that the gear teeth only mesh together by about 3/4 of a tooth. This can be easily set by putting a plastic bag between the gears and squeezing the gears together, then removing the bag. You can check the mesh by holding one gear and rotating the other. If the gear mesh is correct, there should be some free play. This will allow the gears to transfer power more efficiently.

4. If using a tail belt drive, make sure it's not too loose nor too tight.

5. The flybar paddles should be an equal distance from the main rotor hub. You may need to loosen the flybar and slide it in or out to ensure the flybar paddles are an equal distance from the head. If using flybar weights, they should also be an equal distance from the rotor hub.

6. The flybar paddles should be parallel to each other. If you have the KSJ-624 paddle gauge set, then you should use these to align the paddles. (Not applicable to the Corona.)

7. The flybar should tilt very smoothly and easily. If you blow on the flybar paddle, the flybar should tilt. If the rotor head is built absolutely perfectly, then the flybar paddle should tilt down, then bounce and come back up. You should be able to keep the flybar paddle bouncing by blowing on it with the right timing.

   If the flybar does not tilt easily, then you will have very little cyclic control, which is dangerous. This problem must be fixed before you attempt to fly the model. To fix this, you may need to:

   i. Loosen some ball links using a pair of pliers or ball link sizing tool

   ii. Lubricate the flybar pivot with powdered graphite

Chapter 13. Helicopter and Transmitter Setup

Please disconnect the motor from the ESC when performing setup steps which do not require the main rotors to spin. If the disconnected ESC wires might touch each other when disconnected then you should wrap electrical tape around the connectors to prevent the ESC from being shorted.

Note

This section is very sequence-dependent, and you MUST perform the steps in this order.

13.1. Center of gravity setup

13.1.1. Fore/aft center of gravity balancing

The lengthwise CG of a helicopter should be at its main rotor shaft or slightly forward. Otherwise, the heli will have a tendency to drift forwards or backwards.

To check this, first install the heli's batteries. Rotate the main rotor so the blades are perpendicular to the body. Hold the main rotor blade grip closet to you and raise the heli up to eye level. Locate a wall corner or door jamb, and rotate the heli so you can see the vertical line of the wall corner behind the helicopter.

Now try to align the main shaft with the vertical line. If the main shaft aligns perfectly with the line, then no adjustment is necessary. If the nose is light, then you will need to pull the battery pack forward. If the nose is heavy, then pull the battery pack backwards. Repeat until you find the correct battery position to balance the heli correctly.

If you use a tail servo mount on the ECO, the battery pack will need to be shifted forward quite a bit to adjust the CG properly. If you do this, you will need to put a rubber band over the two front side frame pegs to support the battery pack.

If you use 8 cells on a Corona, the heli will be very nose-heavy. You will need to push the battery backwards as far as possible, and possibly add a little tail weight.

Note

Note: Do not add weight to adjust the left/right CG of the helicopter. This can be adjusted using the transmitter left/right cyclic trim later.

Note

If the CG is too far backwards and you have already pulled the battery as far forward as possible, then you may need to modify the frame to allow the battey to be mounted further forward. Avoid adding weight to the nose because a large amount of weight will be required to counteract the leverage of the tail.

13.2. Swashplate setup

13.2.1. Swashplate type setup

If your transmitter supports swashplate types, then configure your swashplate type according to the following chart. If your transmitter is not listed, consult your transmitter manual for the swashplate type.

Table 13.1. Swashplate type setup

	m CCPM	90 CCPM	120 CCPM	Notes
Futaba 7C	H-1	HE3	HR3	
Futaba 9C	SWH1	SWH4	SR-3	Ignore 4th servo for SWH4
Hitec Optic 6	NOR	n/s	120	
Hitec Eclipse 7	NOR	90	120	
Multiplex Evo	n/s	90	120	
Airtronics/Sanwa	NOR	CP4F	CP3F	

Note

You MUST set the swashplate type FIRST before any other settings because setting the swashplate type will erase the model memory on many transmitters.

Note

The 90 or 120 CCPM servo diagram in your transmitter manual may not match your model's servo layout. Your model may have one servo in front but the manual may have one servo in back, or vice versa. This will be fixed later in a later step by reversing the fore/aft cyclic mixing in the swashplate mixing menu.

13.2.2. Swashplate servo setup (CP heli only)

Note

This setup only applies for CP helicopters. Skip this section for FP helicopters.

Note

For this step, disconnect the motor wires from the ESC. This will prevent the motor from accidentally spinning. Do not rely on the Throttle Hold function.

Turn on the transmitter then power up the helicopter.

Remove any transmitter trim from the cyclic controls.

13.2.2.1. Swashplate servo reversing

Move the throttle stick up and down. When you move the throttle stick up, the swashplate should move up. When you move the throttle down, the swashplate should move down.

Some helicopters may be designed so the swashplate moves in the opposite direction. If your helicopter's directions say this is correct, please use this instead.

If some servos are not moving in the correct direction, then reverse the servo direction in the transmitter until all servos move correctly.

13.2.2.2. Swashplate servo centering

First, move the throttle stick to the center of its range. The servo horns should be perfectly horizontal when the throttle stick is in this position. If the servo horn is not horizontal, then remove the servo horn from the servo and rotate it before reinstalling it. It may help to rotate the servo horn 180 degrees before reinstalling, because the servo horn will only install at fixed angles.

After you have mechanically leveled the servo horn, you can electrically fine-tune the servo arm position by using the transmitter subtrim feature. This will allow you to change the servo rotation in very small increments. Second, adjust the linkages which link the swashplate to the servos so the swashplate is in the center of its travel range when the throttle stick is centered.

13.2.2.3. Swashplate leveling

Once the servo centering has been set, the swashplate should be:

- In the middle of its travel range
- Perfectly perpendicular to the main shaft.

There should be no tilt to the left/right or forwards/backwards.

If the swashplate is not perfectly level, then remove and adjust the length of the linkages from the servos to the swashplate until the swashplate is perfectly level when the cyclic servos are centered.

13.2.3. Pitch curve setup (CP heli only)

Place the pitch gauge on the helicopter main rotor blades following the pitch gauge directions.

Go to the pitch curve menu on your transmitter.

13.2.3.1. Normal mode setup

13.2.3.1.1. Setting the first pitch curve point

Lower the throttle stick to zero throttle and adjust the first point on the pitch curve. You should see the main blade pitch change. Leave the throttle stick in this position to set the first pitch curve point.

If you are planning to fly in calm conditions, set the first point on the pitch curve so the pitch gauge reads zero degrees of pitch.

If you anticipate flying in slightly windy conditions, set the first point on the pitch curve so the pitch gauge reads -2 degrees of pitch.

13.2.3.1.2. Setting the last pitch curve point

Raise the throttle stick to full throttle and adjust the last point on the pitch curve. You should see the main blade pitch change. leave the throttle stick in this position to set the last pitch curve point.

For microhelis, set the last point on the pitch curve so the pitch gauge reads 12 degrees. If the helicopter is not a micro, set the last point on the pitch curve so the pitch gauge reads 10 degrees.

13.2.3.1.3. Setting the middle pitch curve points

Set the pitch curve to be a straight line between the first and last points by setting the value of the middle points.

Note

Some micro helis may need about 10 degrees of pitch to hover. If you do not have enough pitch to hover, then increase the last pitch curve point to 15 degrees and adjust the middle points.

Note

If you do not have enough pitch range to set the first and last pitch curves points properly, then you may need to enter the swashplate mixing menu and increase the pitch mixing value.

13.2.3.2. Setting all pitch curve points

Copy the pitch curve values used in the normal mode pitch curve to the idle-up 1 pitch curve, and the throttle hold pitch curve (if the throttle hold has its own pitch curve).

13.2.4. Cyclic setup (CP heli only)

Note

This setup only applies for CP helicopters. Skip this section for FP helicopters.

Note

The collective pitch setup (swashplate servo reversing) must be completed before cyclic setup, otherwise the servos will not move correctly.

13.2.4.1. For transmitter mode 2 (US and Europe)

Move the RIGHT transmitter stick up and down. This should move the swashplate forwards and backwards.

Move the RIGHT transmitter stick left and right. This should move the swashplate left and right.

13.2.4.2. For transmitter mode 1 (Asia and Europe)

Move the LEFT transmitter stick up and down. This should move the swashplate forwards and backwards.

Move the RIGHT transmitter stick left and right. This should move the swashplate left and right.

13.2.4.3. Correcting swashplate tilt (JR/Futaba/Hitec)

If you are using a swashplate mode and if any of these swashplate movements are reversed, then go to the swashplate mixing menu (SWASH AFR on a Futaba 9C) and change the aileron or elevator mixing percentage from positive to negative or negative to positive until the swashplate moves correctly.

If you are not using a swashplate mode and if any of these swashplate movements are wrong, then reverse the appropriate servo to correct the swashplate movement.

When the sticks are centered, the swashplate should be level. The easiest way to check this is by holding the helicopter at eye level, then looking at a bookcase behind it.

Align the main shaft with the edge of the bookshelf, then raise/lower the helicopter until the swashplate is at the same level as one of the shelves. You should be able to easily tell if the swashplate is perfectly level or not.

13.2.4.4. Correcting swashplate tilt (Mutiplex Evo)

If the fore/aft swashplate movement is not correct, then go back to the swashplate type (geometry) menu and add a negative to the swashplate type, e.g. if the value was "120" change it to "-120".

If the left/right swashplate movement is not correct, then you will need to swap the servo channels by swapping the servo plugs in the receiver.

If you swap the left/right servo plugs, then you will need to go back to Section 13.2.2, “Swashplate servo setup (CP heli only)” to check the servo reversing and level the swashplate again.

13.2.4.5. Correcting swashplate tilt (Airtronics/Sanwa)

If the fore/aft swashplate movement is not correct, then go back to the swashplate type (geometry) menu and look at the swashplate type. If the last letter is a F, change it to an B, and vice versa. For example, CP3F would be changed to CP3B, etc.

If the left/right swashplate movement is not correct, then you will need to swap the servo channels by swapping the servo plugs in the receiver.

If you swap the left/right servo plugs, then you will need to go back to Section 13.2.2, “Swashplate servo setup (CP heli only)” to check the servo reversing and level the swashplate again.

13.2.4.6. Check for cyclic/collective pitch interaction (eCCPM only)

Move the throttle stick to the lowest position.

Now watch the swashplate carefully and apply left/right cyclic, then fore/aft cyclic, then test with both together.

Now move the throttle stick to the highest position. Watch the swashplate carefully and apply the same cyclic test again.

The swashplate should only change tilt and should not move up or down when the fore/aft cyclic and left/right cyclics are moved.

If the swashplate moves up and down, then you should move the ball link outward one hole on the swashplate servos.

If you are already at the outermost hole on the servo horn, then this can be fixed in one of two ways:

- Replace the servo horn with a longer version
- Decrease the aileron and elevator mixing on the swashplate mixing menu. This will decrease your cyclic control, so this should be a last resort fix for this problem.

13.2.4.7. Check for binding

Perform the cyclic/collective pitch test again, and check for servo binding. If the servo is reaching the mechanical limit of movement and emitting a buzzing sound, then it is binding.

You will need to fix this binding because the servo will draw a large amount of power when it is binding, which can overload the BEC and the BEC may shut down. This will cause a loss of heli control and probably a crash.

To solve the servo binding, you will need to enter the swashplate mixing menu and reduce the aileron and elevator mixing to eliminate the servo binding. Ensure the aileron and elevator mixing is equal after reducing the mixing values.

13.2.5. Cyclic setup (FP heli only)

Note

This setup only applies for FP helicopters. Skip this section for CP helicopters.

13.2.5.1. For transmitter mode 2 (US and Europe)

Move the RIGHT transmitter stick up and down. This should move the swashplate forwards and backwards.

Move the RIGHT transmitter stick left and right. This should move the swashplate left and right.

13.2.5.2. For transmitter mode 1 (Asia and Europe)

Move the LEFT transmitter stick up and down. This should move the swashplate forwards and backwards.

Move the RIGHT transmitter stick left and right. This should move the swashplate left and right.

13.2.5.3. Correcting the swashplate tilt

If any of these swashplate movements are reversed, then reverse the servo so the swashplate moves correctly.

When the sticks are centered, the swashplate should be level.

The easiest way to check this is by holding the helicopter at eye level, then looking at a bookcase behind it. Align the main shaft with the edge of the bookshelf, then raise/lower the helicopter until the swashplate is at the same level as one of the shelves. You should be able to easily tell if the swashplate is perfectly level or not.

13.2.5.4. Check for binding

Move the fore/aft and left/right cyclic to all extremes simultaneously, and check for servo binding. If the servo is reaching the mechanical limit of movement and emitting a buzzing sound, then it is binding. You will need to fix this binding because the servo will draw a large amount of power when it is binding, which can overload the BEC and the BEC may shut down. This will cause a loss of heli control and probably a crash.

If you are using a transmitter with swashplate support, then you will need to enter the swashplate mixing menu and reduce the aileron and elevator mixing to eliminate the servo binding. Ensure the aileron and elevator mixing is equal after reducing the mixing values.

If you are using a transmitter without swashplate support, then you will need to reduce the for/aft and left/right servo endpoints to eliminate the servo binding. Be sure the servo travel is the same after reducing the values.

13.2.6. Transmitter exponential setup for cyclic

The transmitter expo function can be used to decrease cyclic sensitivity when the cyclic stick is near the center (without decreasing total servo travel). This will allow you to make smaller cyclic corrections and avoid "overcontrolling" the helicopter.

For Futaba/Hitec transmitters, a negative value decreases cyclic sensitivity. A value of -20 to -40 is recommended.

For JR/Graupner/Multiplex/Airtronics/Sanwa transmitters, a positive value will decrease cyclic sensitivity. A value of 20 to 40 is recommended.

Note

If you increase the collective pitch range, you will need to add more expo to retain the same effect.

13.3. Main rotor setup - part 1

13.3.1. Main rotor blade balancing using the KSJ-528 blade balancer

It is important to balance the main rotor blades because this reduces vibration. Reduced vibration will make hovering easier, increase the flight time because less power will be wasted, and will reduce gyro drift and allow the gyro to function more efficiently.

There are multiple ways to balance the blades, but this method works best for me so far. It minimizes the amount of tape used and we avoid disrupting the airflow where the blades generate the most lift by putting most of the tape near the bolt holes and the CG.

Be sure to use ELECTRICAL tape to balance the blades. Regular transparent tape is not heavy enough. Electrical tape weighs about 0.1 gram per 2.5cm (1 inch).

13.3.1.1. Step one: Matching the CG

1. Remove the blade holder posts from the balancing tray of the KSJ-528.

2. Make sure the balancing tray balances evenly when nothing is on the tray. If necessary, use the setscrews to balance the tray.

3. Place one blade in the KSJ-528 tray and delicately shift the blade left or right across the balancing tray until the blade balances.

4. Mark the balance point with a felt tip pen. The balance point is the point where the center line on the balance beam touches the leading edge of the blade tip.
5. Repeat for the other blade.
6. Stack the rotor blades, then insert a bolt through the hole to align the blades perfectly. Check if the CG of the blades match within 1/16th of an inch (1.5mm).
7. If the CGs are close enough, go to Step two: Matching weight
8. Determine which blade has CG farthest away from the mounting bolt hole.
9. Move the CG of the blade closer to the bolt hole by placing placing 1-2 inches of electrical tape on the underside of the blade next to the leading edge near the bolt hole.
10. Measure the CG on this blade again and mark the new CG location.
11. Go to step 6

13.3.1.2. Step two: Matching the weight

1. Determine which blade holder posts fit your blades, then mount them on the balancing tray.
2. Make sure the balancing tray balances evenly when nothing is on the tray. If necessary, use the setscrews to balance the tray.
3. Mount the blades on the blade holder posts and make sure both blades balance and are perfectly horizontal.
4. If the blades do not balance, put a small strip of electrical tape on the underside of the lighter blade at the CG point next to the leading edge of the blade.
5. Add or remove tape on the lighter blade at the CG point until the blades balance.

13.3.1.3. Step three: Optimizing tape usage (optional)

1. If you applied tape to only one blade or less than seven inches of tape were used in steps one and two, you can skip this step.
2. If one blade has a large amount of tape near the bolt hole and the other blade also has a large amount of tape on the CG, then you should definitely perform this step.
3. On the blade with tape near the bolt hole, remove all the tape.
4. On the blade with tape at the CG, remove the tape and discard half of the tape. Reapply the other half of the tape to the blade but at a point halfway between the CG and the tip.
5. Go back to Step One: Matching the CG and rebalance. The blades should require less tape to balance this time.

13.3.2. Blade grip tension adjustment

1. Loosen the main blade grip bolts so the main blades move freely.

2. Hold the helicopter so the right side or left side is facing down.

3. Turn the main rotor hub so the blades are parallel to the ground.

4. Tighten the blade grip bolts just enough so the blades won't droop much when the heli is lightly shaken. If you overtighten the main blade grip bolts, then the main rotor blades will not straighten out at full headspeed and this will cause vibration.

   If you have too many boom strikes later, you can tighten the blade grip bolts after running up the heli to full headspeed to ensure the blades have straightened out.

13.3.3. Flybar paddle setup

This step is not necessary for the Corona since it is already performed by the instructions in the construction manual. The tilt of the flybar paddles should match the tilt of the swashplate. This is done by adjusting one flybar paddle at a time.

1. First, make sure the flybar paddles are parallel to each other. This can be done using the KSJ-624 paddle gauge or just by visual inspection. If the paddles are not parallel to each other then loosen the paddle mounting screw or setscrew and twist the paddle and retighten the screw.

   If you use the KSJ-624 paddle gauge on a micro heli, the weight of the paddle gauge will twist the paddle and change the pitch by a few degrees. To avoid this, hold the heli so the flybar is perpendicular to the ground and then sight along the edge of the paddle gauge down to the ground. This will prevent the weight of the gauge from twisting the paddle.

2. Next, rotate the main rotor so the main rotor blades are aligned with the body, e.g. one points forward and the other points backwards.

3. Pick one flybar paddle, and lower it slightly so it almost obscures the swashplate. Now align the outer edge of the flybar paddle with the top of the swashplate. It should be level with the top of the swashplate. If the paddle is tilted relative to the swashplate, then this should be fixed by shortening or lengthening the linkages between the swashplate and the flybar paddles

4. Now rotate the rotor head 90 degrees so the flybar paddles are aligned with the body. Check the same paddle against the top of the swashplate again. It should still be aligned.

5. Repeat the last two steps for the other flybar paddle and make sure it is aligned with the top of the swashplate at two different angles 90 degrees apart.

13.4. Main motor setup

13.4.1. Transmitter throttle reverse setup

If you have a Futaba transmitter and a Castle Creations or Schulze ESC, then you will need to reverse the throttle for this step. The throttle reverse may be necessary for other transmitter and controller combinations as well.

13.4.2. ESC programming

Note

Be sure to remove the motor pinion when programming the ESC! This will ensure the main rotor will not spin accidentally.

If you are using a programmable ESC which uses the transmitter to set the ESC options and you have previously set a throttle curve for this model, then you may need to reset the throttle curve to default (e.g. linear from 0 to 100%) to program the ESC otherwise the ESC may not be able to recognize the low-middle-high stick positions.

13.4.2.1. Castle Creations ESC parameters for the MAIN motor

- Cutoff Voltage: as low as possible so the heli will not fall out of the sky. If you are using lithium polymer batteries, you will need to be careful not to drain the batteries beyond the recommended minimum voltage.
- Current Limiting: insensitive
- Brake: disabled - so we don't strip the main gear when the motor spools down.
- Throttle Type:
  - For FP helis: fixed endpoint
  - For CP helis: If you are learning hovering (and are planning to fly in normal mode) then you must use the fixed endpoint mode. Otherwise, if you plan to use the idle-up mode, you should use try the low governor mode first, and if there is not enough headspeed, try the high governor mode.
- Timing Advance: depends on motor, choose standard if unknown
- Cutoff: soft
- Soft start:

  FP helis: fast start (soft start has problems when used with FP helis on some firmware versions)

  CP helis: softest start
- PWM Switching Rate: for coreless (non-cogging) motors, set to the highest switching frequency; for other motors, set to a lower frequency.

Note

Do NOT use autocalibrate mode. This mode only works properly if the throttle is moved to full throttle to set the high throttle endpoint position. This cannot be safely done on a helicopter because the helicopter will climb very rapidly.

13.4.2.2. Castle Creations ESC parameters for the TAIL motor

If you have a tail motor ESC, then it will require programming as well. You should temporarily plug the tail motor ESC into the throttle channel on the receiver to program it.

For the Castle Creations ESCs used as the TAIL motor ESC, the following parameters should be used:

- Cutoff Voltage: as low as possible so the heli will not fall out of the sky. If you are using lithium polymer batteries, you will need to be careful not to drain the batteries beyond the recommended minimum voltage.
- Current Limiting: insensitive
- Brake: disabled - so we don't strip the main gear when the motor spools down.
- Throttle Type: fixed endpoint
- Timing Advance: depends on motor, choose standard if unknown
- Cutoff: soft
- Soft start: Choose fast start
- PWM Switching Rate: depends on motor, but 11 khz is fine for most tail motors

13.4.2.3. Schulze ESC parameters for MAIN motor

Note

0 = switch in LEFT position with label readable

1 = switch in RIGHT position with label readable

1. Switch 1: 0 - aircraft mode

2. Switch 2: 1 - helicopter mode

3. Switch 3:

FP helis: 0 - normal speed controller

CP helis: 1 - governor mode

4. Switch 4: 0 - high rpm mode

5. Switch 5: 1 - soft timing

6. Switch 6: Set to 1 (19 khz) for coreless (non-cogging) motors; for other motors, set to 0 (9khz)

For other ESCs, set the parameters using the above parameters as a general guide.

If you have a programmable ESC which is programmed using beeps then you should carefully watch the tail servo when the ESC beeps. If your tail servo wiggles every time the ESC beeps, then your gyro or gyro wires are too close to the ESC.

13.4.3. Transmitter throttle setup

1. Remove the MAIN BLADES from the helicopter
2. Secure the helicopter so it cannot move.

   For a nonmicro heli, put a wooden beam or two-by-four through the skids and place a brick or other heavy object on each end of the beam. For a micro heli, put a piece of wood through the skids and clamp the wood to a table on both sides. Also, make sure the tail rotor is away from any objects.

3. Install a battery in your heli, then follow the ESC directions to arm the ESC. If your ESC does not arm, then you may need to reverse or unreverse the throttle direction.

4. Give just enough throttle on your transmitter to make the head spin a little.

5. If your main rotor blades are spinning backwards, and

   i. If you have a brushed motor and a brushed motor controller, then you need to swap the two motor wires.

      If you have a diode (looks like a black barrel with a grey stripe around it, and two wires at either end of the barrel) wired to your motor, then be sure to swap this also because the grey band should be on the positive (red) wire to the motor. The capacitors (usually yellow discs with two leads) are not polarized and do not need to be swapped.

   ii. If you have a sensored or sensorless brushless motor and a sensorless brushless motor controller, then you should swap any two of the three motor wires.

   iii. If you have a sensored brushless motor and a sensored brushless motor controller, then you should consult your motor manufacturer. This usually requires the motor to be sent back to the factory to have the motor retimed.

13.4.4. Transmitter throttle hold setup

You should follow the transmitter manual directions to enable the throttle hold function on your transmitter.

Throttle hold is very good because it prevents the heli from throttling up if you must work on the heli while it's powered and something bumps the joysticks.

Note

The throttle hold mode may have its own pitch curve.

If this is the case, you will need to set this the same as your normal mode or idle-up mode to ensure the heli does not "hop" when you hit throttle hold to spool down the heli.

13.4.5. Transmitter throttle curve setup (FP heli only)

For a fixed pitch heli the throttle curve should be left as default - linear from 0 to 100%. It is not necessary to check the headspeed because you are unlikely to exceed the maximum headspeed, as the heli will take off like a rocket if the headspeed is too high.

13.4.6. Transmitter throttle curve setup (CP heli only)

Note

This step should be performed outdoors for two reasons.

The first reason is: tachometers do not work well with flourescent light because the light flickers at high speed.

The second reason is: It is very difficult to dodge an out-of-control helicopter inside a small room.

For this step you will need a tachometer. Borrow one from a friend if necessary.

First, set your normal mode throttle curve using these settings:

- Five point throttle curve: 0-50-90-90-90
- Three point throttle curve: 0-90-90

Second, determine the your desired headspeed using this table:

Table 13.2. Recommended headspeeds

	Headspeed
CP micro heli	2000-2400 rpm
ECO 8	1400-1800 rpm
Other CP nonmicro heli	1600-2000 rpm

If you are a beginner, then use a headspeed at the lower end of the range. If you are experienced, then use a headspeed at the upper end of the range.

Third, immobilize your heli so it will not fly by weighting it. For a micro heli, you can put a small ruler on top of the skids and weigh down the ruler with bricks on both ends. For a nonmicro, you can use a larger piece of wood and cinder blocks. Be sure to use a heavy weight on both ends. Make sure your landing skids will not separate from the helicopter frame.

Fourth, select the two-blade propeller mode on the tachometer. Next, place the tachometer underneath the helicopter so the sensor points upward and the rotor blades will pass over the sensor. Make sure the flybar and flybar paddles do not pass over the sensor because this will cause an incorrect headspeed reading.

Now follow the helicopter power-on procedure and arm the helicopter ESC. Be sure to stand a reasonable distance away. Slowly spool up the helicopter using the throttle stick and watch the tachometer reading. If the headspeed goes beyond the upper expected range, stop immediately, because the helicopter may throw a blade if the headspeed is too high.

If your headspeed is too high before you reach half stick (90% throttle), then you should use a pinion with a lower tooth count. If you are already using the smallest tooth count pinion, then you may need to lower the maximum throttle values to 85% or so to lower the headspeed slightly. Do not use a maximum throttle value of less than 85% because this may overheat the motor. See Section 30.1.10, “How ESCs work” for an explanation.

If your headspeed is still too low by the time you reach half stick (90% throttle) then you should try a pinion with a higher tooth count.

After you have adjusted the headspeed properly, copy the maximum throttle value to all points on the idle-up 1 throttle curve. If your maximum throttle value is still 90%, the idle-up 1 throttle curve should be:

- Five point throttle curve: 90-90-90-90-90
- Three point throttle curve: 90-90-90

13.5. Tail rotor setup

13.5.1. Tail belt tension setup

This only applies if your heli has a tail belt, obviously.

The tension of the tail belt should be set according to your flying style:

For beginners and light sport flying, the tail belt tension should be firm but not loose. This will decrease friction and increase your flight time and tail belt life.

For aerobatic flying, the tail belt tension should be somewhat tighter. This will increase friction, decrease flight time and tail belt life, but will prevent the tail from slipping during hard maneuvers.

13.5.2. Tail rotor pitch servo direction setup

Note

For this step, disconnect the motor wires from the ESC This will prevent the motor from accidentally spinning.

Do not rely on the Throttle Hold function. The tail servo should be in the middle of its travel range when the tail pitch lever is also in the middle of its travel range. If this is not true, then adjust the linkages until the midpoints are matched.

13.5.2.1. For heading hold gyros

- If you have an ECO 8, when you hold the heli and turn it, the heading hold gyro should push the tail pitch lever lever to the BACK.

13.5.2.2. For all helis

- If your tail rotor is on the right side of the boom and you push the rudder right, the tail blades should increase in pitch.
- If your tail rotor is on the left side of the boom and you push the transmitter rudder left, the tail blades should increase in pitch.

The tail pitch control servo should be able to move the tail pitch control lever all the way from one limit to the other with about 120-150 degrees of servo arm travel.

If the servo needs more than 150 degrees of travel to reach both limits of the pitch control lever, then replace the servo arm with a longer one.

If the servo needs considerably less than 120 degrees of travel to reach bot limits of the pitch control lever, then move the servo arm linkage to a hole closer to the servo arm pivot then check again.

You can fine-tune the amount of tail servo travel by using the LIMIT adjustment on the GY401.

13.5.3. Tail rotor pitch servo centering

Plug the tail servo directly into the rudder channel and bypass the gyro temporarily.

When the rudder stick is centered the servo horn on the tail servo should be very close to perpendicular to the servo body. If this is not the case, then loosen the servo horn screw and rotate the servo horn.

Be sure to restore the original wiring configuration after this step.

13.5.4. Gyro setup - variable pitch tail rotor

Heading Hold Gyro setup:

First, if you are using a heading hold gyro (such as the GY240 or GY401) you must make sure your transmitter REVO MIXING option is disabled, because this option is only for non-heading hold gyros.

13.5.4.1. GY240 setup

13.5.4.1.1. Setting LIMIT

The GY240 servo travel limit cannot be set electronically, so the limit must be set mechanically.

1. Set the GY240 AVCS switch to OFF temporarily
2. Turn on the transmitter
3. Disconnect the heli motor
4. Plug in the heli battery
5. Wait for the gyro to initialize
6. Make sure the tail servo horn is perpendicular to the tail servo body.
7. If the tail servo horn is not perpendicular, then remove the servo horn from the servo and rotate it before reinstalling it. It may help to rotate the servo horn 180 degrees before reinstalling, because the servo horn will only install at fixed angles.
8. Move the rudder stick to full left and then to full right
9. Make sure the tail servo can push the tail pitch slider to the limits of its travel without binding.
10. If the tail servo cannot push the tail pitch slider through the full range of its travel, then you may need to move the servo horn linkage outwards one hole.
11. If the tail servo binds at the full left or full right rudder stick position, then you may need to move the servo horn linkage inwards one hole.

12. You may need to drill a new hole in the servo horn for the best results.

There are three controls which require setup on the GY240.

13.5.4.1.2. Setting AVCS

Set to ON. AVCS is Futaba's name for "heading hold" and you want this enabled.

13.5.4.1.3. Setting DIR

1. Turn on the transmitter.
2. Disconnect the heli motor.
3. Plug in the heli battery.
4. Wait for the gyro to initialize.
5. Turn the heli right about 20 degrees. If your tail rotor faces left(Corona) then the tail rotor blades should increase in pitch. If your tail rotor faces right (ECO, Logo) then the tail rotor blades should decrease in pitch.
6. If the tail rotor blade pitch change is wrong, then flip the direction switch on the gyro, and retest.

13.5.4.1.4. Setting GAIN

1. For the Corona, the GY240 does not hold the tail well without high gain (because it's fixed pitch) so set this to about 75%.
2. Otherwise, set this to 50% to start. It can be adjusted later if the tail wags too much.

13.5.4.2. GY401 setup

There are five controls on the gyro and one on the transmitter which require setup on the GY401.

13.5.4.2.1. Setting DS

This should be OFF unless you are using a S9253 S9250, S9450, etc. digital servo compatible with a fast update rate. Not all digital servos are compatible with the GY401 DS mode!

13.5.4.2.2. Setting DIR

See the GY240 section on setting this switch.

13.5.4.2.3. Setting DELAY

The DELAY adjustment tells the gyro the expected speed of the tail servo. Low delay values should be used for fast servos, and high delay values should be used for slower servos. If this value is set too low, then the tail will wag a little after the heli is turned.

Set this to about 50 initially.

If your tail servo is fast (<0.11 sec/60 degrees) set this to a lower value.

If your tail servo is slower or you are using a fixed pitch tail driven by a variable speed motor (Piccolo Hummingbird, etc.) then set the DELAY to a higher value.

13.5.4.2.4. Setting LIMIT

This controls the amount of tail servo travel.

1. Turn on the transmitter.
2. Disconnect the heli motor.
3. Plug in the heli battery.
4. Wait for the gyro to initialize.
5. After the gyro has initialized, make sure the tail servo is at the center of its travel range (90 degrees to servo body) and the tail pitch lever is at the center of its travel range as well (90 degrees to tail boom).
6. Turn off the AVCS mode temporarily at the transmitter.
7. Use the rudder stick and give full left rudder and full right rudder. The tail servo should be moving moving the tail pitch slider through its full range of motion.
8. If the tail pitch slider is not moving far enough, then you will need to increase the LIMIT control.
9. If the tail pitch slider is moving too far and hitting the ends of travel and the tail servo is emitting buzzing sounds, then decrease the LIMIT control.
10. It may be necessary to move the tail servo mount on the tail boom or adjust a ball link or something else to ensure that:
    i. The tail servo can move the tail rotor pitch from minimum to maximum without binding (e.g. without the tail servo making a buzzing sound).
    ii. The tail servo should be centered when the tail rotor pitch is at the middle of its range. Be sure to reenable AVCS mode after setting the LIMIT control.

13.5.4.2.5. Setting SENSITIVITY

This is set at the transmitter on channel 5 for both Futaba/Hitec and JR radios.

If you have a transmitter with gyro support, then one of the transmitter toggle switches will switch between two gyro sensitivity settings, and there will be a menu where you can choose the two gyro settings associated with the two switch positions. In this case, set the down switch setting to 50% normal (yaw-rate) mode and the up switch position to 50% heading hold mode. If you do not have a transmitter with built-in gyro support, then you will use the landing gear channel to control the gyro sensitivity. The two gear positions (up/down) will be used to select two gyro sensitivity settings.

If you have a Futaba/Hitec (negative shift) radio without gyro support, then channel 5 settings below 50% are non-heading hold mode sensitivity and settings above 50% are heading-hold mode sensitivity. For the initial settings, set the down switch position to 25% travel and the up switch position to 75% travel.

If you have a JR (positive shift) radio, the settings are swapped, e.g. below 50% is heading hold sensitivity and above 50% is non-heading hold sensitivity. For the intial settings, set the down switch position to 75% travel and the up switch position to 25% travel.

After you have set the gyro settings, you should disconnect the motor wires and power up the helicopter to check the gyro settings. If you power up the gyro in heading hold (AVCS) mode, then the LED on the gyro will blink rapidly for a few seconds during initialization, then stay on. When you switch to yaw rate mode, then the LED will turn off.

If you power up the gyro in yaw rate (NOR) mode, then the LED on the gyro will blink rapidly for a few seconds during initialization, then blink slower. You cannot switch to heading hold mode if you power up the gyro in yaw rate mode.

13.5.4.3. Non-Futaba heading hold gyro setup

You should follow your manufacturer's directions.

In addition, you should set the subtrim step size to the smallest increment possible so you can get very fine control of the rudder neutral point so you can match the transmitter's rudder neutral point to the gyro's neutral point.

On the Futaba 9C, go to the TRIM menu and change the rudder step size from 4 to 1.

13.5.4.4. Yaw-rate gyro setup

If using a separate yaw rate gyro (not Piccoboard):

You need to enable the REVO MIXING feature on the transmitter and adjust the REVO MIX curve to effect revo mix changes.

If using any Piccoboard WITHOUT the heading hold module:

You will need to adjust the REVO MIX dial on the Piccoboard to effect revo mix changes.

The revo mix controls the speed or pitch of the tail rotor relative to the throttle position. This is required to counteract the torque generated by the main rotor blades so the heli does not yaw while in flight.

You will need to adjust the revo mix so the heli does not yaw at all throttle positions.

The best way to do this is to buy a "lazy susan" type turntable that will allow the helicopter to rotate freely while the helicopter is weighed down so it won't take off inadvertently. (Rubbermaid appears to make one which is probably suitable)

Perform preflight checks, then slowly apply throttle.

The helicopter will start to yaw as you apply throttle.

You will need to adjust the revo mix so the heli has no tendency to yaw as you slowly apply throttle. It is normal for the tail to swing a little when changing the throttle, as long as the heli does not continuously rotate while the throttle is not changing.

If the helicopter is rotating and you need to increase the thrust of the tail rotor to counteract the rotation, then you should increase the revo mix at that throttle position or turn right the revo mix dial on the Piccoboard.

If the heli is rotating and you need to decrease the push of the tail rotor to counteract the rotation, then you should decrease the revo mix at that throttle position or turn left the revo mix dial on the Piccoboard.

If you plan to use the idle-up mode, you will need to set the revo mix curves for both normal and idle-up modes.

13.5.5. Gyro setup - fixed pitch tail rotor

Heading Hold Gyro setup:

First, if you are using a heading hold gyro (such as the GY240 or GY401) you must make sure your transmitter REVO MIXING option is disabled, because this option is only for non-heading hold gyros.

If you are using a Piccoboard with a heading hold module, you do not need to trim the helicopter properly without the heading hold module installed (e.g. as a yaw rate gyro). Just install the heading hold module and it should work properly as a heading hold gyro. You may need to adjust the gain however.

13.5.5.1. GY240 setup

There are three controls which require setup on the GY240.

13.5.5.1.1. Setting AVCS

Set to ON. AVCS is Futaba's name for "heading hold" and you want this enabled.

13.5.5.1.2. Setting DIR

1. Disconnect the heli motor and position the heli so the nose is pointing towards you and the tail is facing away from you.
2. Turn on the transmitter.
3. Plug in the heli battery.
4. Wait for the gyro to initialize.
5. Hold the heli firmly with the tail pointed away from you and arm the tail ESC by holding full left rudder on the transmitter.

   The tail motor should start. Rotate the heli left and right by about 30 degrees. If the tail motor is pushing against the direction of rotation, then this is correct.
6. If the tail motor is pushing in the same direction as the rotation, this is incorrect, and you will need to toggle the DIR switch to fix the problem.

13.5.5.1.3. Setting GAIN

Set this to 50% to start. It can be decreased later if the tail wags too much, or increased if the tail wanders too much.

13.5.5.1.4. GY401 setup

There are five controls on the gyro and one on the transmitter which require setup on the GY401.

13.5.5.1.5. Setting DS

This should be OFF. There are no tail ESCs which are compatible with the digital servo mode.

13.5.5.1.6. Setting DIR

See the GY240 section on setting this switch.

13.5.5.1.7. Setting DELAY

The DELAY adjustment tells the gyro the expected speed of the tail servo. Low delay values should be used for fast servos, and high delay values should be used for slower servos. If this value is set too low, then the tail will wag a little after the heli is turned.

The tail motor will behave like a very very slow tail servo so the delay should be set to a large value. Set this to 100% initially.

13.5.5.1.8. Setting LIMIT

This controls the range of throttle for the tail ESC. Set this to 100%. If you set the limit too low (less than about 90%) then you will have problems arming the tail ESC.

13.5.5.1.9. Setting SENSITIVITY

This is done at the transmitter on channel 5 for both Futaba and JR radios. If you have a newer Futaba radio (like a 9C) this is already handled in the GYRO SENS menu. In this menu set the mode to AVC and the sensitivity to about 50%.

If you have a Futaba/Hitec (negative shift) radio, channel 5 settings below 50% are non-heading hold mode sensitivity and settings above 50% are heading-hold mode sensitivity. Initially, set your channel 5 to about 75% travel.

If you have a JR (positive shift) radio, the settings are swapped, e.g. below 50% is heading hold sensitivity and above 50% is non-heading hold sensitivity. Try setting your channel 5 to about 25% travel.

13.5.5.1.10. Non-Futaba Heading Hold gyro setup

You should follow your manufacturer's directions.

In addition, you should set the subtrim step size to the smallest increment possible so you can get very fine control of the rudder neutral point so you can match the transmitter's rudder neutral point to the gyro's neutral point. On the Futaba 9C, go to the TRIM menu and change the rudder step size from 4 to 1.

13.5.5.2. Yaw-Rate Gyro setup

If using a separate yaw rate gyro (not Piccoboard):

You need need to enable the REVO MIXING feature on the transmitter and adjust the REVO MIX curve to effect revo mix changes.

If using any Piccoboard WITHOUT the heading hold module or a 3-in-1 or 4-in-1 combo board:

You will need to adjust the REVO MIX dial on the board to effect revo mix changes.

The revo mix controls the speed or pitch of the tail rotor relative to the throttle position. This is required to counteract the torque generated by the main rotor blades so the heli does not yaw while in flight.

You will need to adjust the revo mix so the heli does not yaw at all throttle positions.

The best way to do this is to buy a "lazy susan" type turntable that will allow the helicopter to rotate freely while the helicopter is weighed down so it won't take off inadvertently. (Rubbermaid appears to make one which is probably suitable)

Perform preflight checks, then slowly apply throttle. The helicopter will start to yaw as you apply throttle. You will need to adjust the revo mix so the heli has no tendency to yaw as you slowly apply throttle. It is normal for the tail to swing a little when changing the throttle, as long as the heli does not continuously rotate while the throttle is not changing.

If the helicopter is rotating and you need to increase the thrust of the tail rotor to counteract the rotation, then you should increase the revo mix at that throttle position or turn right the revo mix dial on the Piccoboard.

If the heli is rotating and you need to decrease the push of the tail rotor to counteract the rotation, then you should decrease the revo mix at that throttle position or turn left the revo mix dial on the Piccoboard.

13.5.6. Transmitter tail setup - both fixed and variable pitch

Move the rudder and make sure the NOSE of the heli will move in the same direction you push the rudder.

This means the when you push the rudder RIGHT, the tail should move LEFT and vice versa.

If the tail rotor is mounted on the LEFT side of the tail boom and it is a pusher configuration, and you press the rudder RIGHT then the tail blades should DECREASE pitch.

If the tail rotor is mounted on the RIGHT side of the tail boom and it is a pusher configuration, and you press the rudder RIGHT then the tail blades should INCREASE pitch.

For a fixed pitch tail, substitute the words "slow down" for "decrease pitch" and "speed up" for "increase pitch".

If the tail moves in the wrong direction, then you should reverse the rudder channel on your transmitter.

13.6. Main rotor setup - part 2

13.6.1. Blade tracking - CP helicopters

If the pitch of the blades is not the same, then one blade will generate more lift than the other when hovering. This will cause vibration and steals power.

Note

If the flybar paddles are not parallel to each other, then it may be impossible to track the main rotor blades properly. Ensure the flybar paddles are parallel to each other before adjusting main blade tracking.

1. Temporarily put a piece of bright colored tape on one of the rotor blades. This will cause the blades to be unbalanced but don't worry about this for now. Just remember to remove

the tape after tracking the blades. You need this tape to determine which blade is higher or lower when checking the tracking.

2. Get a 6 foot length of 1" x 4" board.

3. Take the heli outside where the blades won't hit anything, and slide the board through the landing gear on top of the landing skids then either stake down the board or put cinderblocks on it. The board will hold down the heli in case *Something Really Bad Happens.*

4. Perform a preflight inspection and check everything.

5. Turn on the transmitter.

6. Connect the heli battery.

7. Arm the helicopter and slowly increase the throttle to about 1/4.

8. Walk a safe distance away, then get on your stomach, and apply throttle and look at the rotor blades from exactly the side. If both rotor blades are spinning exactly in the same plane and look like this: -o- then no adjustments are needed.

   If both rotor blades are not tracking in the same plane and look like this: >o< then the blades are not tracking properly and require adjustment.

   An alternative way to check the tracking is to place a mirror on your feet, then tilt the mirror so you can see the blades while standing up. This is considerably safer since your face will not be hit if the heli decides to throw a blade.

9. Shut off the throttle and wait for the rotor blades to spin down.

10. Disconnect the heli battery.

11. If the blades did not track evenly, then increase the pitch of the low blade and/or decrease the pitch of the high blade.

12. Go back to step 4 if necessary.

13.6.2. Blade tracking - FP helicopters

The Corona does not need blade tracking adjustments if you used two 4 degree blade grips. The head mechanics are very stiff and fairly precise which simplifies setup considerably. If you used one 4 degree and one 6 degree blade grip, you should follow the manual directions to set blade tracking.

The Piccolo FP has a soft rotor head and therefore the tracking is frequently off. This is especially bad because bad tracking steals a lot of power in micro helicopters. To check the blade tracking on a Piccolo, temporarily put a piece of bright colored tape on the leading edge of one of the rotor blades. This will cause the blades to be unbalanced but don't worry about this for now. Just remember to remove the tape after tracking the blades. You need this tape to determine which blade is higher or lower when checking the tracking.

Apply throttle and look at the rotor blades from exactly the side. If both rotor blades are spinning exactly in the same plane and look like this: -o- then no adjustments are needed.

If both rotor blades are not tracking in the same plane and look like this: >< then the blades are not tracking properly and require adjustment.

The tracking of the stock Piccolo FP blades can be adjusted by holding the blade firmly at the root and twisting the blade at the widest point. Be sure not to twist the rotor head (67370). You should increase the pitch on the low blade and decrease the pitch on the high blade until the two blades track evenly.

Chapter 14. R/C Heli Rules and Tips

14.1. The proper way to carry a heli

The proper way to carry a heli is by the blade grip. The blade grip carries the weight of the heli during flight and is designed to hold the weight of the heli.

You should hold the blade grip as if you were holding a flashlight. Your thumb should be on top of the blade grip, and the fingers curled under.

You should avoid touching the blades, especially if they are woodies. The trailing edge of wooden blades are made from soft balsa and will crumble very easily.

Also, be sure to keep your fingers away from the control linkages to avoid bending the control rods and changing the tracking of the blades.

14.2. Avoid pointing the transmitter antenna at the helicopter

The signal received by the helicopter's receiver is weakest when the transmitter antenna is pointing directly at it. This can cause glitches.

14.3. The blades are traveling at high velocity!

Warning

THE MAIN ROTOR BLADES ARE TRAVELING AT HIGH VELOCITY AND CAN KILL OR MAIM YOU. BE VERY CAREFUL.

When I first stared flying helicopters, I read every single web page I could find on the Internet regarding helicopters. One web page mentioned a story where a guy was flying his helicopter in a park, and a little dog started chasing his helicopter around. The heli pilot asked the dog owner to retrieve his dog, but the dog owner thought it was cute and wouldn't do it. When the heli landed, the dog ran to the helicopter and lunged at it. The main rotor blades were still spinning at full speed and neatly chopped off the top of the dog's skull.

Also, there are stories about R/C helicopter rotor blades chopping off people's fingers. Don't believe it? Let's do the math.

An ECO 8 has a rotor diameter of 41.7 inches. This means the rotor tips travel 41.7 * 3.14 or 130.9 inches in one revolution.

The rotor is spinning at about 1600 rpm. This means the rotor tips travel 130.9 * 1600 or 209,440 inches in a minute.

In one hour the rotor tips will travel 60 * 209,440 or 12,566,400 inches.

12,566,400 inches/hr = 1,047,200 feet/hr = 198.3 mph!!!

So, when an ECO 8 rotor blade is spinning at 1600 rpm, the blade tips are traveling at 198 mph. That's why helicopter rotor blades can slice off fingers and the top of skulls.

Warning

RESPECT THE SPINNING ROTOR BLADES.

14.4. Always disconnect the battery when working on the helicopter

Warning

ALWAYS DISCONNECT THE BATTERY WHEN POSSIBLE IF WORKING ON THE HELICOPTER. IF YOU MUST WORK ON A LIVE HELI, THEN DISCONNECT AT LEAST ONE OF THE MOTOR LEADS SO THE MAIN ROTOR/TAIL ROTOR WILL NOT SPIN UP AND MAIM YOU.

If the main rotor or tail rotor spins up and maims or kills you, this will probably slow down your helicopter learning process, so please try to avoid this.

See also:

- www.runryder.com/helicopter/t136510p1
- www.runryder.com/helicopter/t70830p1
- www.runryder.com/helicopter/t98388p1
- www.runryder.com/helicopter/t33625p1
- www.runryder.com/helicopter/t12572p1

14.5. Liability insurance

A membership in your country's local R/C modeling club is highly recommended because it provides insurance coverage in case you damage something. This is very useful if your heli damages somebody's car, or injures someone.

In the USA a membership in the Academy of Model Aeronautics (AMA) provides insurance coverage.

In the UK the British Model Flying Association (BMFA) provides this service.

Chapter 15. Learning to Fly an R/C Helicopter

15.1. The skills required

The skills required to fly a helicopter can be categorized into three broad areas:

- Visual skills
- Integration
- Motor skills

Here is a more detailed explanation of the skills involved:

- Orientation. You must be able to instantly determine the position, yaw, pitch, and roll, and the acceleration in yaw, pitch, and roll while the helicopter is moving. (the roll, pitch yaw, and deltas of each)
- Movement. You must be able to track the velocity and acceleration of a helicopter relative to the ground while tracking the orientation of the helicopter. (the x, y, z, and the deltas of each)
- Computation. Your brain must take these 12 data items of orientation and movement and determine the correct direction and distance to move the two joysticks.
- Motor skills. You need extremely fine motor skills to move the joysticks in small increments to effect very small corrections to the helicopter's orientation and movement.

Unfortunately, it is difficult to develop these disparate skills independently, which results in a steep learning curve.

15.2. Making the learning process easier

Here are some recommendations to make this learning process easier.

15.2.1. Hover no higher than eye level

This allows you to more easily determine the movement of the helicopter because the ground provides a visual point of reference.

This also allows you to more easily determine the orientation of the helicopter. If the disc of the rotor blades appear oval, then the helicopter is not level with your eyes.

Also, the helicopter will suffer less damage from a 5 ft crash than from a 30 ft crash. Some helicopters (like the Corona) will probably incur no damage, and you can simply walk over and set it upright and continue practicing.

You should be careful when flying outdoors if there are visually distracting items in the background such as trees, houses, etc. This "background clutter" can pull your eye's focus away from the heli which can result in a crash. You should avoid hovering your heli in front of background clutter so concentrating is easier.

15.2.2. Paint your canopy a bright color or leave it white

It looks really cool to paint your helicopter completely black; however it rapidly becomes less cool when you realize you can't see the orientation of the helicopter beyond ten feet.A black helicopter rapidly turns into a silhouette, and becomes very difficult to fly.

If painting, be sure to paint your canopy a bright color. Flourescent neon colors work well. A two-tone color scheme where the left side is painted a different color than the right side helps visual orientation considerably.

15.2.3. Use white blades

Black blades are cool, but they turn almost invisible when hovering. White blades are much more visible.

15.2.4. Use a heading hold gyro.

This will free you from worrying about the yaw and rate of yaw of the helicopter, which leaves you free to concentrate on the other ten orientation items.

15.3. Minimize downtime; maximize practice time

Several items fit into this category:

- Practice on a durable heli (Corona)
- Use training gear to minimize the chance of tipping over and damaging the rotor blades and tailboom
- Use a boom protector (dowels taped/tiewrapped to boom to reduce damage if main rotor blades hit the boom)
- Practice on the simulator. The helicopters in the simulator do not require a trip to a hobby store or waiting for parts to arrive from an online store. They don't require finding a dealer with parts in stock, or waiting for parts to arrive, or installing the replacement parts, or tedious detective work to identify the cause of vibration problems.

  Simulators and heading hold gyros are probably the two biggest advances in the last five years for reducing the learning curve of R/C helicopters.
- Keep a supply of commonly damaged/lost crash parts. For the Corona, this would be: main rotor blades, tailbooms, vertical tail fins, and Z links.

  For other helicopters, this would include: main rotor blades, flybars, flybar paddles, spindle shafts, main rotor shafts, tail booms, tail rotor blades, tail rotor shafts, vertical tail fins, and landing gears.
- Know your limits for each day. Your limits for each day will change depending on various factors, including: how much sleep you've had, how tired or stressed you are, and other variables.

  Therefore, you should start your practice each day by performing very easy exercises to warm up. This will allow you to gauge your limits for that day. If you are not flying well, then you should hone your existing skills instead of trying to learn new skills. This will reduce your probability of crashing.

15.4. Divide the learning process into smaller, easier steps

The classical steps in learning to fly a heli are:

1. Tail-in hovering

   The first step to flying a helicopter is tail-in hovering. At this step, you are learning to remotely balance an unstable object using a joystick.

2. Side-in hovering and tail-in hovering

   When you reach the side-in and tail-in hovering step, the controls are no longer relative to yourself, and you learn to balance the helicopter in different orientations.

3. 90/180/270 degree turns

   When you reach the 90/180/270 degree turning step, you learn to follow the heli as it changes orientation.

4. Forward flight and figure eights

   At this step, you learn to coordinate the throttle with your cyclic to enter/exit forward flight, and also to coordinate the rudder to perform banked turns.

Chapter 16. Hovering Technique

Hovering a model helicopter is much like balancing a ball bearing on a sheet of glass. This is a half-serious helicopter joke, but it's actually much more accurate than people realize. If you place a ball bearing on a sheet of glass, and tilt the glass left, then the ball bearing will start to roll left and accelerate faster and faster.

If you tilt the glass right until the glass is level , then the ball will stop accelerating but will keep rolling at a constant speed. To stop the ball, you must tilt the glass right a little more until the ball slows down, then level the sheet of glass as it slows down.

A model helicopter behaves the same way. If you apply a little left cyclic and center the stick, the helicopter will tilt left and start to move left, and keep accelerating faster and faster. If you apply a little right cyclic then center the stick to level the helicopter, it will become stop accelerating, but will keep moving left. In order to stop the helicopter, you need to apply enough right cyclic so it will slow down and then level the helicopter as it slows down.

A common beginner problem is to overcorrect the movement and the helicopter will "pendulum" back and forth. This indicates you are either moving the cylic too far and/or holding it too long before centering the stick.

For the section we will divide helicopters into two types:

- Helicopters with rigidly held swashplates

  Helicopters with rigidly held swashplates hold the swashplate by at least three points so it is held rigidly in place. Helicopters such as the Hornet, Hummingbird Elite CP, ECO 8, Logo 10, etc are in this category.

  These types of helicopters require small, delicate movements of the cyclic stick. Penduluming is usually the result of moving the stick too much.

- Helicopters with "floating" swashplates

  Helicopters with floating swashplates usually have a lot of slop in the control mechanism due to the floating swashplate. Helicopters with floating swashplates include: ECO/Fun Piccolo, GWS Dragonfly, Century Hummingbird V3, etc.

  These types of helicopters are less sensitive to cyclic stick movement and are more easily controlled with larger, fast stick movements. These stick motions might be called a "twitch" for lack of a better word. Penduluming is usually the result of holding the stick too long in the pushed position.

Chapter 17. Helicopter Power-On/Power-Off Procedure

17.1. Helicopter power-on procedure

1. First, if you are at a flying field, follow the appropriate procedures for reserving your transmitter channel. Depending on the field, this procedure may be similar to placing a pin on a frequency board.

2. Ensure your helicopter is not powered up, and carry it to the flying spot.

3. Fully extend the transmitter antenna.

4. Turn on the transmitter and wait for it to start transmitting.

5. Make sure the throttle stick is fully down.

6. Turn on the Throttle Hold switch.

7. Make sure the transmitter is transmitting, then connect helicopter battery.

   If you connect the helicopter battery without a transmitter signal, the ESC may go to full throttle which may maim you and/or nearby people.

   Be sure the transmitter antenna is at least 2 ft away from the receiver antenna when you connect the helicopter battery. This will prevent the transmitter from overloading the receiver and causing glitching.

   Make sure you do not bump the helicopter or the rudder stick while connecting the battery because this can affect the gyro initialization.

8. Wait for both the main motor ESC and the gyro to initialize. Do not touch the transmitter sticks yet!

9. If the helicopter uses a heading hold gyro with a tail motor ESC, then hold full left rudder until the tail motor ESC initializes. After the tail motor ESC initializes, release the rudder stick and allow the rudder stick to return to the middle position. The tail motor may spin at this time. This is normal.

10. Perform a radio range check.

11. Walk to where you plan to stand.

12. Ensure the throttle stick is in the zero throttle position, and turn off the throttle hold.

13. If you have not mastered all hovering orientations yet, then you should leave the transmitter in normal mode and practice hovering in normal mode. This will reduce crash damage.

    However, if you have mastered all hovering orientations and are ready for forward flight, then you should fly in idle-up mode. To switch to idle-up mode:

    i. Raise the throttle stick to about 1/4 throttle

    ii. Switch to idle-up mode

    The heli should have less than hovering pitch at this throttle position and should stay on the ground. If the heli starts to lift off, then quickly hit throttle hold to stop the motor and fix the throttle and pitch curves.

You should NEVER change flight modes (from normal to idle-up or the reverse) while the heli is flying. Flight modes should only be changed while the heli is on the ground.

14. You are now ready to fly.

17.2. Helicopter power-off procedure

1. Disconnect the helicopter battery

2. Double-check and make sure the helicopter battery is disconnected then turn off the transmitter.

   If you turn off the transmitter while the helicopter battery is still connected, the ESC may go to full throttle which may maim or kill you and/or nearby people.

3. Collapse the transmitter antenna.

17.3. Safety notes

1. DO NOT CARRY A HELI WITH THE BATTERY CONNECTED! This is very dangerous! A gust of wind can blow your shirt over the transmitter throttle or radio interference may cause the motor to start spinning!

2. Always disconnect the helicopter battery IMMEDIATELY after landing. Do not stand around and chat with your friends while the helicopter battery is connected!

Chapter 18. Tail-In Hovering

The first helicopter orientation to learn is "tail-in" hovering. This is called tail-in because the tail of the helicopter will be the closest to you.

18.1. Preparation

- The most common helicopter "minor crash" is a boom strike. This occurs the helicopter lands too hard and the main rotor blade strikes the tail boom. It is advisable to have at least one extra tail boom on hand to avoiding waiting for parts.
- You should have some practice time on a flight simulator. This will really reduce the number of crashes and save you A LOT of money.
- You should have a training gear on your heli. The training gear prevents the heli from tipping over and damaging itself, and additionally makes the heli more stable by slowing the cyclic response.

  For a 1000-2000 gram heli, the best and cheapest training gear can be made from a small hula-hoop and some 1/4 inch dowels. Do not use a dowel thicker than 1/4 inch, because the 1/4 inch dowels will break in a hard landing and absorb some of the impact.

  i. Put the dowel across the diameter of the hula-hoop, and cut the dowel so it's about 1 inch longer than the diameter.

  ii. Cut another dowel the same length.

  iii. Use two tie-wraps to lash the two dowels together in an X pattern.

  iv. Use tie wraps to attach the X to the hula-hoop.

  v. Use tie-wraps or rubber bands to attach the X to the landing gear of your helicopter.

  vi. Make sure the hula-hoop is on the bottom, so it will slide along the floor on the hula-hoop.

  The CG may shift when you attach the training gear, so be sure to readjust the battery pack to move the forward/aft CG back to the main rotor shaft.

18.2. Tail-in hovering - Phase 1

- The objective for Phase 1 is to slide the helicopter around on the ground to start building the hovering reflexes. We do not want to lift off yet. I recommend doing this for at least a few battery packs.

  You will be learning the "tail-in" orientation, which is the tail of the helicopter pointed towards you and the nose away from you.

  Be sure to focus on the nose of the helicopter, and not the tail. If you focus on the tail, this is very bad. You may want to stand slightly left or slightly right of the helicopter so you can see the nose.
- For a non-micro helicopter, find an empty flat space that is fairly level and is fairly clean (no rocks or debris for the training gear to hit). You will need at least a 20 ft by 20 ft area for this, although bigger is better.

An empty parking lot works well for this. Make sure there are no cars nearby to ensure you won't hit them.

For a microheli, you probably want to find a hard level indoor surface, possibly an empty garage or the kitchen. A 10 ft by 10 ft surface is probably necessary.

- Make sure wind conditions are ideal.

  If you are using a heading hold gyro, then you want as little wind as possible. The best times for this are probably the first three hours of daylight or the last hour of daylight before dusk.

  If you are using a non-heading hold gyro, then you want a little bit of steady breeze (not gusty) to help hold the helicopter tail steady because the helicopter will tend to turn when moving around. You will also want a little bit of forward trim to compensate.

  With either gyro type, make sure you point the heli nose into the wind so the tail fin will help keep the heli straight.

- Place the helicopter and training gear on the ground, with the nose of the helicopter pointed away from you.
- Preflight check the helicopter. Make sure all ball links are properly on the balls.
- Perform the helicopter power-up procedure described in the previous section.
- *VERY, VERY SLOWLY* apply enough power for the helicopter to become light on the skids. *** *DO NOT LIFT OFF* *** If you accidentally lift off at this point, you will probably panic and crash. So try not to lift off.
- You should test the left/right cyclic and the fore/aft cyclic, and ensure the helicopter moves in the correct direction. The helicopter should move equally well in all directions. If the movement is not symmetric, e.g. the helicopter moves quickly left but very slowly right, then this is a serious setup problem which should be fixed before proceeding.

  When you push the rudder stick left, the heli should rotate counterclockwise. When you push the rudder stick right, it should rotate clockwise. If these directions are reversed, then you should fix the problem before continuing.

  The rudder stick should control the *NOSE* of the helicopter and not the tail.

  Some heading hold gyros will have a tendency to "drift" away from the direction they're supposed to hold. This has been reported with the CSM LW200 gyro. If this occurs, then use the trim on the rudder to remove any drift.

- The heli will start to wander around on its own. Use the cyclic control to keep the helicopter within a 10 foot circle.
- The helicopter may have a constant tendency to move in one direction, and you may need to apply some trim to counteract this.

  Note that it will be impossible to perfectly trim the helicopter at this stage since you are hovering in ground effect.

- Always keep the tail of the helicopter pointed towards you. If you are using a heading hold gyro, this should occur automatically. If you are using a yaw rate gyro, you will need to use the rudder to maintain the tail position because the tail will tend to weathervane with the heli movement.
- Always fly the nose of the helicopter. This is very important. Do not fly the tail. Always fly

the nose of the helicopter. When you give left rudder, the nose should turn left, so always look at the nose.

- Try to avoid overcorrecting. Be sure to reread the "Hovering Technique" section if you have problems with overcorrection.
- If the helicopter starts to wander too far, reduce the throttle to let the helicopter settle and stop moving. Don't "chop" the throttle - reduce the throttle smoothly. Later on when you are actually hovering, chopping the throttle will cause the helicopter to crash. So, it's good to not acquire this habit in the first place.
- Focus your attention on the helicopter. Try to tune out any distractions, and don't hold a conversation while learning to hover. Think only of the helicopter and its tilt and direction of movement.
- It may help to watch the disk of the main rotor blades because it will tell you if the helicopter is level.
- When your nerves become frazzled, take a break. Don't push yourself too hard, because you may lose concentration and crash the helicopter.
- When your batteries become weak, switch packs. Be sure to wait a little while between flights to allow the motor to cool down. For maximum battery life, let the battery cool a little (about 5 mins) before recharging.
- For a non-micro helicopter, when you can hold the heli in a 10 foot circle, you are ready for the next phase.

  For a microheli, you should be able to hold the heli in a 3 foot circle.

18.3. Tail-in hovering - Phase 2

- The objective for Phase 2 is to hover at 3-4 inches of altitude (2-3 inches for a micro). Do not go any higher.

  You will be in "ground effect" so the helicopter will be twitchier than normal. This is a little awkward, but I highly recommend you practice this for at least a few battery packs to start building the necessary reflexes.
- Go back to the hovering area, preflight the helicopter, and perform range check/servo movement checks.
- If you are using a heading hold gyro, then make sure there is no wind or as little wind as possible.

  If you have a non-heading hold gyro, you will need a slight wind to help keep the tail steady. If you try to hover a non-HH helicopter without wind, this will be very difficult because the helicopter will "weathervane" into the direction it's moving. This is very bad because you will need to try to keep the tail steady while simultaneously hovering the helicopter.

  When hovering with wind, practice hovering with the nose of the helicopter facing INTO the wind. When the heli is facing into the wind, the vertical tail fin will help keep the heli from turning (yawing).
- Perform the helicopter power-up sequence described in the previous section.
- SLOWLY apply enough throttle to lift the helicopter to the desired altitude.

- When the helicopter tilts, you will hear a scraping sound, because the edge of the hula-hoop (or a ping-pong ball) will drag along the asphalt (or carpet). Pay attention to this sound, because it indicates your helicopter is tilted.
- Watch the disk of the main rotor blades as they spin. Try to keep the circle level, because when the circle is level, your heli is level.
- When the helicopter moves left, you should push the joystick right to halt the movement, then when the helicopter has stopped moving you need to nudge the joystick left to level the helicopter. Same for the other three directions.

  So, to stop a heli from moving in direction x requires two small stick movements. This requires a while to learn properly.
- The helicopter may have a constant tendency to move in one direction, and you may need to apply some trim to counteract this.

  Note that it will still be impossible to perfectly trim the helicopter at this stage since you are hovering in ground effect.
- Try to avoid "overcontrolling" the helicopter. You want to use small, delicate stick movements to gracefully correct the movement. It takes a while to develop this delicate, smooth touch. Be patient with yourself.
- Try to keep the helicopter within a 10 foot circle, and try to keep it level.
- At some point, you will start to hover longer and longer periods without an edge of the training gear touching the pavement. This may require 5-10 battery charges or more.
- When you become more comfortable with the controls, you should gradually increase the altitude until you are hovering at about waist level (for micro helis) or eye level (for nonmicro helis)
- Congrats. You're tail-in hovering. :)
- When you can hold the heli within about a 5 ft circle, you should practice hovering with the heli slightly to the left of you or slightly to the right of you (in about the 10 o'clock position and 2 o'clock position) to prepare for the next section.

Chapter 19. Side-In and Nose-In Hovering Orientations

The next step after tail-in hovering is side-in hovering. There are two orientations for side-in hovering: left-in and right-in hovering where the left side and the right side of the helicopter are facing you,respectively.

You should make sure your tail-in hovering is fairly solid before attempting side-in hovering. You will turn the heli back to the tail-in orientation if you start to lose control, so make sure your tail-in hovering is very solid before attempting this.

Tail-in hovering is easiest if the learning process is divided into two steps:

- Translating into side-in
- Turning into side-in

Translating into side-in is easier than turning into side-in, and should be practiced first.

19.1. To translate into a left side-in hover

Assuming you are facing north, set the heli down about 15 ft in front of you and lift into a tail-in hover. Now move the heli east about 15 ft. This is a 45 degree side-in hover. Once you are comfortable with this hovering position, you should move the heli south about 15 ft so the heli is 15 ft east of you.

Turn to face the heli.

Once you are comfortable with this, you should practice turning into a side-in hover.

19.2. To turn into a left side-in hover

Lift off into a tail-in hover, then use the rudder to turn the heli to a left side-in orientation. You should turn very slowly to avoid losing orientation, and increase the turn rate as your proficiency improves.

Once you can hover both left-in and right-in hovering, you should increase practice more on the weaker orientation to strengthen it. This is very important to avoid developing "handedness" in orientation. After left-in and right-in hovering, you might choose to learn nose-in hovering. Some people say this is "very difficult" but really it's just another orientation to learn. If you've learned three orientations, you might as well learn the fourth before you go on to the next part.

It's probably okay to remove the training gear after you are fairly comfortable with side-in hovering or nose-in hovering. The removal of the training gear will change the flight characteristics of the helicopter and make it more sensitive to stick input, so this will require some mental adjustment. After you have removed the training gear, you should hover at about 3ft to eye level.

I would recommend spending at least two months learning each hovering orientation to ensure you are very comfortable with each orientation. When you can hover entire packs with each orientation and feel reasonably in control of the heli, you are probably ready to progress to the next stage.

Chapter 20. Orientation Exercises

20.1. Introduction

> "...what flyers need most is solid fundamentals."
> —Jason Krause interview, Model Helicopter Technique #36

> "I think you should really focus on the fundamentals.... A pilot should make sure he is completely confident with all orientations of the machine before attempting any 3D maneuvers."
> —Pete Niotis interview, Model Helicopter Technique #44

The foundation of your helicopter flying skills is good orientation. If you do not have good orientation skills, it will seriously hinder your ability to learn forward flight and advanced skills.

Also, probably the #1 reason for beginner helicopter crashes is losing orientation. If you can follow the helicopter orientation as it moves, you will crash less often.

Here are some exercises to practice which will help you close the "orientation gaps" you may have. You may want to practice these in a simulator first to become comfortable with them.

20.2. Inverted T

Start with helicopter hovering tail-in at a comfortable distance away from you. Do not turn (yaw) the helicopter while performing this exercise.

1. Move the helicopter right about 3ft, then back to the start location.
2. Move the helicopter left about 3ft, then back to the start location.
3. Move the helicopter away from you about 3ft, then back to the start location.

This exercise can also be performed starting at a side-in or nose-in orientation.

20.3. 90 degree yaw

While hovering, turn 90 degrees. Turn from either side-in to nose or tail in, and back. Try to keep the helicopter stationary while turning.

There are four different variations on this exercise

- Tail-in to left-in and then back
- Tail-in to right-in and then back
- Nose-in to left-in and then back
- Nose-in to right-in and then back

20.4. 180 degree yaw

While hovering, turn 180 degrees. Start with one side-in orientation and switch to the other side-in orientation. Also, practice switching from tail-in to nose-in and back, and tail-in to nose-in and back. Try to keep the helicopter stationary while turning.

There are two different variations on this exercise

- Nose-in to tail-in and then back
- Right-in to left-in and then back

20.5. 45 degree nose-in orientations

The straight nose-in orientation easy, but the angled nose-in orientations with the nose pointing 45 degrees left and right are more difficult, so this is good to practice.

Chapter 21. Forward and Backward Flight

21.1. Using idle-up mode

If you have been learning to hover in normal mode, you should now switch to using idle-up mode for practicing forwards and backwards flight.

The idle-up mode will allow you to keep a constant headspeed regardless of the throttle stick position, which will make the helicopter more responsive to the throttle stick. This is necessary to perform proper banked turns during fast forward and backward flight.

Be sure to reread the Helicopter power-on procedure section to learn the proper procedure for switching into idle-up mode.

21.2. Entering and exiting fast forward flight

Forward flight is a little tricky on helicopters. It requires simultaneous coordination of both the throttle and cyclic to enter and exit forward flight smoothly.

To enter forward flight, it is necessary to tilt the heli forward (use forward cyclic) and simultaneously apply a little throttle. If you tilt the heli forward without applying throttle, the helicopter will slide nose-first into the ground. This is because the thrust from the heli is being vectored at an angle relative to the ground, and you lose some vertical lift because it's being converted to horizontal thrust.

Once the helicopter starts moving, you will need to tilt the heli back a little and simultaneously reduce throttle below hover. You will need to reduce the throttle because translational lift will occur and you will now get extra lift. Exiting forward flight into a hover is the reverse process. You will need to tilt the heli back (use back cyclic) to reduce forward motion, and simultaneously reduce throttle to prevent the heli from climbing up. After the forward motion has been reduced, you will need to level the helicopter (use forward cyclic) and add throttle to transition to a stable hover.

One way to practice forward flight is to pick two points a comfortable distance apart (maybe five feet for a micro, ten or fifteen feet for a nonmicro) then practice flying back and forth between those two points (stop into a hover at each point and turn 180 degrees).

21.3. Banked forward turns

Banked turns are also a little tricky, and require simultaneous coordination of the throttle and cyclic.

The first phase of a banked turn is to apply left or right cyclic in the direction of the turn until the desired bank angle is reached.

The second phase of a banked turn is to simultaneously apply a small amount of back cyclic and rudder in the direction of the turn. The third phase is to straighten out after the turn. This requires using forward cyclic to maintain forward motion and centering the rudder stick.

Be careful when making a turn in windy conditions. This is the main cause of beginner crashes at this stage.

When you are flying into the wind, you will gain translational lift and the heli will rise, so you will decrease throttle. As you perform the turn and are flying with the wind, you will all of a sudden lose translational lift very abruptly and the heli will start to sink.

With a fixed pitch heli, the throttle changes are not immmediate because the main rotor needs to gain RPM. So, you will need to apply throttle early before you lose translational lift (about halfway through the turn), otherwise the heli will lose some altitude when finishing the turn.

21.4. Backwards flight

> "I always lead with the tail. As I watch the heli I'm keying off the tail, as far as I know, and I steer along with the tail."
>
> —Todd Bennett, Model Helicopter Technique #35

Backwards flight is tricky because it requires unlearning some of the reflexes learned for forward flight. You will need to fly backwards by concentrating on the tail of the helicopter (not the nose!), and the controls to slow down and speed up are reversed.

You will need to be very careful about letting the tail tilt too low, because it will hit the ground and flip the helicopter over.

If you don't have a good heading hold gyro by this point, I highly recommend you buy one now. Backwards flight is much more difficult without heading hold because the tail will have a strong tendency to weathervane suddenly and flip around, which can cause you to lose orientation and crash.

If you have a horizontal fin on your tail boom, you will want to remove it, because the fin will pull the tail up or down during backwards flight and make level flight difficult.

You may want to perform the "fly between two points" exercise mentioned in the forward flight section in a backwards orientation to become comfortable with backwards flight.

21.5. Banked backwards turns

Banked backwards turns are tricky because the cyclic does not follow the rudder...it is the opposite of the rudder. This requires a bit of explanation.

For forwards flight, a left turn consists of left rudder with LEFT cyclic, because the left side of the helicopter faces the inside of the loop.

For backwards flight, a left turn consists of left rudder with RIGHT cyclic, because the right side of the helicopter faces the inside of the loop.

There are two turns in two orientations, which results in four backward turns:

- Right turn where heli is tail-in relative to you (e.g. heli is traveling from your left to your right, then makes a right turn towards you)
- Left turn where heli is tail-in relative to you (e.g. heli is traveling from your right to your left, then makes a left turn towards you)
- Right turn where heli is nose-in relative to you (e.g. heli is traveling from your right to your left, then makes a right turn away from you)
- Left turn where heli is nose-in relative to you (e.g. heli is traveling from your left to your right, then makes a left turn away from you)

The potential for crashing is pretty high, so I highly recommend practicing these in a simulator before trying them on your heli. I recommend learning the tail-in turns before the nose-in turns because the tail-in turns are easier.

When performing backwards turns, there are three things you need to watch simultaneously:

- The bank of the helicopter. If the helicopter banks too much then it will lose lift and slide into the ground.
- The angle of the tail. If the tail sinks too low then your heli will dive into the ground.
- The yaw rate. If you yaw too much, you will wind up merely performing pirouettes, and if you yaw too little the turn will look sloppy.

Chapter 22. Forwards and Backwards Exercises

A "remote circle" in this section means flying in a circle not around yourself, but at some distance away.

22.1. Figure eights

This is a combination of the forward flight and banked turn skills.

This is a bit tricky on the Corona because it does not turn well when the main rotor is throttled down, because the tail rotor is also throttled down. If you try to do turns when the tail is throttled down, it will turn very slowly then snap into position when the helicopter enters forward flight.

To do proper figure eights on the Corona, you will need to throttle up slightly when entering turns to ensure the tail has enough authority to turn the Corona, and throttle down slightly when exiting the turn and entering the forward flight section.

Practice easy figure eights first where the heli turns tail-in at both ends of the figure eight. Once you are comfortable with these, try the hard figure eights where the heli turns nose-in towards you. *BE SURE* to attempt the nose-in turns at a reasonable distance from yourself to avoid hitting yourself with the helicopter!

For added complexity, try doing a pirouette or two in the middle of the forward flight section of the figure-eight.

22.2. Backwards remote half circles

Fly in a circle, but fly only half of it backwards. So, you will need to perform two 180 degree pirouettes during the circle to change orientation. This is easier than a backwards full circle because you can learn the tail-in backwards turn first, which is easier.

For a clockwise circle, do the right half of it with a backwards orientation. For a counterclockwise circle, do the left half with a backwards orientation.

22.3. Backwards remote full circles

Fly in a full circle backwards. Try to keep the helicopter moving smoothly at a constant speed. Be sure to practice both clockwise and counterclockwise circles.

22.4. Backwards tail-in figure-eight

Fly in a figure-eight backwards where the heli turns nose-in to you during the turn.

22.5. Backwards nose-in figure-eight

Fly in a figure-eight backwards where the heli turns nose-in to you during the turn.

Chapter 23. Advanced Exercises

23.1. Single pirouette

While hovering tail-in/side-in/nose-in, execute a full 360 degree yaw, and resume hovering. Be sure to practice both clockwise and counterclockwise pirouettes to avoid developing "handedness".

23.2. Multiple slow pirouettes

These pirouettes should take about 16 seconds to complete a full 360 degree rotation. Try to keep the helicopter stationary while performing the pirouettes. Be sure to practice both clockwise and counterclockwise pirouettes to avoid developing "handedness".

The slow pirouettes are particulary good for diagnosing your own orientation weaknesses because you will lose control of your slow pirouettes at your weakest orientations. You should practice these weak orientations to improve them.

23.3. Pirouetting remote circles

This exercise should be performed at eye level, or slightly below.

There are four variations on this exercise:

a. Clockwise pirouetting remote clockwise circles

b. Counterclockwise pirouetting remote counterclockwise circles

c. Clockwise pirouetting remote counterclockwise circles

d. Counterclockwise pirouetting remote clockwise circles

The first two are easier because the pirouette goes with the travel direction, so they should be mastered first.

For nonmicro helis, these should be done with about a 4 second pirouette in a 20-30 ft circle.

For micro helis, these should be done with about a 4 second pirouette in about a 10 ft circle.

When attempting this exercise, do not bank too much, because this increases the risk of hitting the tail boom on the ground.

23.4. Pirouetting figure eights

There are four variations on this exercise:

a. Clockwise pirouetting easy figure eights

b. Clockwise pirouetting hard figure eights

c. Counterclockwise pirouetting easy figure eights

d. Counterclockwise pirouetting hard figure eights

The "easy" figure eights are figure eights where the heli moves away from you at the ends of the figure eight, and the "hard" figure eights are figure eights where the heli moves towards you at the ends of the figure eight.

Chapter 24. Tweaking Helicopter Twitchiness

As a beginner, you may find that your helicopter is much too twitchy to comfortably learn hovering. Here are some tips to reduce the cyclic sensitivity and make hovering easier:

(Note that you can reverse any of these actions to increase the cyclic sensitivity for aerobatics later when you're ready, e.g. increase headspeed, increase swashplate mixing, decrease exponential, lighten the flybar paddles, etc.)

24.1. Reduce the headspeed (CP helis only)

Reducing the headspeed is good for multiple reasons; it gives longer flight times, and reduces damage if a crash occurs. Most non-micro helis are comfortably flyable down to about 1400 rpm of headspeed. Be sure to leave enough "climb-out" so you can correct a bad mistake.

24.2. Reduce the swashplate mixing

You can reduce the aileron/elevator mixing percentages in the swashplate mixing menu of your transmitter to reduce the amount of cyclic throw. Probably 10-20% of the total is the most you can safely reduce without losing too much cyclic control. Be sure to leave enough cyclic so you can correct a bad mistake.

24.3. Increase exponential on aileron/elevator

This will decrease the cyclic sensitivity around the stick center while still giving you full movement at the periphery of stick movement. Don't forget that increasing exponential is a larger negative number for Futaba/Hitec radios and a larger positive number for JR radios. For other manufacturers please consult your owner's guide.

24.4. Add flybar weights

You can slide a shaft collar onto both sides of the flybar. The shaft collars can be slid in or out from the head to adjust the cyclic sensitivity.

As the shaft collars are slid away from the head, this increases the inertia of the flybar and makes the cyclic less sensitive. Make sure the shaft collars are at the same distance from the center of the head to avoid unbalancing the flybar.

As you gain proficiency at hovering, you should gradually move the flybar weights inwards towards the head and eventually remove them. When you can hover without the flybar weights, you are ready for forward flight.

Chapter 25. Your First Major Crash

> "There are two kinds of helicopter pilots: those who have crashed, and those who *will* crash."
>
> —probably a paraphrasing of a motorcycle quote

Your first major crash is the hardest crash, psychologically. My informal guess is over 80% of the people who "give up" on R/C helicopters do so after their first major crash.

However, everyone crashes. Even the best helicopter pilots such as Curtis Youngblood and Alan Szabo have crashed in public, and have been recorded on tape.

If you can get past the first major crash, then your chance of succeeding is fairly good.

Your helicopter may look like a pretzel. However, most helicopter crashes look much worse than they actually are. Also, if you have bought from a reputable dealer, than they will stock every single part of the helicopter individually, and you should be able to buy every single replacement part.

If the replacement cost of the individual parts exceeds the cost of a new kit, then you should buy a new kit and use the parts from the kit. This is rather rare, though.

Chapter 26. Troubleshooting Common Problems

26.1. Vibration problems

Heli vibration can be broadly categorized into two types:

- Main rotor vibration

  The main symptoms of this are landing gear vibrating, and the vertical tail fin vibrating left/right.

- Tail rotor vibration

  The main symptom of this is the tail boom vibrating up/down at high speed.

If you follow these directions step-by-step, you should be able to solve most vibration problems.

The basic methodology is to keep removing parts from the helicopter until the vibration stops, and when the vibration stops the last piece you removed was causing the vibration problem.

Note that some helicopter models are known to have problems. For example:

Many Hummingbird Elite CPs appear to have been shipped with warped plastic head blocks (CNE205).

Early models of the Robbe Eolo were shipped with warped tail parts which caused tail vibration.

26.1.1. Excessive vibration (entire heli)

Checklist for main rotor vibration

- Check the obvious

  Check if main gear mesh is too tight.

  Check if the main gear is missing teeth.

  Check if the tail belt is too loose or too tight.

- Check main blade tracking. Put a piece of marking tape on one blade and run up the motor. Check if the blades are tracking properly. If the blades do not track properly, then see the section on blade tracking.
- Check if the blade grip bolts are too loose or too tight. Hold the helicopter so the right side or left side is facing down, and see if the main rotor blades will stay horizontal to the ground. If they just barely stay horizontal then this is just right.
- Check main rotor blade CG and balance. Balance the main blades on a blade balancer and ensure the CGs match and the blades balance. If the CG does not match or the blades do not balance, then see the section on blade balancing.
- Check if the feathering shaft is bent. Disassemble the main rotor hub and remove the feathering shaft. Check the feathering shaft using the directions given for the main shaft below.

The Corona doesn't have a feathering shaft, and instead has an aluminum rod which holds the subrotor on the rotor hub. This rod is very thin and has a tendency to bend after a few crashes. You will notice this because the subrotor paddles will "droop down" and will not be parallel to each other. This problem can be easily fixed by carefully bending the subrotor paddles up to straighten the aluminum rod or bye replacing the aluminum rod.

- Check if the rotor head is balanced. Reinstall the head and swashplate assembly but remove the main rotor blades. Connect the battery and slowly apply throttle. If the heli is vibrating then you should check if the flybar is straight and centered and balance the main rotor head using a Tru-spin prop balancer or equivalent.

- Check if the main shaft is bent. A quick test for this is to remove the main rotor head, swashplate and all the related linkages. Run up the motor without the head and hold a screwdriver against the top of the shaft as the shaft turns. If you feel vibration while holding the screwdriver against the turning shaft, then the shaft is obviously bent.

  If you do not feel any obvious vibration, then the shaft may still be bent. To perform a more precise test for bent shaft checking, first you need a perfectly flat surface, preferably a sheet of glass. It isn't necessary to remove the glass cover from a frame; just use the entire photo or award.

  Second, take a new shaft and place it on the glass and tilt the surface slightly. Watch it roll back and forth as you tilt the surface. The first thing you should notice is a straight shaft will easily start rolling from a stopped position. You do not need to tilt the surface very much to start it rolling. The second thing to notice is a straight shaft can be rolled at all speeds. If you tilt it only slightly, it rolls very slowly. If you tilt it a lot, it rolls very quickly.

  Now remove the new shaft and place the suspect shaft on the glass. Roll the suspect shaft back and forth as you did the new shaft. If the suspect shaft requires more tilt to start rolling than the new shaft, then it is bent. If the suspect shaft cannot be rolled as slowly as the new shaft, then it is bent.

  If you hold the surface to your eyes and roll the suspect shaft, then you may be able to see gaps between the shaft and glass as the shaft rolls. If you can see these gaps, then the shaft is obviously bent.

- Check the main rotor bearings. Remove the main shaft bearings from the helicopter. Put the main shaft through each bearing and spin it by hand. If the bearing does not rotate smoothly or feels gritty, then replace it.

26.1.2. Excessive vibration (tail only)

Checklist for tail rotor vibration

- Check tail rotor blade balance

  Reinstall the main rotor shaft and main gear, but do not reinstall the head and swashplate assembly. Remove the tail rotor blades and run up the helicopter. If the vibrations are gone, then the tail blades need to be balanced or replaced.

- Check the tail blade grip spacing

  If the tail blade grip screw is not screwed in equally on both tail blade grips, then the tail blade grips will not be the same distance from the center of rotation which will cause vibration.

- Check the tail rotor shaft

  Remove the tail rotor shaft and follow the directions in the Bent Shaft Checking section.

- Check the tail rotor bearings

  Remove the tail shaft bearings from the helicopter. Put the tail shaft through each bearing and spin it by hand. If the bearing does not rotate smoothly or feels gritty, then replace it.

- Tail rotor hub balancing

  If the vibrations remain, then the tail rotor shaft and hub need to be balanced. Put the entire assembly on a Tru-spin prop balancer or equivalent for balancing.

If the tail is vibrating left/right (usually noticeable by looking at the vertical tail fin) then this is usually caused by problems in the main rotor system, such as a bent main rotor shaft or unbalanced main rotor blades.

If the tail is vibrating up/down, then this is usually caused by problems in the tail rotor system, such as a bent tail rotor shaft or damaged tail rotor blades.

- On a Corona, the gear on the hollow TR shaft (56633) can become chipped, and it's very hard to notice because the gear is inside the tail case. Try cleaning the old lithium grease out of the tail case with a Q-tip and check for orange pieces of plastic in the old grease. If you do find these plastic bits, then the TR shaft (56633) should be replaced.

- Tail vibration can be caused by tail blade holders being too tight. Some helicopter upgrade tail hubs promise "dual or triple ball bearings which remove all slop..." This is a bad idea. Most variable-pitch tail rotors are designed as a flapping hinge rotor which require slop in the tail blade holder.

  If this slop is removed, then this destroys the ability of the flapping hinge to equalize the thrust from both tail rotor blades. This causes high-speed vibrations which may weaken the tail blade holder screw and eventually shear it.

  For more information on flapping hinges, search the web for the phrase "delta three angle" or go to the following URL: www.scotiabladerunners.ca/delta.htm

26.2. Tail control problems

26.2.1. Tail keeps spinning and will not stop with HH gyro

The gyro reverse switch probably needs to be reversed.

- If the gyro reverse is correct:

  When the tail moves left, the gyro will push it right until the turn is reversed.

  When the tail moves right, the gyro will push it left until the turn is reversed.

- If the gyro reverse is incorrect:

  When the tail moves left, the gyro will push it left some more until the turn is reversed. Since the gyro cannot reverse a left turn by pushing the tail left, the tail will keep spinning left forever.

When the tail moves right, the gyro will push it right until the turn is reversed. Since the gyro can't reverse a right turn by pushing the tail right, the tail will keep spinning right forever.

26.2.2. Tail jerks around when spooling up with HH gyro

- The gyro may be too close to the ESC. On a non-micro heli, the gyro should be at least four inches away from the ESC.
- Tail belt may be twisted around. Removing the tail rotor assembly from the tail boom and make sure the tail drive belt isn't twisted.

26.2.3. Tail wags (hunts) constantly with HH gyro

Tail wag occurs because the heading hold gyro cannot precisely control the thrust of the tail rotor. This can be caused by several problems:

1. Inconsistent tail rotor speed

   If the tail rotor speed is not consistent, then the gyro will have difficulty controlling the tail rotor thrust. This is unavoidable on fixed pitch helicopters to some extent. This may be caused by:

   - Tail belt may be loose
   - Main gear or other gear may be missing a tooth

     Visually inspect the teeth of all gears and ensure no teeth are missing.

2. Tail rotor blade pitch resolution problem

   For example, the heading hold gyro may want the tail blade pitch at 10.4 degrees. If there is a problem, and the tail blade pitch can only be at 10.2 and 10.6 degrees, then the heading hold gyro will alternate the blade pitch between 10.2 and 10.6 degrees. This will cause the tail to wag back and forth.

   This tail rotor pitch problem may be caused by:

   - Excessive play in the tail rotor blade pitch control system.

     A little play is acceptable in the control system, but you should strive to minimize the play.

   - Tail rotor pitch slider may be sticking to the tail shaft

     This is usually caused by a dirty tail rotor shaft and/or dirty pitch slider. The tail rotor shaft can be wiped with a tissue, and the inside of the tail pitch slider can be cleaned by using a cotton swab.

     Do *NOT* use oil to lubricate the tail rotor shaft because it will attract dirt and become sticky. Use powdered graphite instead.

   - Tail blade grip bearings may be dirty, damaged, or loctited to the screw.
   - Tail blade grip screw may be bent.
   - Tail servo has too much leverage on the tail pitch control lever.

You can increase the effective resolution of the tail servo at the cost of decreasing the travel speed which may reduce or eliminate the tail wag. To do this. you can move the tail pitch linkage *IN* one hole on the tail servo arm or *OUT* one hole on the tail pitch control lever.

- Tail servo may not have enough resolution

  This HS-50 servo, in particular, does not work very well with a heading hold gyro due to the servo slop.

3. Gyro or tail servo mounting problems
   - Gyro not mounted securely to frame. Use only the supplied gyro tape or 1/8" (3mm)thick 3M foam tape. Do *NOT* use velcro!
   - Servo not mounted securely to the frame or tail boom mount.

     Check for loose or stripped screws. Also, rubber servo grommets can cause wag when used on tail servo mounts.

4. ESC with poor governor mode
   - Some ESCs have a badly programmed governor mode, and the motor speed will fluctuate when the governor mode is enabled.

     This occurs because the gyro will apply extra tail pitch which increases the load on the motor, which causes it to slow down. The governor mode will apply more power to the motor, which causes the motor speed (and tail rotor speed) to increases, which causes the tail to overshoot the proper position. The same problem occurs when the tail pitch is decreased, and the tail overshoots the correct position again.

     Basically, the ESC governor mode and heading hold gyro can go into a vicious cycle which causes the tail to wag. This is known to happen on Align ESCs and Castle Creations ESCs with older firmware versions.

5. Other problems
   - Gyro gain too high. Smaller helis usually require lower gain settings.
   - Worn tail servo.

     Metal geared servos tend to wear quickly when used for tail rotor pitch control.
   - Gyro gain too high. Smaller helis usually require lower gain settings.
   - Tail servo may be missing a tooth on a gear from previous crash damage.
   - Tail servo may not have enough torque to move the tail pitch lever smoothly.
   - Tail rotor may be too large (micro helis only)

     This is a common problem when a GWS IPS motor with a 3x2 prop is used. Trimming the propeller by a little may help.

26.2.4. Tail swings 30-90 degrees abruptly then corrects itself

- This could be caused by radio glitches. See Section 26.5, “Glitching”.

- The one-way bearing in the autorotation hub may be loose.

26.2.5. Tail servo responds in one direction only

- Tail servo responds properly when tail swings one direction but tail servo fails to respond in other direction.
- The gyro may be damaged.

26.2.6. Tail drifts as battery discharges

Tail holds fine at the beginning of a flight, but starts to drift as the battery discharges. This is normal for a yaw rate gyro. Heading hold gyros do not have this problem.

26.2.7. Tail motor runs at low throttle

The heli tail runs even at low throttle when using a heading hold gyro and a tail motor. This is normal. The heading hold gyro does not output zero throttle unless it receives a full left rudder stick. This is why you need to hold full left rudder to initialize the tail ESC.

26.2.8. Tail servo creeps or does not recenter

Tail servo slowly moves in one direction (creeps) when heli is on the ground with heading hold gyro. This is normal. Don't worry about it.

26.2.9. Tail servo travel is unequal

Tail servo travel is unequal on both sides of the neutral point with heading hold gyro. This is normal. You should set the servo travel in the non-HH mode and the heading hold mode will work automatically.

26.2.10. Tail motor has insufficient tail thrust

Helicopter has a tail motor, and has insufficient tail thrust to counter main rotor torque. Tail prop may be mounted backwards. Examine the prop airfoil - the prop should be mounted so the airfoil will gradually increase pitch as the air moves past the rotor.

26.2.11. Tail servo travel is not settable using Transmitter EPA with heading hold gyro

This is correct. With a heading hold gyro, the transmitter EPA controls the pirouette rate. The tail servo travel must be set using the LIMIT adjustment on the gyro. If the gyro does not have this feature, then the tail servo travel cannot be set, and you must move the tail servo linkage to a different servo horn hole to increase or decrease the linkage travel.

26.2.12. Tail servo moves in the wrong direction with a heading hold gyro. Reversing the transmitter rudder channel has no effect.

The transmitter rudder channel reverse function does not change the servo rotation direction with a heading hold gyro. It only changes the yaw direction command to the gyro.

The tail servo rotation direction can only be fixed by using the reverse switch on the gyro, or if the gyro has no reverse switch (such as the CSM LW200 gyro), it must be mounted upside down.

See Section 30.1.7, “How gyros work” for more information.

26.2.13. Tail drifts during flight with heading hold gyro

This can be caused by three problems:

- With non-Futaba gyros such as the CSM LW200 or Ikarus Profi gyro, the transmitter rudder channel neutral point will need to be matched with the gyro's expectation of the neutral point, because these gyros do not calibrate the neutral point when the gyro is powered up. Use the transmitter subtrim to center the rudder channel. It may help to set the rudder channel subtrim to a smaller increment.
- With a Futaba gyro, this problem is usually caused by bumping and/or moving the helicopter while the gyro is initializing. Do not bump or move the helicopter when connecting the helicopter battery.
- Excessive vibration can cause a heading hold gyro to "drift" and slowly lose the correct position.

Also, the ESC will generate an electrical spike when the battery is connected, and if the gyro wires are close to the ESC or motor, this will disrupt the gyro calibration of the rudder neutral point. The solution is to route the gyro wires away from the ESC and motor wires.

26.3. Throttle/ESC problems

26.3.1. Motor ESC will not arm, or motor runs at zero throttle

- You may need to reverse the throttle channel on the transmitter.
- You may need to decrease the "zero throttle" endpoint to arm the ESC properly. This is a common problem with the Castle Creations ESCs, but also happens occasionally with the Schulze ESCs as well.

26.3.2. Lost throttle control

Lose throttle control on a fixed pitch helicopter and it becomes impossible to bring down (heli flies away on its own).

This can happen if the heli ESC is set to "adjustable endpoint mode". When this mode is set, the heli ESC will treat the lowest throttle position it sees as the zero throttle. However, this can cause serious problems for a heli.

Imagine that your low throttle position is -100. A radio glitch occurs and the throttle ESC receives a fake -200 throttle position. Now, when your stick is at -100, this looks like mid-stick to the ESC, and you will be unable to turn the main motor off.

26.3.3. Motor does not start turning till about 40% throttle

If you are using a Castle Creations controller, then the controller is probably in auto calibrating throttle mode. This is not correct. See Chapter 13, *Helicopter and Transmitter Setup* for correct ESC programming parameters.

26.3.4. Motor surges with governor mode

If you are using a ramped throttle curve (0-50-85-85-85) or V-shaped throttle curve (100-90-80-90-100) with a main motor ESC in governor mode, then the motor will be unable to maintain a constant RPM and the headspeed will "surge".

You must use a horizontal throttle curve such as 90-90-90-90-90 in order for the governor mode to work properly.

26.4. Swashplate problems

26.4.1. Cyclic servos wiggle around when motor is running

This is probably caused by radio interference. See Section 26.5, “Glitching”.

26.4.2. eCCPM swashplate does not move correctly.

Either the collective pitch works properly but the cyclic doesn't, or vice versa.

The collective pitch servo movement is configured using servo reversing, but the cyclic swashplate movement is configured using swashplate mixing.

For more information, see Chapter 13, *Helicopter and Transmitter Setup*.

26.5. Glitching

- Check your component placement to ensure electrically noisy components are placed away from eletrically sensitive components.

  See also Section 11.2, “Component placement” for more info.

- Check your wire routing to ensure wires to/from eletrically noisy components are placed away from wires to/from eletrically sensitive components. See section 11.3 Wire routing for more info.

  See also Section 11.3, “Wire routing” for more info.

- Replace the receiver crystal if it has been in a crash. Receiver crystals are fragile devices which can be easily damaged.

- Check for bad bearings. Bad bearings will generate electrical interference. See section 30.8.9 Ball bearings for more info.

  See also Section 30.10.9, “Ball bearings” for more info.

- Connect a wire from the metal or CF tail boom to the battery negative lead. The tail belt can generate static electricity as it slaps the inside of the tail boom.

- Connect a wire from the metal frame to the negative battery lead. The frame can generate an electrical charge in some cases.

- Wrap the ESC receiver wire through a ferrite ring several times to reduce ESC interference.

- Try wrapping the receiver in aluminum foil temporarily. If the glitching stops, then the receiver is too close to an electrically noisy component.

- If using a brushed motor, check the brushes and commutator. Worn brushes and/or a dirty commutator can increase electrical noise generated by the motor.

26.6. Other problems

26.6.1. Heli twitches randomly in roll/pitch/yaw

This is probably caused by radio interference. See Section 26.5, “Glitching”.

26.6.2. Short flight times and/or not enough power

- For brushed motors: the commmutator may be dirty. See section on maintenance.
- Pinion meshing may be too tight. The pinion should not be firmly fitted against the main gear. The motor pinion should be able to wiggle just a tiny bit without turning the main gear.
- Motor pinion may be slipping on motor shaft. If your motor pinion uses a setscrew, then your motor should have a flat spot on the motor shaft so the setscrew will not slip on the motor shaft.

  If the motor shaft has no flat spot for the setscrew to bite, then you should make one with a Dremel and a diamond cylinder point bit (#7123).

  For the Piccolo using the stock motor (G280 or G310)and the plastic motor pinions, it may be necessary to glue the plastic pinion onto the motor shaft to prevent it from slipping.
- Woodies may be trashed:

  Most larger wooden blades are made of a hardwood leading edge and a balsa trailing edge all shrinkwrapped together.

  On hard crashes, the balsa part can be severely damaged but the blade looks fine due to the shrinkwrap holding the blade together.

  If you look closely you may be able to see the breaks in the balsa. If you can see this, then the blade should be replaced.

26.6.3. Slight tilt to the right (or left)

This is normal. The helicopter will tilt slightly due to the thrust of the tail rotor.

26.6.4. Unstable hover or wobbling

- Your headspeed may be too low and you may be compensating for this by using more main motor pitch which makes the heli motor bog down and the heli unstable.
- Your rotor head may not be firmly attached to the main rotor shaft. This usually occurs when the hole in the rotor head is reamed out after multiple hard crashes. If the rotor head is not fitting snugly on the main rotor shaft, it should be replaced. This problem is seen on MS Hornets. because the E044 pivot support is fragile.

26.6.5. The blade tracking becomes worse at higher head speeds.

- On a CP Piccolo, this is usually caused by a broken pitch arm base (68211). Visually inspect the two thin "legs" which are between the arms and the tube. One of the legs may have broken.
- The feathering shaft may be bent. Disassemble the head and put the feathering shaft in a

drill and spin it to check if the shaft is bent.

Chapter 27. Electric Helicopter and Parts Vendors

These are vendors which are mentioned frequently on various popular Internet discussion forums. I do not necessarily endorse any vendors on this list. For brevity, any e-heli vendors who also stock servos/motors/etc. will not be listed again in the servos/motors/etc. section.

Lite Machines Corona and replacement parts

- (US) www.litemachines.com
- (US) www.roffeetvhobby.com
- (DE) www.rc-city.de

Mikado Logo 10

- (US) www.fxaeromodels.com
- (US) www.cyberheli.com
- (US) www.aero-model.com
- (DE) www.rc-city.de
- (HK) www.cyberheli.com
- (DE) www.nennos-helishop.de

Ikarus ECO Piccolo and Piccolo Fun

- (US) www.dreamhobbies.com
- (US) www.fxaeromodels.com
- (US) www.hobby-lobby.com
- (DE) www.rc-city.de
- (UK) www.modelhelicopters.co.uk

Ikarus ECO 8/16

- (US) www.dreamhobbies.com
- (US) www.fxaeromodels.com
- (US) www.hobby-lobby.com
- (US) www.cmehobbies.com
- (DE) www.rc-city.de

Viper 70/90

- (US) www.fxaeromodels.com
- (US) www.3dhobbyshop.com

MS Composit Hornet and Hornet II

- (US) www.fxaeromodels.com
- (US) www.edogfight.com
- (US) www.aeromicro.com
- (US) www.hobby-lobby.com
- (UK) www.skylinemodels.co.uk
- (DE) www.rc-city.de

Maxir SE

- (CA) www.icare-rc.com
- (US) www.elektrorc.com
- (US) www.littleheli.com

Robbe Eolo R22

- (US) www.rchover.com
- (UK) www.rchelibits.co.uk

Quick EP 10 and Sweet 16

- (US) www.quickheli.com

Feda Skylark/Century Hummingbird/GWS Dragonfly

- (US) www.centuryheli.com
- (US) www.gwsparts.com
- (UK) www.sussex-model-centre.co.uk
- (UK) www.centuryuk.co.uk

Protech Zoom 400/Evoflight Shogun/Zap 400

- (US) www.towerhobbies.com
- (US) http://www.hobbypeople.net
- (US) http://www.grandrc.com
- (US) http://www.rchover.com
- (US) http://www.modefosheli.com

Align T-rex 450X/450XL

- (US) www.fxaeromodels.com
- (US) www.grandrc.com
- (US) www.rchover.com
- (US) www.helidirect.com
- (US) www.rcworldofplanes.net
- (US) http://www.gwsparts.com
- (US) www.modefosheli.com

ARK X-400

- (US) www.deeeteeenterprises.com
- (US) www.grandrc.com
- (US) www.rchover.com
- (US) www.helidirect.com

Motor vendors

- (US) www.towerhobbies.com
- (CA) www.icare-rc.com
- (US) www.megamotorusa.com
- (US) www.aveox.com
- (UK) www.overlander.co.uk
- (UK) www.puffinmodels.com
- (US) www.hackerbrushless.com

- (US) www.medusaproducts.com
- (JP) www.aircraft-world.com
- Also check the RC Groups sponsor links

ESC vendors

- (US) www.dionysusdesign.com
- (US) www.castlecreations.com
- (US) www.kontronikusa.com
- (US) www.hackerbrushless.com
- (DE) www.schulze-elektronik-gmbh.de
- (CZ) www.mgm-compro.cz

Servo vendors

- (US) www.servo-city.com
- (US) www.bphobbies.com
- (US) www.nesail.com
- (US) www.towerhobbies.com
- (US) www.horizonhobby.com
- (US) www.shredair.com
- (US) www.hobbyclub.com
- (US) www.brucknerhobbies.com
- (UK) www.inwoodmodels.co.uk
- (UK) www.servoshop.co.uk

Batteries and related supplies

- (US) www.dynamoelectrics.com
- (US) www.batterystation.com
- (US) www.eflightpacks.com
- (US) www.nicdlady.com
- (US) www.modelelectronicscorp.com
- (US) www.cheapbatterypacks.com

- (US) www.battlepacks.com
- (US) www.edogfight.com
- (US) www.b-p-p.com
- (ES) www.rcmaterial.com
- (DE) www.orbitronic.de
- (DE) www.schulze-elektronik-gmbh.de

BEC manufacturers

- (US) www.koolflightsystems.com (UBEC)
- (US) www.firmtronics.com (SBEC)
- (ZM) www.medusaproducts.com (Potencia)

Main rotor blades

- (US) www.carbonblades.com (FP microhelis)
- (US) www.like90.com (FP & CP microhelis)

Carbon fiber tubes and rods

- (US) www.cstsales.com
- (US) www.acp-composites.com
- (US) www.bphobbies.com
- (US) www.airdyn.com
- (UK) www.atsmayneline.com

Other suppliers

- (US) www.microheli.com (Micro heli upgrades)
- (US) www.sparrowproducts.com (Micro heli upgrades)
- (US) www.ballistictechnology.com (Corona upgrades)
- (US) www.chopper-1.org (Corona upgrades)
- (US) darthdrk.4t.com (Canopies and fuselages)
- (US) www.jameco.com (Connectors, etc)
- (UK) www.maplin.co.uk (Connectors, LEDs etc.)

- (UK) www.modelfixings.co.uk (Bearings, screws etc.)
- (US) www.geocities.com/pierrehollis/microheliparts1.htm (upgrades)
- (US) www.heliworkz.com (Zoom upgrades)
- (US) www.rjrcooltools.com (Wiha and other tools)
- (JP) ks.jp.org (K&S aftermarket parts)
- (DE) www.wes-technik.de (micro parts)
- (DE) www.micro-heli.tuning.com (micro parts)

Hobby associations

- www.ircha.org Int'l Radio Controlled Helicopter Assoc
- (US) www.modelaircraft.org Academy of Model Aeronautics
- (UK) www.bmfa.org British Model Flying Association
- (UK) www.befa.org.uk British Electric Flight Association

Useful webpages and forums

- www.rcgroups.com RCgroups discussion forums
- www.pgoelz.com Paul Goelz's Piccolo site
- www.logoheli.com Glen Peden's Logo site
- www.ikarus-germany.com Piccolo and ECO 8/16 forums
- www.rchelispot.com RC Helicopters in general
- www.dream-models.com ECO 8/16 information
- www.hornet-heli.com MS Composit Hornet Forums
- www.trextuning.com T-rex info
- www.x400tuning.com X-400 info
- www.maxir.logoheli.com Glen Peden's Maxir site
- www.daddyhobby.com Singapore Helicopter forum
- Brushless motor info:
- Helicopter rotor head dynamics:

Aerobatics

- http://www.dokidoki.ne.jp/home2/tohrus/heli-00/acro-tech-e.html 3-D Aerobatics

- http://www.dokidoki.ne.jp/home2/tohrus/heli-00/invertedE.html Inverted

Magazines

- www.rotory.com Rotory
- www.modelheliworld.com Model Helicopter World
- www.mht.net Model Helicopter Technique
- www.rotorworld.co.uk Rotorworld

Helicopter theory

- www.copters.com/helo_aero.html
- www.scotiabladerunners.ca and click on "technical"
- www.w3mh.co.uk/articles/html/csm1_2.htm
- www.w3mh.co.uk/articles/html/csm3_4.htm
- www.w3mh.co.uk/articles/html/csm5_6.htm
- www.w3mh.co.uk/articles/html/csm7_8.htm
- www.w3mh.co.uk/articles/html/csm9_11.htm

Chapter 28. Frequently Asked Questions

28.1. General questions

28.1.1. How much does it cost?

A typical cost breakdown for a minimum beginner setup is:

Table 28.1. Beginners setup cost breakdown

Item	Cost ($)
Transmitter	200
Helicopter kit	200
Receiver	60
Servos	80
Brushed ESC	50
Brushed motor	50
Gyro	120
2x batteries	70
Battery charger	100
Total	**940**

This estimate is based on:Futaba 7c or Hitec Eclipse 7 transmitter, Corona barebones helicopter kit, Hitec Electron 6 receiver, Hitec HS-85MG servos for swashplate Hitec HS-81 servo for tail, Castle Creations Fusion 7 ESC, Kyosho Atomic Force or equivalent brushed motor, Futaba GY240 or GY401 gyro, 2 packs of 7 cell Sanyo CP2400, Great Planes Triton battery charger

Prices will vary greatly depending on your local region.

It is possible to buy an ARF microheli for as little as $150, but as with most things in life, the quality of the items you receive will be proportional to however much you pay.

The Romans did not have R/C helicopters but they understood the principle perfectly: *caveat emptor.*

28.1.2. How high will an R/C helicopter fly?

A R/C helicopter does not balance by itself, and must be balanced by radio control. When you can't see the R/C helicopter anymore, it will fall from the sky because it can no longer be balanced. Therefore, the maximum altitude of an R/C helicopter is limited by the visual acuity of the person flying it.

28.1.3. How long will an R/C helicopter fly?

This depends on the battery and motor. Aerobatic models will typically fly from 5 to 10 minutes, but models which are configured for duration flight can fly up to 30 minutes. The unofficial world record for an electric R/C helicopter flight is 1 hour and 48 minutes.

28.1.4. How fast will a helicopter go?

This question is often asked by R/C car people, and is similar to asking "How fast does a skateboard go?". A high-end skateboard is designed for doing tricks, not for speed. Similarly, a high-end helicopter is designed for fast flip/roll rates for aerobatics, not for high cruising speed.

28.1.5. What is the best helicopter?

This question is too broad to be meaningful, and is similar to asking: What is the best car? If you ask 10 different people this question, you will receive 10 different answers. A more specific question makes more sense, such as "What is the best aerobatic helicopter between 1kg and 2kg?"

28.1.6. Which helicopter should I buy?

See Chapter 3, *First Helicopter Selection Guide*

28.1.7. Should I buy an ARF helicopter?

No. When you crash a helicopter, you will need to disassemble the helicopter to replace the damaged parts. If you built the helicopter, then you will know how to disassemble it. Also, you will gain much knowledge about helicopters by building one.

28.1.8. How does an R/C helicopter fly inverted?

A fixed pitch helicopter cannot fly inverted except momentarily, such as at the top of a loop.

A collective pitch helicopter can change the pitch of the main blades. With positive pitch, the air is pushed down relative to the helicopter. With negative pitch, the air is pushed up relative to the helicopter. So to fly inverted, a collective pitch helicopter uses negative pitch on the main rotor blades.

28.1.9. Why does a CP helicopter handle wind better than an FP helicopter?

When an R/C helicopter flies in wind, it tends to bob up and down due to varying amounts of translational lift.

An FP helicopter controls the altitude by increasing and decreasing the main rotor RPM to generate more or less lift. The main rotor has some inertia, so there is some control lag between when the RPM changes are commanded and when the change actually occurs. Also, an FP helicopter loses cyclic control authority when the main rotor blades are at a lower RPM because the flybar paddles are spinning slower.

A CP helicopter in idle-up mode maintains a constant main rotor RPM and changes the amount of lift by varying the main blade pitch. The main blade pitch change occurs much faster than rotating the main rotor blades faster/slower, so there is less control lag. Also, since a CP helicopter in idle-up mode maintains constant main rotor RPM, it does not lose cyclic control authority when decreasing the main rotor blade pitch to generate less lift.

28.2. Transmitters

28.2.1. What is the difference between an airplane transmitter and a helicopter transmitter?

For most transmitters, there are only two differences:

- An airplane version will have a ratchet on the throttle. A helicopter version has a smooth throttle with no ratchet.
- An airplane version has the idle-up switch on the right side, and the throttle hold switch on the left side. A helicopter version has the idle-up switch on the left side and the throttle hold switch on the right side.

For Futaba transmitters, there is no firmware difference betweeen the airplane and heli versions of the transmitters, so the two physical differences are the only difference.

Some JR transmitters have separate airplane and transmitter versions where the airplane version does not support CCPM modes. The JR transmitters known to have this problem are:

- JR XP783 airplane (CCPM unlockable via service menu)
- JR X-388S airplane (CCPM unlockable via service menu)
- JR X-347 airplane (CCPM unlockable via service menu)
- JR 10X airplane (CCPM not unlockable)

For more information on transmitters see Chapter 9, *Transmitters*

28.2.2. Can you give me your transmitter settings for helicopter X?

This is a meaningless question, because the transmitter settings for a helicopter are dependent on:

- Servo type. Different servos have different ranges of movement.
- Servo horn type and hole used. If the servo horn is not exactly the same, and the same linkage hole used, then the range of motion will be different.
- Servo rotation direction. Different servos have different rotation direction
- Linkage length. The settings will be different depending on the length of the the linkages from the servo to the swashplate and from the swashplate to the main rotor blades and the flybar.
- Transmitter type. Different transmitters use different ranges for servo movement

So therefore, unless all of these different factors are exactly the same as your helicopter, the transmitters settings will be significantly different.

28.2.3. Which receivers are compatible with my Walkera transmitter?

None of the standard receivers from Futaba, JR, Hitec, Airtronics, etc are compatible with Walkera transmitters.

28.2.4. Which transmitters are compatible with my Walkera receiver?

None of the standard transmitters from Futaba, JR, Hitec, Airtronics, etc are compatible with

Walkera receivers.

28.2.5. Which transmitters are compatible with my E-flight Blade CP receiver?

The E-flight Blade CP transmitter uses negative shift, so any transmitter which can transmit with negative shift, such as Futaba, Hitec, Airtronics and Multiplex, are compatible.

28.2.6. What is the difference between FM, PPM, and PCM?

Basically, FM is frequency modulation, which is the method used to send the data.

PPM is pulse-position modulation, which is an analog method of encoding the data to be sent.

PCM is pulse code modulation, which is a digital method of encoding the data to be sent.

Both PPM and PCM send the data using FM, but encode the data differently.

For more info see:

www.aerodesign.de/peter/2000/PCM/PCM_PPM_eng.html

davesrcflight.mysite.wanadoo-members.co.uk/frame_pages/radio_control_topics_frame2.htm

28.2.7. Can I use a JR/Graupner/Futaba/Robbe PCM reciever with my JR/Graupner/Futaba/Robbe transmitter in PCM mode?

The Graupner transmitter/receivers are manufactured by JR so they are compatible with JR equipment. The Robbe transmitter/receivers are manufactured by Futaba, so they are compatible with Futaba equipment.

The Futaba and JR PCM standards are not compatible, so JR/Graupner PCM equipment is not compatible with Futaba/Robbe PCM equipment.

Futaba has two incompatible PCM systems: an older PCM512 (9-bit) system and a newer PCM1024 (10-bit) system. The newer Futaba transmitters only support PCM1024, and not PCM512.

JR has two incompatible PCM systems: an older Z-PCM (9-bit) system and the new S-PCM (10-bit) system. The newer JR transmitters support both Z-PCM and S-PCM standards.

28.2.8. Can I use a crystal from manufacturer X in my receiver from manufacturer Y?

It may or may not work. If both manufacturers use the same intermediate frequency in their receivers, then the crystal may work. However, if the intermediate frequency is slightly different, then the receiver will work erratically. Therefore, it is best to use a crystal from the same manufacturer as the receiver. Why risk a $100 crash to save $10?

See this URL for more info:

www.torreypinesgulls.org/Radios.htm

28.2.9. Can I use a single-conversion crystal in my dual-conversion receiver?

No. Single-conversion crystals are not compatible with dual-conversion crystals.

See this URL for more info:

www.torreypinesgulls.org/Radios.htm

28.2.10. Can I change the transmitter channel by changing the transmitter crystal?

An R/C transmitter is carefully tuned to a specific frequency. If you change the transmitter crystal to a different frequency, then the other components in the transmitter will not be tuned properly and the transmitter may generate interference on adjacent channels.

In the US, this change is covered by FCC section 95.222 Rule 22. It is illegal for the user to change the transmitter crystal to change the operating frequency.

If a transmitter does not use a transmitter plug-in module, then it must be sent to an authorized service center to change the frequency. However, if the transmitter does use a plug-in module (such as some Futaba models) then it is legal to change the module to change the operating frequency.

In non-US countries, it may be legal to change the transmitter crystal, but it is not recommended to change the channel by more than two up or down (from the original channel) to avoid detuning the transmitter and generating interference on adjacent channels.

See these URLs for more info:

http://www.rcgroups.com/forums/showthread.php?t=94580

http://www.torreypinesgulls.org/Radios.htm

28.2.11. Why are channel 20 and/or channel 21 not recommended for use or banned at my flying field?

If there is a strong television channel on TV channel 4 nearby, then a transmitter on R/C on 72 Mhz channel 20 or 21 can cause interference on all 72 Mhz R/C channels.

For more info, see this URL:

www.rchelibase.com/radiofaq

28.2.12. Can I use brand X servos with brand Y receivers?

Yes. All R/C servos are compatible with all R/C receivers. However, some manufacturer's servos rotate clockwise, and some rotate counterclockwise. This can be compensated by reversing the channel, however.

28.2.13. When should I move from an FP helicopter to a CP helicopter?

It is best to buy a CP helicopter after you have mastered everything which can be done with an FP helicopter.

Basically, you should be able to hover in all four orientations, do forward/backwards flight, stall turns, and slow pirouettes in both clockwise and counterclockwise directions.

28.3. Helicopter parts selection

28.3.1. Do my servos need to be of identical type for eCCPM?

Yes. If you use different servo types for eCCPM, then the swashplate will not move evenly up and down with throttle movement. This will cause unwanted cyclic/collective pitch interaction and make hovering difficult.

28.3.2. How does the Castle Creations Phoenix ESC governor mode work?

The Phoenix series governor mode functions the same as standard governor mode, but the RPM is selected by a different method.

Here is the explanation of the Phoenix governor mode, directly from Patrick del Castillo, the designer of the Phoenix ESCs:

www.rcgroups.com/forums/showthread.php?t=134039

28.4. Gyros

28.4.1. Can I hover without a gyro?

As a beginner, it is extremely unlikely that you would be able to learn how to hover a helicopter without a gyro.

28.4.2. Is a heading hold gyro worth the cost?

Yes. Many people have mentioned that they were unable to hover their helicopter until they installed a heading hold gyro.

28.4.3. If I put a gyro on each swashplate servo, will the heli hover by itself?

The short answer is: no. Gyros (as used in model helicopters) are only sensitive to angular acceleration and not linear acceleration. Therefore, they would only help stabilize the tilt of the helicopter and not the movement of the helicopter, regardless of whether yaw rate or heading hold gyros are used.

28.5. Helicopter setup

28.5.1. How do I set the collective pitch of the main blades?

See the Main blade pitch adjustment section in Chapter 13, *Helicopter and Transmitter Setup*.

Chapter 29. Helicopter Myths

29.1. Expo is bad because it slows cyclic response

This is incorrect, because expo does not slow down the cyclic response. It only decrease the amount of cyclic response near center stick while retaining full control throw at the stick extremes.

Regardless of how much expo you use, the heli will flip or roll at the same rate with full cyclic.

29.2. Heading hold gyros are bad

Some people say "heading hold gyros are like cheating" but this is usually the result of machismo and lack of understanding. A heading hold gyro not only make hovering easier, it will teach you to use the rudder deliberately to change the orientation of the helicopter.

With a yaw rate gyro, the tail will naturally swing behind the helicopter in the direction of motion. This will develop sloppy rudder technique which is difficult to correct later. Note that the top pilots in the world, such as Curtis Youngblood, Alan Szabo, etc all use heading hold gyros, not yaw rate gyros.

29.3. Shorter flybar increases cyclic response

Imagine a flybar so short the paddles touch the head. With this length flybar, the paddles will be traveling in a small circle and have very little airspeed, so they will not exert much force to change the main rotor blade pitch.

Also, since the flybar is so short, the paddles will also have less leverage against the main rotor blades and will exert even less force to change the main rotor blade pitch.

Therefore, a longer flybar increases the cyclic response, not a shorter flybar.

29.4. Rate gyros do not need revo mixing

If you mechanically trim the tail pitch so the hovering thrust naturally corresponds to the rudder neutral position, then you may believe you don't need revo mix. However, as soon as you throttle up or down, the tail will swing around because the tail rotor thrust will not increase nor decrease due to the lack of revo mixing.

Chapter 30. Technical Appendix

30.1. How helicopters work

(Please consult Chapter 31, *Glossary* for any unfamiliar terms)

30.1.1. From the user to the transmitter

The helicopter's control system begins at the joysticks of the transmitter. There are two common configurations for converting the user's joystick movements into helicopter movements:

- Mode 1 (Asia, Australia, Europe, and some UK)
- Mode 2 (US, some Europe and some UK)
- Mode 3
- Mode 4

Table 30.1. Mode 1 stick assignments

Joystick	Direction	Usage
left stick	u/d	fore/aft cyclic
left stick	l/r	rudder
right stick	u/d	throttle + pitch
right stick	l/r	left/right cyclic

Table 30.2. Mode 2 stick assignments

Joystick	Direction	Usage
left stick	u/d	throttle + pitch
left stick	l/r	rudder
right stick	u/d	fore/aft cyclic
right stick	l/r	left/right cyclic

Table 30.3. Mode 3 stick assignments

Joystick	Direction	Usage
left stick	u/d	fore/aft cyclic
left stick	l/r	left/right cyclic
right stick	u/d	throttle + pitch
right stick	l/r	rudder

Table 30.4. Mode 4 stick assignments

Joystick	Direction	Usage
left stick	u/d	throttle + pitch
left stick	l/r	left/right cyclic
right stick	u/d	fore/aft cyclic
right stick	l/r	rudder

30.1.2. Inside the transmitter

30.1.2.1. Throttle stick

The "throttle stick axis" (left stick, vertical motion in mode 2) controls both the throttle and collective pitch channels.

The stick position goes through the throttle curve to generate the throttle channel, and the same stick position also goes through the pitch curve to generate the collective pitch channel.

Note that there are usually two or more flight modes, such as normal, idle-up1, idle-up2, etc and each flight mode usually has a programmable throttle and pitch curve.

30.1.2.2. Rudder stick

The rudder stick goes through the rudder exponential curve to generate the rudder signal. The rudder expo curve can be used to decrease or increase the tail movement near center stick.

30.1.2.3. Fore/aft and left/right cyclic stick

First, the values for both cyclic sticks go through the elevator and aileron exponential curves.

If an eCCPM swashplate mode is enabled, then the output of these curves goes into the swashplate mixer, and the signals for the three swashplate servos are generated.

If an eCCPM swashplate mode is not enabled, then the output of the aileron and elevator exponential curves go directly to the fore/aft and left/right swashplate servo channels.

30.1.3. From the transmitter to the lower swashplate

There are three systems which are widely used to control the lower swashplate from the transmitter:

- Mechanical mixing (also known as mCCPM)
- Electronic mixing (also known as eCCPM)
- non-CCPM

30.1.3.1. Mechanical mixing (mCCPM)

For mechanical mixing, there are three servos that control the lower swashplate indirectly through a mechanical mixer.

So, the transmitter sends separate signals for fore/aft cyclic, left/right cyclic, and blade pitch.

The servos for these functions plug directly into the receiver channels. The control horns for the servos are connected to the mechanical mixer which mixes the movement of the individual servos into the lower swashplate movement.

The fore/aft servo output goes to the mechanical mixer, and its motion is converted into the fore/aft tilt of the swashplate.

The left/right servo output goes to the mechanical mixer, and its motion is converted into the left/right tilt of the swashplate.

The pitch servo output goes through the mechanical mixer, and its motion is converted into the swashplate height.

The most common type of mechanical mixer is the type used on the Raptor and T-rex helicopters. This consists of a "rocker arm" of which one side is connected to the swashplate. The left/right servo is mounted inside the other side of the swashplate, and the fore/aft and pitch servos are mounted under the rocker arm.

The ECO 8 when configured for a mechanical mixer uses a "sliding platform" type of mixer. This mixer performs all the functions of a rocker arm mechanical mixer and also performs revo mixing as well, so there are four servos connected to this type of mechanical mixer.

30.1.3.2. Electronic mixing (eCCPM)

For electronic mixing, there are three or four servos which are directly connected to the lower swashplate which control the height and tilt of the swashplate.

There are usually three servos which are connected to the lower swashplate at 90 or 120 degrees apart, although there are variations which use four servos or have the servos placed 140 degrees apart.

So, the transmitter reads the stick positions and performs calculations internally to determine the positions of the servos to create the correct swashplate height and tilt.

These servo positions are transmitted to the receiver which sends the information to the servos.

The movement of the swashplate is the same as with mechanical mixing. The fore/aft cyclic controls the fore/aft tilt of the swashplate, the left/right cylic controls the left/right tilt of the swashplate, and the pitch controls the height of the swashplate.

The Logo 10, ECO 8 configured for electronic mixing, Hummingbird Elite CP, Hornet CP, and other helicopters use this system.

30.1.3.3. non-CCPM

For a non-CCPM control system, there are two servos which are directly connected to the lower swashplate, and a third servo which directly controls the main blade pitch.

So, the transmitter sends separate signals for fore/aft cyclic, left/right cyclic, and blade pitch.

The servos for these functions plug directly into the receiver.

The fore/aft servo is directly connected to the lower swashplate and controls the fore/aft tilt of the swashplate.

The left/right servo is directly connected to the lower swashplate and controls the left/right tilt of the swashplate.

The pitch servo is not connected to the swashplate and controls the main blade pitch through a separate mechanical connection.

From the transmitter's point of view, the mechanical CCPM and non-CCPM control systems are identical, because both have independent servos for collective pitch, fore/aft cyclic, and left/right cyclic.

On the Zoom 400, the main shaft is hollow, and there is a rod which runs through the main rotor shaft and controls the main blade pitch.

On the Piccolo Pro, the there is a hollow tube which goes around the main shaft and inside the swashplate and controls the main blade pitch.

30.1.4. From the upper swashplate to the rotor head

There are three systems which are widely used to control the rotor head from the upper swashplate:

- Bell control system
- Hiller control system
- Bell-Hiller control system

30.1.4.1. The Bell control system

For a Bell control system, the upper swashplate is directly connected to the main blade grips. Usually there are two main rotor blades and these are directly connected to two control balls on the upper swashplate. This is sometimes called a "flybarless" control system.

One advantage of the Bell control system is very quick cyclic response. The control system directly controls the main blade pitch, so the system is very sensitive to swashplate changes.

One disadvantage of the Bell control system is the lack of stability. The system is very sensitive to minor gusts. It also stresses the control linkages because they control the heavy rotor blades directly and therefore strong servos must be used.

The early helicopters using Bell control systems had a "stabilizer bar" which was perpendicular to the main rotor blades, which had heavy weights attached to the ends (similar to a flybar but with weights instead of paddles and no tilting). This added stability to the system.

There are no popular helicopters which implement a pure Bell control system.

30.1.4.2. The Hiller control system

The Hiller control system was invented by Stanley Hiller in the 1940s. This was originally called the "Rotormatic" control system, and was so stable the first prototypes could be hovered hands-off for minutes at a time.

For a Hiller control system, the upper swashplate does not directly control the main blade pitch. Instead, it indirectly controls the main blade pitch by changing the pitch of the flybar paddles. As the flybar seesaws up and down, it changes the main blade pitch.

Two advantages of the Hiller system are:

- It places less stress on the swashplate servos because they only control the pitch of the flybar paddles.
- The flybar paddles dampen pitch and roll which improves stability.

One disadvantage of the Hiller system is the lag in control response. The flybar paddles must change their plane of rotation in order to change the main blade pitch.

Two popular helis which implement the Hiller control system are the Piccolo ECO/Fun and the GWS Dragonfly.

30.1.4.3. The Bell-Hiller control system

The Bell-Hiller control system is a hybrid of both the Bell and Hiller control systems. The key component of this system is the Bell-Hiller mixer which mechanically mixes both the flybar tilt and the swashplate tilt.

There are two basic types of Bell-Hiller control systems:

- Nonmovable flybar systems
- Movable Flybar systems

In a Bell-Hiller system with a nonmoving flybar, there are usually four control balls on the upper swashplate.

Two of the control balls on the upper swashplate are connected to the washout unit which is a mechanical isolation device which allows the flybar to tilt with the swashplate, but not move up and down.

The other two control balls are connected directly to the Bell-Hiller mixer. The tilt of the flybar also affects the Bell-Hiller mixer. The output of the Bell Hiller mixer controls the main blade pitch.

So, in a Bell-Hiller control system, the swashplate controls the flybar pitch and the flybar tilt affects the main blade pitch. This is the Hiller component of the Bell-Hiller control system.

The swashplate tilt also affects the main blade pitch through the Bell-Hiller mixer. This is the Bell component of the Bell-Hiller control system.

Two popular helis which use a Bell-Hiller system with a nonmoving flybar are the ECO 8 and Logo 10.

The Bell-Hiller system with a moving flybar works exactly the same as the nonmoving flybar system except the washout unit is eliminated and the flybar is allowed to move up and down with the swashplate.

Advantages of the Bell-Hiller system include:

- Less control force required (as in the Hiller system)
- More stable than a Bell system (as in the Hiller system)
- Faster cyclic than the Hiller system due to some direct swashplate input

Disadvantage of the Bell-Hiller system include:

- Slightly slower cyclic response than a pure Bell system
- More complexity than either a Bell or Hiller system

The advantage of the moving flybar system is it has fewer parts (no washout unit) therefore has less slop in the control system.

Three popular helis which use a Bell-Hiller system with a moving flybar are the Hensleit 3DNT, Hensleit 3DMP and the Century Hummingbird Elite CP.

30.1.5. The rotorhead

There are two types of rotorhead designs commonly used on R/C helicopters:

- Flapping head (technically a fully articulated rotor head)
- Seesaw head (technically a semi-rigid rotor head)

A flapping head allows each rotor blade to flap, lead/lag, and feather independently. This is accomplished by having having three hinges per blade:

- flapping hinge, which allows each blade to flap (move vertically)
- lead/lag hinge, which allows the blade to lead and lag (move horizonally)
- feathering shaft, which allow the blade to feather (rotate along long axis)

This is typically used on helicopters with more than two blades, but some two-bladed helis such as the Corona use this.

A seesaw head typically has the blade grips for two blades connected by a feathering shaft. This feathering is rigid and only allows the two blades to seesaw as a single unit, e.g. when one blade rises, the other is forced to sink. The two blades will still feather and lead/lag independently, however.

Most R/C helicopters use this system, including the ECO 8, Logo 10, Shogun, T-rex, etc.

30.1.6. Basic helicopter aerodynamics

30.1.6.1. Dissymmetry of lift

When a helicopter flies forward, the rotor blades generate unequal lift. This phenomenon is called "dissymmetry of lift".

For a clockwise rotating rotorhead, the blade on the left side of the helicopter is moving into the wind (advancing blade) and the blade on right side of the helicopter is moving with the wind (retreating blade). The advancing blade generates more lift, and the retreating blade generates less lift.

(Technically this is dissymmetry of moment, because the center of lift for the advancing/retreating blades is at different points along the length of the blade, but most most helicopter texts reference this as dissymmetry of lift.)

This dissymmetry of lift is equalized in different ways by the flapping and seesaw rotor heads.

For a flapping head, the upward motion of the advancing blade decreases the relative speed of the wind, and the downward motion of the retreating blade increases the relative speed of the wind. This is similar to holding your hand at the window at 40-50 mph. If your hand is slightly titled up at the leading edge, and you raise your hand, this decreases the apparent lifting pressure, and lowering your hand increases the apparent lifting pressure.

The flapping head may also use a rotor head where the two blades feather together (are rigidly connected on the feathering axis) and use blades where the center of pressure (center of lift) is behind the feathering pivot point. This causes the two blades to naturally equalize lift as the blade generating more lift will push its leading edge downward which also raises the leading edge of the other blade.

For a seesaw head, the advancing blade will rise up due to the extra lift. This rising motion causes the blade to feather and slightly decrease the angle of attack because it pivots around the blade grip's control ball. The amount of feathering is dependent on the angle formed by a line drawn between the blade grip control balls and a line perpendicular to the rotating axis of the blades, and is called the delta-three angle.

The delta-three angle may also be used with the flapping head to induce the blade to feather as it flaps up and down.

Note that this dissymmetry of lift is experienced by both the main and tail rotors on an R/C helicopter. The two rotor heads may use different methods of equalizing lift; for example, the ECO 8 uses a seesaw main rotor but uses a flapping tail rotor relying upon the delta-three angle to equalize lift.

30.1.7. How gyros work

Many people seem to be confused about how gyros work. In order to understand how a gyro works, it is necessary to first understand the relationship between the main rotor and the tail rotor.

Most helicopters have a clockwise main rotor, so for this section, we will assume the main rotor blades are spinning clockwise.

Also, some helicopter use a variable pitch tail rotor and some helicopters use a variable-speed motor for the tail rotor, so this section will use the terminology "increase/decrease tail rotor thrust" to accomodate both cases.

30.1.7.1. The functions of the tail rotor

The three basic function of the tail rotor are:

- Counter main rotor torque
- Turn (yaw) the helicopter
- Stabilize yaw

30.1.7.1.1. Counter main rotor torque

The first function provided by the tail rotor is to counter main rotor torque.

The motor in a helicopter spins the blades clockwise. But in order to spin the blades, the motor needs to push against something. In this case, the motor is pushing against the body of the helicopter. So, when the motor spins the main rotor blades clockwise, the body of the helicopter tends to spin counterclockwise. This is consistent with Newton's Third Law of Motion which states:

> "For every action there is an equal and opposite reaction."

In this case, the action is a clockwise rotation of the main rotor blades, and the reaction is the body of the helicopter turning counterclockwise. So, the tail rotor needs to provide the correct amount of clockwise thrust thrust to balance the counterclockwise reaction to the clockwise main rotor. For lack of a better term, we will call this "main rotor counter thrust".

30.1.7.1.2. Turn (Yaw) the helicopter

The second function provided by the tail rotor is to turn (yaw) the helicopter.

If we need to turn left, then we set the tail rotor thrust to slightly less than the main rotor counter thrust. This means the counterclockwise force (reaction of main rotor) will be greater than the clockwise force (tail rotor thrust) so the body of the helicopter will turn counterlcockwise.

If we need to turn right, then we set the tail rotor thrust to slightly more than the main rotor counter thrust. This means the counterclockwise force (reaction of main rotor) will be less than the clockwise force (tail rotor thrust) so the body of the helicopter will turn clockwise.

If we don't need to turn, then the tail rotor thrust is exactly the main rotor counter thrust. For lack of a better term, we will call this the "turning thrust".

30.1.7.1.3. Yaw stabilization

The third function provided by the tail rotor is yaw stabilization.

When airflow hits the side of the helicopter, the helicopter will tend to "weathervane" into the airflow because there is more leverage against the tail of the helicopter than the nose.

This airflow can be either a random gust of wind, or the helicopter may be moving sideways relative in still air.

We can use the tail to correct the orientation of the helicopter by increasing or decreasing the thrust of the tail rotor. For lack of a better term, we will call this the "yaw stabilization thrust".

So the total thrust of the tail rotor should be all three of these variables added together, or:

tail rotor thrust = main rotor counter thrust + turning thrust + yaw stabilization thrust

30.1.7.2. Yaw rate gyros and how they work

For a yaw rate gyro, the functions are controlled by the following devices:

- Counter main rotor torque - transmitter revo mixing
- Turn (yaw) the helicopter - rudder stick
- Stabilize yaw - yaw rate gyro

A yaw rate gyro is a very simple device. It only senses the turn rate (angular acceleration) and it cannot sense the absolute orientation of the helicopter. In technical terms, it "dampens" the tail movement.

Imagine you are blindfolded, and are standing on a frozen lake wearing smooth shoes. A person will try to turn you, and you are only allowed to resist the turning force by digging in your shoes into the smooth slippery ice. Basically, you cannot resist the turning force very much,and once you have been turned, you do not know the original orientation.

This is very much like a yaw rate gyro.

Therefore, a yaw rate gyro can only provide partial yaw stabilization thrust. Usually the amount of yaw stabilization thrust is controlled by the gyro gain. Increasing the gain will make the helicopter more resistant to random turning, but it also decreases the pirouette rate because the gyro will fight against both random and intentional yawing movement.

A yaw rate gyro cannot provide "heading hold" capability because it only pushes against the turning movement but will slip somewhat, and once it's been turned it cannot return the helicopter to the original orientation.

A yaw rate gyro "slips" when trying to countering tail movement, so it cannot effectively counter main rotor torque. Therefore, the main rotor counter thrust is provided by the revo mixing function on the transmitter.

The revo mixing allows you to set the tail rotor thrust for each throttle position so the tail rotor thrust exactly counters the main rotor torque. There is no formula for setting these values; they must be empirically set by trial and error.

The turning thrust is governed by the rudder stick on the transmitter, the same as in a heading hold gyro.

30.1.7.3. Heading hold gyros and how they work

For a Heading-hold gyro, the functions are controlled by the following devices:

- Counter main rotor torque - heading hold gyro
- Turn (yaw) the helicopter - rudder stick via heading hold gyro
- Stabilize yaw - heading hold gyro

A heading hold is more sophisticated than a yaw rate gyro and functions completely differently.

The first big difference between a heading hold gyro and a yaw rate gyro is that the heading hold gyro has a microprocessor on-board and can remember how much the helicopter has turned. Therefore if a random wind gust turns the helicopter, it can always return the helicopter to the original orientation.

Therefore, the heading hold gyro can supply the correct main rotor counter thrust automatically because it doesn't "slip". When you apply throttle and the tail starts to move because there's more main rotor torque, the heading hold gyro can increase the tail rotor thrust to turn the tail back to its original position.

Also, the heading hold gyro can provide the correct yaw stabilization thrust because it doesn't "slip", and therefore it can retain the correct orientation at all times.

The second big difference is the rudder signal from the transmitter does not directly control the tail rotor thrust. Instead, the rudder signal is considered a high-level command to "turn the tail at x degrees per second" and the heading hold gyro will automatically use the correct amount of tail pitch to create this tail motion and compensate for wind and other external factors which affect the tail.

Note that the revo mixing MUST be disabled for the heading hold gyro to work properly. If the revo mixing is enabled, then the heading hold gyro will interpret it as a signal to turn the helicopter.

30.1.7.4. The difference between yaw rate and heading hold gyros

Imagine we have a helicopter with a properly configured yaw rate gyro and the motor is disconnected and it is on the ground where it cannot turn. If we hold left rudder on the transmitter for one second and then center the stick, the servo will move to one extreme servo position for one second and then center.

Now, imagine we have the same helicopter with a properly configured heading hold gyro, and the motor is disconnected and it is on the ground where it cannot turn. Imagine that the setting for this heading hold gyro is full left stick is 180 degreees per second.

If we hold left rudder on the transmitter for one second and then center the stick, the heading hold gyro will know the helicopter should turn counterclockwise 180 degrees.However, since the helicopter is on the ground and cannot turn, the tail servo will stick at one extreme and stay there - the heading hold gyro will keep trying to turn the helicopter. If we manually pick up the helicopter and turn it counterclockwise 180 degrees, the servo will finally center.

Note that both types of gyros only stabilize YAW. Neither type of gyro will stabilize roll or pitch. Technically speaking, a helicopter gyro contains an angular acceleration sensor for only one axis.

30.1.8. GY-series gyro technical info

30.1.8.1. GY401 setup

There are six adjustments on the GY401: direction, DS, delay, limit, gain and pirouette rate. The delay and limit are controlled by trimmers on the gyro itself. The gain adjustment is controlled at the transmitter by setting the value of the gyro channel, and the pirouette rate is set by adjusting the endpoints of the rudder channel.

30.1.8.1.1. GY401 direction switch

For a heli with a tail servo, the GY401 direction switch configures the direction the gyro moves the servo for clockwise and counterclockwise movement.

For a heli with a tail motor ESC, the GY401 direction switch configures whether the gyro moves the throttle up or down to turn the heli clockwise or counterclockwise.

For both heli types, If this switch is set incorrectly, the heli will pirouette wildly and out of control.

30.1.8.1.2. GY401 DS (digital servo) switch

The GY401 DS switch allows the gyro to update a digital servo about 4x faster then a normal servo.

Do not set this switch unless you are using a servo which supports a 270 hz frame rate, such as the S9253, S9254, or Volz Speed-Maxx.

Do not set this switch if you are using a tail motor ESC.

30.1.8.1.3. GY401 delay trimmer

The Delay adjustment is on the gyro itself, and allows you to configure the gyro for the response of the tail rotor system. This is only used in heading hold mode.

The delay setting of 0 is used for very fast servos such as the S9253/S9254. The delay setting of 100 is used for very slow tail servos and for tail motor ESCs. A tail motor ESC requires at least half a second to go from half throttle to full throttle, which is about twice as slow as the slowest tail servos (0.25 sec/60 degrees)

For a heli with a tail servo, if the delay setting is too low, then the gyro will assume the servo is faster than it really is. So the gyro will send commands to the servo to move very quickly, and the servo will try to move to the new position but it will be too slow, and it will lag behind the gyro commands.

For a heli with a tail motor ESC, if the delay setting is too low, the gyro will assume the tail motor can change RPM very fast. So the gyro will try to change the speed of the tail motor very quickly but the tail motor RPM will lag behind the gyro commands.

This delay setting seems to affect the end of a turn (yaw). At the end of a turn, the gyro needs to increase the tail thrust to slow down the tail then decrease it to maintain a steady tail position.

For example, imagine you are performing turning the heli (yaw) and you suddenly stop. If the delay setting is too low in this situation, the tail will wag a few times before settling down because the gyro will overshoot the end of the turn and need to correct the heading a few times.

If you increase the delay, this may allow you to increase the gain, although you may not need this as a beginner.

30.1.8.1.4. GY401 limit trimmer

The limit adjustment is on the gyro itself, and allows you to set the endpoints of the servo travel.

For a heli with a tail servo, if the limit setting is too high, then the gyro will attempt to move the tail servo too far in one or both directions. This will cause the servo to bind and emit a buzzing noise, which creates accelerated wear on the servo motor and early servo failure.

If the limit setting is too low, then this will decrease the range of the tail blade pitch. This will reduce your pirouette rate and may cause tail control problems.

For a heli with a tail motor ESC, if the limit setting is too low, then the tail motor ESC may fail to arm when holding the rudder stick full left. Therefore you cannot set the limit too low when using a tail motor ESC, but this is dependent on the tail ESC.

For a heli with a tail motor ESC, if the limit setting is too high, then this causes severe problems. The tail motor ESC will not arm because holding left rudder will cause the gyro to emit a signal that is too low for the tail motor ESC to arm. Also, if you hold extreme right rudder, the tail motor ESC may shut down because the signal is outside the valid range.

Therefore, for a heli with a tail motor ESC, the limit trimmer should be set to 100%.

30.1.8.1.5. GY401 gain setting

The gain adjustment is done at the transmitter via the gyro gain connector on the channel. This

MUST be plugged into a receiver channel.

There isn't good documentation for the gain setting available, so the following information is what I have personally deduced from my own observations, which may not be completely correct.

The gain setting seems to control how much the tail is allowed to drift before the gyro will correct the position. It is basically a "fussiness" value. A low gain allows the tail to drift of about 2 or 3 degrees in either direction before the gyro will correct the position. A high gain allows a drift of less than 0.5 degrees.

There are two factors which limit the maximum gain setting:

For a heli with a tail servo, the limiting factors are the tail servo resolution and the amount of slop in the tail rotor pitch control mechanism.

If the tail servo resolution is low, then the gain setting must be fairly low to prevent wag.

For a heli with a tail motor ESC, the limiting factors are the tail motor ESC's throttle resolution and the inertia of the tail motor and tail rotor.

Imagine a tail servo or tail motor ESC with an extremely low resolution; let's say only 9 steps between the low and high endpoints. So, any position between 0 and 9% is truncated to 0%, any position between 10% and 19% is truncated to 10%, etc.

Imagine that hovering requires a tail channel position of 57%. However, the tail servo or tail motor ESC has limited resolution and can only be at 50% or 60%.

If the gyro gain is set very high, then the gyro will be very fussy about the tail position, and will keep changing the tail position. This will cause tail wag.

If the gyro gain is set fairly low, then the gyro will be less fussy about the tail position and will allow some drift before correcting the tail position. This reduces or eliminates the tail wag.

If the tail rotor pitch control mechanism has a lot of slop, then the gyro will need to move the tail servo past the slop in either direction before the tail pitch will change.

If the gyro gain is set to a high value, then the gyro will be fussy and will try to move the tail servo often. This will cause wag.

If the gyro gain is set to a low value, then the gyro will be less fussy about the tail position and won't care about small changes in tail position, and this will decrease or eliminate wag.

Many guides recommend the gain value be set as high as possible without causing wag, but this causes the servo to wear more quickly. I recommend this value be set to a slightly lower value than the maximum possible value to reduce servo or tail motor wear.

If your transmitter o supports the GY mode (Futaba 8U, 9C, 7C, etc) then you can set the mode to either heading hold (AVC) or yaw rate (NOR). If your transmitter does not support the GY mode, then you can set the mode with this formula:

For heading hold mode, take the 50 and add the heading hold gain percentage divided by two, and this is the percentage of the travel you should use for the transmitter's gyro gain channel.

For example, to set heading hold with 60% gain, then this would be (60 / 2) + 50 = 80% of full travel.

For yaw rate mode, take 50 and subtract the yaw rate gain divided by two and this is the percentage of travel you should use for the transmitter's gyro gain channel.

For example, to set yaw rate mode mode with 40% gain, this would be 50 - (40 / 2) = 30% of full travel.

30.1.8.1.6. GY401 pirouette rate

The pirouette rate adjustment is done at the transmitter via the rudder channel EPA. 100% EPA is roughly about 720 degrees/second maximum pirouette rate. Setting this to a lower value decreases the max pirouette rate, and increasing it will increase the max pirouette rate.

30.1.8.2. GY240 setup

There are only three adjustments on the GY240: direction, gain and pirouette rate.

30.1.8.2.1. GY240 delay setting (fixed)

The GY240 has a fixed delay setting and this is not adjustable. However, the GY240 assumes a very slow servo, and the fixed delay setting appears to be greater than 100% delay on the GY401. This is one reason why the GY240 appears to work better with tail motors than the GY401.

See also the GY401 delay setting for more info.

30.1.8.2.2. GY240 limit setting (fixed)

The GY240 limits are not adjustable.

If you are using a heli with a tail servo, you will need to adjust the mechanical linkages so the tail pitch slider does not bind at both extremes of travel. Pragmatically, this means you will need to try different holes in the tail servo horn and/or tail pitch lever until the tail pitch slider can travel to both extremes without binding.

If you are using a heli with a tail motor ESC, then there is no adjustment required.

See also the GY401 limit setting for more info.

30.1.8.2.3. GY240 direction switch

This functions identically to the GY401. See the GY401 direction switch explanation for more details.

30.1.8.2.4. GY240 gain trimmer

The GY240 gain trimmer works similar to the GY401 gain trimmer, however the GY240 gain is less sensitive than the GY401 gain. My rough guess is the GY240 60% gain is about the equivalent of the GY401 30% gain.

30.1.8.2.5. GY240 pirouette rate

This GY240 pirouette rate is configured in the same way as the GY401 pirouette rate. However, the maximum piroutte rate is only about quarter that of the GY401.

30.1.9. Yaw-rate gyro technical info

The gain on a yaw-rate gyro functions differently than on a heading hold gyro. It controls how much the gyro dampens (works against) movement. This is fine if you are not using the rudder. However, if you use the rudder, a yaw-rate gyro will dampen this movement too.

So increasing the gain on a yaw-rate gyro has two effects:

- It dampens random movement more, so the tail is more stable. This is good.
- It also dampens intentional tail movement, so this decreases the maximum pirouette rate. This is bad.

A standard single-rate yaw-rate gyro exhibits these bad behaviors. There are more sophisticated yaw-rate gyros which partially fix some of these problems:

Dual-gain gyros allow you to set two gain settings on the gyro and switch between these two gain settings from the transmitter, so you can decrease the gain when you need high pirouette rates.

Remote-gain gyros allow you to set the gain from the transmitter by a knob or switch, so you can decrease the gain when you need high pirouette rates.

30.1.10. How ESCs work

30.1.10.1. Pulse-width modulation

To fully understand how brushed and brushless ESCs work, it is necessary to understand the concept of pulse-width modulation.

First, imagine that you have a water pipe with a valve which can only be fully opened or fully closed. If you open this valve, the water flows through the pipe at 10 gallons per minute. If you close this valve, it stops the water flow.

Now, if you want a water flow of 5 gallons per minute, you can open the valve for 5 seconds, then close it for 5 seconds, and repeat. Since the valve is open for 50% of the time, the average water flow will be half of the max flow rate, or 5 gallons per minute.

If you want a water flow of 2 gallons per minute, you can open the valve for 2 seconds, then close the valve for 8 seconds. The burst (peak) water flow will be 10 gallons per minute, but the average water flow will be 2 gallons per minute.

An ESC works in the exactly the same way. If the throttle signal is 50%, then the ESC will apply full power to the motor for 50% of the time. If the throttle input is 20%, then the ESC will apply full power to the motor for 20% of the time.

This pulse-width modulation technique has several important limitations. If you ignore these limitations, you will overload your power systems, and your heli will likely crash and/or the motor, ESC, or battery may be damaged.

30.1.10.2. Motor startup

An R/C brushless motor controller turns on/off three sets of windings in sequence to rotate the motor. This turning off the windings on/off in sequence is called "commutation".

The brushless motor controller measures the "back EMF" from each set of windings to determine how fast to commutate. Basically, the current draw of the winding drops as the magnet passes by the winding. The problem is this only works properly when the motor is running at a reasonable speed. When the motor is starting from a dead stop, the motor controller must pulse the windings in sequence without back EMF feedback to start the motor spinning to about 100 rpm.

Once the motor is running at 100 rpm, the brushless motor controller can rely on the back EMF to sense the magnet position and can commutate the motor using strictly back EMF sensing.

In an R/C model helicopter, the motor has a high load because it is coupled to the main (and possibly tail) rotor which is fairly heavy. So, with lower torque motors and high motor loads, the motor may not start spinning when the ESC goes through the blind commutation stage. The main symptom for this is the motor will wiggle back and forth instead of starting to spin.

30.1.10.3. Governor mode

A feature of an ESC which will try to keep the motor speed constant despite variable load placed on the motor. This is like the cruise control on a car as it's going up and down hills. Even though the load on the motor is variable as the car goes up and down hills, the cruise control will try to maintain the same speed. The governor mode on an ESC will try to do something similar. Even if the heli is performing wild maneuvers and the load on the main rotor blade is highly variable, it will try to maintain a constant head speed.

If using a governor mode, the throttle curve should not be set to 100%. This is because the governor mode needs a little bit of extra power so it can maintain headspeed. Using the cruise control analogy, if you set the cruise control of a car to its maximum speed the cruise control cannot maintain the maximum speed going up hills. Similarly, if you set the throttle to 100% RPM then the governor mode will not be able to maintain it when the rotor is heavily loaded.

This is why the motor pinion should be selected so the desired headspeed can be achieved at 90 to 95% of the throttle - so the governor mode can work properly.

30.1.10.4. Timing Advance

The timing advance determines how early the ESC applies power to the electromagnets during motor rotation. A higher timing advance will cause the electromagnets to be energized for a longer period, which will increase the motor power but will also increase the current draw. This is appropriate for aerobatic flight. A lower timing advance will cause the electromagnets to be energized for a shorter period, which will decrease the motor power and will decrease the power used. This is appropriate for duration flight.

30.1.10.5. For fixed pitch helicopters

You must select an ESC that can handle the current draw at full throttle, even if you do not plan to fly the helicopter at full throttle.

For example, if a Corona hovers at half throttle and draws 14 amps, then the current draw from the battery and ESC is NOT 14 amps. What actually happens is the battery and ESC are delivering 28 amps to the motor only 50% of the time.

Therefore, if you use a Phoenix 25 for the Corona, it will be overloaded even when hovering, and will probably overheat and shut down when you apply more throttle.

Also, you want to select a motor that will hover your helicopter at no lower than 50% throttle for this reason.

30.1.10.6. For collective pitch helicopters

If you select a motor with the proper Kv and the CP helicopter reaches 1600 rpm of headspeed at 90% throttle and draws an average of 18 amps of current, then the ESC and battery are actually supplying 20 amps of current for 90% of the time.

If you select a motor with an excessively high Kv rating and the CP helicopter reaches 1600 rpm of headspeed at 25% throttle and draws an average of 18 amps of current, then the ESC and battery are actually supplying 72 amps of current for 25% of the time!

Therefore, if you use a motor with a very high Kv rating and you are forced to use a low throttle setting to compensate for the high Kv, this will increase the load on the ESC and battery. In extreme cases, this will shorten the life or destroy the ESC and/or battery.

30.1.11. How batteries work

A battery is basically a electrochemical device which stores electrical power.The closest physical equivalent to a battery is a water tank, which stores water.

Batteries have several important characteristics:

- Voltage (volts). Voltage is an electrical term which describes the force of the electrical pressure.

  This is similar to the pressure in a water tank. The higher the water pressure, the more water will flow through a pipe connected to the tank. Similarly, the higher the voltage, the more current will flow through wires (with some constraints).

- Capacity (maH). The capacity of a battery is measured in milliampere-hours, or maH. One thousand milliampere-hours (1000 maH) is equal to one ampere-hour (1 AH).

  One milliampere-hour is the ability to supply one milliamp of current for one hour, or two milliamps for 30 minutes, etc.

- C rating. The C rating describes the maximum instantaneous (burst) power that a battery can supply. A battery rated for 10C continuous discharge is capable of being discharged at 10 times its rated Capacity, or in other words, it is capable of being fully discharged from a fully charged state in 60/10 or 6 minutes.

  So, a 2100 maH pack rated at 10C continuous can supply approximately 2100 milliamps * 10 = 21,000 milliamps (21 amps) for six minutes.

- o Pack configuration. This is typically described as 3s1p or 3s2p, etc. The number before the "s" denotes the number of cells in series, and the number before the "p" denotes the number of cells in parallel.

  So, a 4s2p pack of individual 3.7 volt 2100 maH cells would have a total voltage of 11.1 volts, and a total capacity of 4200 maH.

30.1.12. How motors work

A motor is basically a mechanical device which converts electrical power into a rotary mechanical force.

For the motors used in R/C helicopters, there is a permanent magnet and an series of coils of wire (called the motor windings) which act as an electromagnet. The windings are pulsed on and off to sequentially push on the magnets, and either the magnets or the windings are attached to the motor shaft which makes the motor turn.

(Note that there are some motor types which do not have permanent magnets, such as induction motors, but these are not used for R/C helicopters and will not be discussed here).

The part of the motor which is stationary is called the stator. The motor mount is part to the stator, since the R/C model should not turn with the motor shaft. The magnets or windings may be part of the stator, depending on the motor type.

The part of the motor which rotates is called the rotor. If the stator has the windings, then the rotor will have the permanent magnets, and vice versa.

In order for the motor to rotate, the magnet windings must be switched on and off. This process of switching the windings on and off is called commutation. The motor can be commutated either mechanically or electrically.

There are many different arrangements of coils and magnets which will make the motor shaft turn, and therefore many different categories of motors.

The first two categories which we will discuss are: brushed and brushless motors.

30.1.12.1. Brushed motors

For a typical brushed motor, the magnets are attached to the inside of the motor case, and the motor windings are attached to the motor shaft.

The motor windings are commutated by a mechanical device which makes and breaks the electrical connection. There are a few (usually three) copper contacts mounted in a circle around the motor shaft called the commutator. The stator has two brushes which touch thes copper contacts as the motor rotates.

The are two main types of brushes: carbon (graphite) and precious metal.

Carbon brushes are typically used for larger motors designed for higher current because the carbon brushes can handle high currents well.

The carbon brushes in smaller motors are attached to a springy metal which presses the carbon brushes against the commutator. Imagine a tiny toothbrush where the bristles are replaced by a small block of carbon, and the handle is replaced by a springy metal.

The carbon brushes in larger motors are a block of graphite (about 4mm x 4mm) which are pressed against the commutator by a spring. In these types of motors, the brushes can be replaced.

Precious metal brushes are typically used for smaller motors because they are easier to manufacturer for small motors, and they do not handle high current well.

A precious metal brush is usually a strip of springy metal (usually a beryllium alloy) with the end cut into thin fingers. These fingers are pressed against the commutator to make and break the electrical connection.

The are three main reasons for brushed motor failure:

a. Dirty commutator

   When the motor is new, the commutator will be shiny. As the motor is used, the commutator will become dirty due to arcing and brush material deposition. When the commutator becomes dirty, it will not conduct electricity well, and the motor becomes less efficient and loses power.

b. Brush wear

   As the motor spins, it will cause wear on the brushes, and eventually the brushes will fail.

For carbon brushes, the brush will become so short that it will no longer touch the commutator. For precious metal brushes, the ends of the metal fingers will wear away and the brushes will no longer touch the commutator.

c. Overheating

If the magnets of the motor are overheated, they will lose magnetization. This is a vicious cycle - when the magnets are weakened, the motor will run even hotter, which will weaken the magnets further, etc.

The commutator and the brushes are the only parts of a brushed motor which wear significantly, so these are the primary limiting factors for brushed motor life.

There are six main methods of extending brushed motor life:

a. Proper motor break-in

Motor break-in is covered in Chapter 10, *Helicopter Construction*

b. Proper motor timing.

Most motors which are used for R/C helicopters are originally designed for R/C car or R/C airplane use. R/C car motors are usually manufactured for counterclockwise rotation, and R/C airplane motors are usually manufactured for neutral timing so it rotates equally well (equally badly) for both clockwise and counterclockwise rotation.

(The CW/CCW rotation of a motor is the direction of motor shaft rotation when viewing the FRONT of the motor.)

Most R/C helicopters use a CW rotating rotor with the main shaft driven by a main gear/pinion configuration, and the motor faces downwards. This motor arrangement requires the motor to rotate in a CW direction. The few exceptions to this generalization are: Hornet, Zoom 400, T-rex, and Viper 70/90 which all use upwards-facing motor.

When a motor which is designed for CCW or neutral rotation is used for CW rotation, then the motor runs very inefficiently because the motor windings are switched on and off at the wrong times. This causes sparking which increases brush wear, dirties the commutator, generates heat and creates RF interference.

There are some brushed motors which are properly timed for CW rotation, such as the GWS 300H motor and the QRP Hyper S400 (red label).

On some motors, the timing can be changed. Most Speed 540 brushed motors have an endbell (back face of the motor) which can be loosened by loosening two screws. After the endbell is loosened, it can be rotated to the desired position.

Some other motors have an endbell which is secured by two tabs of metal which are bent over the endbell. These can be bent out to loosen and rotate the endbell.

c. Regular motor maintenance

Regular motor maintenance will maintain the efficiency of the motor and decrease average motor temperature and extend the motor life.

The commutator should be checked every few flights to ensure it is clean and shiny. If the commutator starts to look dirty, it should be cleaned.

If the endbell is removable, then the endbell should be removed and the rotor can be removed. The commutator can be cleaned with some extra fine steel wool until it is shiny.

If the endbell is not removable, then the motor will usually have slots in the motor case near the commutator. A cotton swab (such as a Q-tip) may be used on these types of motors to clean the commutator.

Motors with metal brushes (such as the Team Orion Elite Micro Modified) do not require the commutator to be cleaned, and the motor should not be disassembled.

There are some "commutator lathes" designed for cleaning R/C car motor commutators, but these are not recommended, because it is a better investment to buy a good brushless motor and ESC combination.

d. Use a high frequency ESC.

   A high frequency (about 100 khz) ESC minimizes brush and commutator wear by providing a smoother flow of electricity and minimizing the arcing between the brushes and commutators.

   A high frequency ESC is required for motors with metal brushes because metal brushes will typically disintegrate within 10 flights with conventional ESCs. Motors which use metal brushes include the Team Orion Elite Micro Modified and the grey endbell IPS-style motors.

e. Keep the motor cool by running the motor in the efficient range

   See Section 30.1.10.1, “Pulse-width modulation” for more info.

f. Keep the motor cool by using a heatsink

   There are many different heatsinks available which fit R/C helicopter motors.

   See Section 30.2.2.5, “Cooling options” for more info.

30.1.12.2. Brushless motors

For a typical brushless motor, the magnets are attached to the motor shaft (rotor) and the motor windings are attached to the motor case (stator)

The commutation is performed by a brushless motor ESC which pulses the motor windings in sequence to make the motor shaft rotate.

A brushless motor has no commutator nor brushes, so there are no parts which encounter significant wear, so a typical brushless motors should never wear out. In extreme cases, the bearings may fail, but this is rather unusual.

The primary failure mode of brushless motors is motor overheating, which is explained in more detail in the brushed motor section.

Motor overheating can be avoided in two ways:

a. Keep the motor cool by running the motor in the efficient range

   See Section 30.1.10.1, “Pulse-width modulation” for more info.

b. Keep the motor cool by using a heatsink

   There are many different heatsinks available which fit R/C helicopter motors.

   See Section 30.2.2.5, “Cooling options” for more info.

c. Use the correct switching frequency

   Brushless coreless motors require a high switching frequency to run efficiently and avoid overheating. Some motors require an extremely high switching frequency to avoid overheating. For example, the Kontronik Tango documentation states that a brushless ESC with a switching frequency of 32 khz or more is required for this motor.

30.1.12.3. Coreless motors

A brushed or brushless motor can be either a cored or coreless motor.

A coreless motor has no iron core for its motor windings. Therefore the windings are overlapped in a tubular fashion and looks like a woven basket. This woven basket of windings can either be layered around the inside of the motor case for a brushless motor, or wrapped around the motor shaft for a brushed motor.

This type of motor can usually be recognized by spinning the motor shaft while the motor wires are disconnected. A coreless motor will allow the rotor to turn freely because there is no iron core to attract the magnets and therefore has no preferred angular rest position.

Coreless motors have several advantages which are relevant to R/C helicopters:

a. Size/weight

   Coreless motors can be made smaller and lighter than motors with iron cores of the same size.

b. Efficiency

   Coreless motors have no eddy current losses, although this can be minimized on a cored motor by using very thin laminations from exotic materials (such as Magnesil).

c. Lower Io

   Because a coreless motor has no cogging (torque losses), the no-load current is much lower. Some iron core motors eliminate cogging using a skewed armature, but this is complicated.

30.1.12.4. Iron core rotor motors

A motor with an iron core for its windings can usually be recognized by spinning the motor shaft. An iron core motor will exhibit a cogging effect where the motor rotation feels "rough" because the shaft will have certain preferred rest positions. Not all iron core motors will have a cogging effect because this effect can be minimized or eliminated by staggering the rotor.

Cored motors have two main advantages:

a. Thermal stability

The motor windings in a cored motor can dissipate heat much better because the iron core acts as a heat sink. This characteristic is important for extended operation at high power levels.

b. Smaller air gap.

The clearance between the rotor and iron core can be minimized which increases efficiency.

30.2. Motor selection guide

There are many, many motors available, but only a few are suitable for each helicopter. This is because the rpm/V or the Kv of the motor is very important due to the fixed gearing ratio of the drive system.

There are ten main criteria to consider when choosing a motor:

30.2.1. Electrical characteristics

30.2.1.1. Motor Kv

For a definition see Kv .

For collective pitch helicopters, the motor Kv and pinion size must be carefully selected so the throttle will be between 90% and 100% when running at the desired headspeed. See the Section 30.1.10, “How ESCs work” section for more information.

For a fixed pitch helicopter, the motor cannot run at a constant speed so some inefficiency is unavoidable. The motor Kv and pinion size should be selected so the hovering headspeed is about 50% of the maximum headspeed possible. (The hovering headspeed for most wide-blade fixed pitch helicopters is about 1200-1300 rpm.)

Given two motors which are identical except for the Kv, the motor with the higher Kv will be more powerful and use more current, and the motor with the lower Kv will be weaker but use less current.

30.2.1.2. Motor Io

For a definition see Io .

The motor's Io is one factor which will help you determine the motor's efficient operating range.

For example, an ECO Piccolo requires about 3 amps to hover with a Hacker B20-36S. This motor has an Io of about 400 ma, so about 2.6 amps is used for hovering (minus other efficiency losses).

A Mega 16/15/4 would fit in the ECO Piccolo frame, but its Io is 1.1 amps. Therefore, the power usage would probably rise to 2.6 amps + 1.1 amps = 3.7 amps. About 30% of the hovering current is consumed by Io, which is a very high value, so therefore this motor is not very efficient when used in the 3 amp range.

A good rule of thumb for micro is to allocate about 10-15% of the hovering current for the motor's Io. For nonmicros, the percentage should be lower - about 7-10% is usually reasonable.

Better quality motors usually have a lower Io because they are more efficient and expend less power just idling the motor.

High-power motors usually have a higher Io because the are designed to run efficiently at high loads and therefore run much less efficiently at low loads.

30.2.1.3. Motor efficiency

Motor efficiency is important because the power not used to fly the helicopter is wasted as heat. For example, you might compare two motors, one with 80% and 90% efficiency. The difference appears to be only 10%.

In terms of heat generation, the 80% efficient motor will generate almost twice as much heat as the 90% efficient motor. If a helicopter requires 150 watts to hover, then the 90% efficient motor will use 166.7 watts of power and waste 16.7 watts as heat.

The 80% efficient motor will use 187.5 watts of power, and waste 27.5 watts as heat. This generates 65% more heat than the 90% efficient motor. So, motor efficiency is very important because efficient motors run much cooler.

30.2.1.4. Motor rated RPM

Some motors are rated for a very low maximum RPM, such as:

- JETI motors have a maximum rating of 15k-20k RPM
- Older Kontronik Tangos have a maximum rating of 25k RPM

If you use the motor past its rated RPM, then motor failure will probably occur (most likely the magnets will loosen from the rotor).

30.2.2. Physical characteristics

30.2.2.1. Motor size

Some motors are too large to fit in the some helicopters. For example, the C50-13L is too large to fit in the ECO 8.

30.2.2.2. Motor weight

A quick guide to suitable inrunner motors is to allocate 10-15% of the helicopter's AUW to the motor So, the inrunner motors suitable for an ECO 8 (AUW ~1600 grams) will be between 160-240 grams in weight.

Outrunner motors can be lighter because they are more efficient at dissipating heat. For outrunner motors, it is only necessary to allocate about 7-10% of the helicopter's AUW for the motor.

If you are not experienced with selecting motors, then you should select a motor in the 13-15% of AUW range. Motors in the 10-12% AUW are somewhat small and must be selected carefully to fly the helicopter well and avoid overheating.

30.2.2.3. Motor mounting holes

Some motors are unsuitable for helicopter use because the motor mounting holes are nonstandard.

For example, the "Nippy Black" series of brushless motors cannot be used for micro helis because it is designed for a "firewall mount" and therefore the motor mounting holes are on the rear of the motor. Other examples include the Typhoon Micro series which have a triangle-shaped pattern for the motor mounting holes, which do not fit standard helicopter motor mounts.

The Hacker B20-xxS/L, Feigao 138084xxS/L, Himaxx HA20xx, and Model Motors MiniAC 1215/xx motors have a "bearing bump" which makes installation in helicopters rather difficult. Maxx Products sells the a motor adapter (ACC3900) which eliminates this problem.

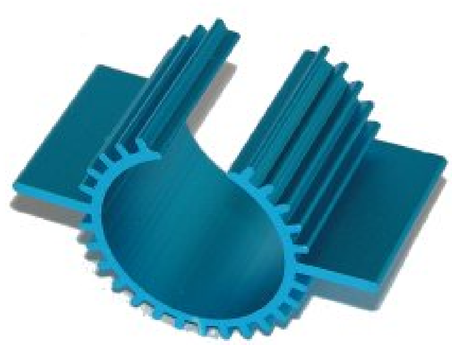
30.2.2.4. Shaft diameter and available pinion sizes

Theoretically, an Orbit 15-16 (1067 rpm/V) will fly an ECO 8. However, you would need about a 28-30 tooth 5mm pinion, and the largest available 5mm pinion is 24 tooth. So, the available pinion sizes will limit your motor choices.

30.2.2.5. Cooling options

For inrunner motors, a heatsink or fan is recommended when flying in ambient temperatures over about 70F/21C or when flying for long duration with lithium-ion or lithium-polymer batteries.

The Hacker B20, B40, and B50 heatsinks are probably the most commonly used for helicopters.



GWS style heatsink

Table 30.5. Heatsinks

Motor	Heatsink
20mm diameter motors (Hacker B20, HiMaxx 2015/2025 etc)	Hacker B20 heatsink Sparrow Products 20mm heatsink Hyperion 20L heatsink
23mm diameter motors:	GWS EHS-100 (green color)
24mm diameter motors (Speed 300	GWS EHS-300 (red color)

Motor	**Heatsink**
motors)	
28mm diameter motors (Mega 16/x/x, Hacker B40, etc)	Hacker B40 heatsink Hacker B40 heatsink Kontronik KK480 heatsink GWS Speed 400c heatsink (GW/EHS-400) (blue color) Sparrow Products 28mm heatsink
36mm diameter motors (Hacker B50, Kontronik 500/600, etc)	Hacker B50 heatsink Kontronik KK600 heatsink

The Mega 22/20/3H has the shaft extending out the backside for mounting a small fan using a 5mm prop adapter instead of a heatsink. A fan can be made by modifying a Maxx Products MPIACC328. Cut off the top part of the prop adapter so the prop adapter looks like a cylinder with a disc attached. Next, disassemble a small computer fan to extract the fan portion, and epoxy the fan to the top of the prop adapter.

Be careful of motor amp ratings. These are usually specified for airplanes in a tractor prop configuration where the propeller blows air directly onto the motor. In a helicopter, there is no forced air cooling, so the same motor will only handle about half the max amp rating or less.

Most brushless motors use neodymium magnets. These magnets will lose their magnetization when operated at temperatures over 70C/158F to 120C/248F depending on magnet type. Therefore, it is important to keep the motor temperature below about 150F (by using a heatsink) to avoid demagnetizing the motor magnets.

Some brushless motors use samarium cobalt magnets (Astroflight, etc). These magnets will lose their magnetization above 250C/482F, so overheating is less of a concern with these magnets. The Hacker C40/C50 series is the same as the B40/B50 series except the C40/C50 series has a built-in heatsink so no additional heatsink is necesary. The Hacker B40/B50 series require an additional heatsink available for $15.

The easiest way to install a Hacker B40/B50 heatsink onto a motor is to use a drill bit that is slightly larger than the gap in the heatsink, and press the base (not the spiral side) of the drill bit into the gap to force it open, then slip the motor inside. This technique works extremely well. To install a B40 heatsink onto a Mega 16/15/3, you should use a 4mm drill bit.

Motors are listed from mild to powerful. Please note that I have no experience with most of these motors therefore the ordering should only be considered a rough guide, and not absolute oracle. In general the lower Kv motors with a larger pinion are milder and better for duration flying, and the higher Kv motors with smaller pinions are better for sport/aerobatic flying.

For more info on motors and pinion sizes, I recommend searching the *RC Groups electric helicopter and micro helicopter forums* for people's opinions on various motor and pinion combinations.

30.2.3. Other characteristics

30.2.3.1. Motor quality

The quality of motors is rather subjective, but here is a list of motors and their general quality:

Table 30.6. Motor quality

Quality	Manufacturer
Best	Plettenberg, Lehner, Actro, Neumotor
Better	Hacker, Kontronik, Mega
Good	Multiplex Permax, Astroflight
Fair	Himaxx, Feigao, JETI, Model Motors AXI

The motors in the best category are relatively efficient over a wide load range.

The Kontroniks are slightly better than Hacker for helicopters due to better part load efficiency.

30.3. Motor selection table

Here is a table of motors sorted by weight to make motor selection easier.

Table 30.7. Motors sorted by weight

Manufacturer	Motor	Weight grams	Shaft Size mm	Kv range	Notes
Feigao	1208430S	10	1.5	5250	
Medusa Research	MR-012	15	1.5	4000, 5300	
Feigao	12084XXL	16	1.5	4122, 5322, 5866	
AON Electric	T1215	17	1.5	4100, 5000	
Motor Max Motors	300ST	24	3	1200	
Himax	HC2208	25	2	870, 1260	
Model Motors	AXI 2204	25	3.17	1400	
Motor Max Motors	300DF	25	2.3	2250	
Hacker	A20-S	29	3	1088, 1500	
ARC	20-27-80	29	?	4500	
Himax	HC2212	30	2	840, 1180	
Hyperion	Z2205	30	3	???, 1340, 1530	
AstroFlight	Mighty Micro 010	32	2	2300, 3570, 4150	
Motor Max Motors	400ST	38	3	1100	
Mega Motor	RC 400/7	39	3.17	857, 1115	
ARC	20-34-110	39	?	3199	

Manufacturer	**Motor**	**Weight grams**	**Shaft Size mm**	**Kv range**	**Notes**
ARC	20-34-130	39	?	4600	
Aircraft World	DIYMOT-VL	40	2		
Hacker	B20-S	40	2	2077, 3086, 3700, 4630	
Motor Max Motors	400F	40	2.3	2250	
Motor Max Motors	400T	40	3	1300	
Lehner	1010	40	3.17	3000-9231	Delta mode x1.7Kv
Hyperion	Z2209	42	3	910, 1120	
Ultrafly	B/06	42	3.17	1000, 1200, 1450	
Ultrafly	D/13	42	2.3	3200?	
Ultrafly	B/12	42	3.17	750, 1000, 1200	
Hacker	A20-M	42	3	980, 1130	
Kontronik	Mini Dancer	42	?	1000	
Motor Max Motors	400DH	42.1	2.3	4000?	
Cyclon	Mini Cyclon CPLR	45	3.17	1320	
Z-power	400	45	2.3	1150, 2900	
Model Motors AXI	2808	46	4	1420, 1820	
Motor Max Motors	400DF	46	2.3 or 3	3000	
Motor Max Motors	400F	46	2.3	2250	
Motor Max Motors	400T	46	3.17	1300	
Ultrafly	C/13	46	2.3	2000, 2400, 2800, 3300	
Kontronik	Micro Dancer	46	2.3	2800	
Himax	HA2015	48	2	2800, 2600, 4100, 5400	
Castle Creations	Mamba	48	2	3600, 4200, 5400, 6800, 8000	
Hyperion	Y22S	48	2	2850, 3600, 4200, 5000, 6000	
Mega Motor	ACn 16/7	48	3.17	1000, 1430, 1700, 2125,	

Manufacturer	**Motor**	**Weight grams**	**Shaft Size mm**	**Kv range**	**Notes**
				2450, 2850, 3450, 4420, 5580	
Model Motors	MiniAC 1215/x	48	2.3	3000, 3800, 4750, 6370	
E-flite/Hacker	E3	48	2	3700, 4900	
Feigao	13084XXS	50	2 or 2.3		
Lehner	1015	50	3.17	2000-7273	Delta mode x1.7Kv
Ultrafly	A/30	50	2.3	2400, 2900	
Cyclon	Mini Cyclon Heli	50	2.3	2835	
Cyclon	Mini Cyclon Turbo	50	2.3	2835	
Cyclon	Mini Cyclon CAR PUNCH	50	2.3	5367	
Cyclon	Mini Cyclon Heli Punch	52	3.17	3450	
Hyperion	Z2213	53	3	850, 1025	
Motor Max Motors	450F	55	2.3	3450	
Motor Max Motors	450TH	55	3.17	2900	
Motor Max Motors	450XT	55	3	950	
Model Motors	AXI 2212	57	3.17	710, 920, 1150, 1950	
Hacker	A20-L	57	3	924, 1022	
Z-power	450	57	2.3/3.17	2950, 3500, 4000	
Great Planes	Ammo	58	2	3600, 4300, 5100	
Hacker	B20-L	58	2 or 2.3	2195, 2500, 2903, 3462, 4091	
Feigao	13084XXL	60	2.3		
Lehner	1020	60	3.17	1500-5455	Delta mode x1.7Kv
Motor Max Motors	450FT	60	3	2250	
Mega Motor	RC 400/15	63	3.17	800, 915, 1070, 1210	
Align	420L	64	3.17	3200	
Motor Max Mo-	450XT	64	3	950	

Manufacturer	Motor	Weight grams	Shaft Size mm	Kv range	Notes
tors					
NeuMotors	1105	65	2.3 or 3.17	3000, 3500, 4000, 5200, 6800	
Align	430L	66	3.17	3550	
Himax	HA2025	66	2	2700, 3200, 4200, 5300	
Kontronik	Maxi Dancer	66	?	1200	
Hyperion	Y22L	70	2.3	2840, 3600, 3900, 4400, 5000	
Medusa Research	MR-028-032	70	3.17	1200, 1500, 1900, 2400, 2800, 3400, 4200	
Hacker	A30-S	71	4	1140, 1440	
MPJet	AC 25/35-20 Mk2	74	3	2650	
RCer	BL4-15	75	3	1190, 1430, 1810, 2580, 3880	
Hyperion	HP-Z3007	75	4	1050, 1240, 1580	
Mega Motor	ACn 16/15	76	3.17	1250, 1300, 1500, 1800, 2200, 3000, 4600, 9200	
Model Motors	AXI 2808	76	3.17	1190, 1490, 1820	
AstroFlight	Astro 020	78	3.17	2567, 3330, 4460	
Lehner	1511	79	3.17 or 4	1949-12991	Delta mode x1.7Kv
Aveox	27/13	81	3.17	2071, 2564, 3389, 5023	
Mega Motor	RC 600/10	85	5	1200, 1695	
Himax	HB2815	86	3.17	1400, 2000, 3000, 4000	
Hyperion	YH22XL	89	?	3900	
Lehner	1515	90	3.17 or 4	1429-9527	Delta mode x1.7Kv
Ultrafly	B/18	91	3	650, 800, 1000	
NeuMotors	1107	91	2.3 or	2060, 3400	

Manufacturer	**Motor**	**Weight grams**	**Shaft Size mm**	**Kv range**	**Notes**
			3.2		
Kontronik	Evo Dancer	92	?	850	
MPJet	AC 2810-13	94	5	1050	
AON Electric	V2815	98	3.17	3500	
AON Elctric	V2815-3500	98	3.17	3500	
Medusa Re-search	MR-028-040	100	3.17	1000, 1200, 1700, 2500, 3400	
Cyclon	Cyclon 20	100	5	1790	
Mega Motor	ACn 22/10	104	5	1200, 1485, 1980, 2400, 2950, 5000	
Mega Motor	ACn 16/20	105	3.17	3100	
Hacker	A30-M	105	5	1060, 1370	
Model Motors	AXI 2814	106	4	1390, 1640	
Hyperion	Z3013	110	5	985, 1085	
Kontronik	Fun400 -xx	110	3	2300, 2800, 3600, 4200	
Multiplex	Permax	110	3.17		
Plettenberg	Moskito 4	110	?	3000?	
Plettenberg	Moskito 6	110	?	2023?	
Plettenberg	Moskito 8	110	?	1524?	
Mega Motor	ACn 16/25	111	3.17	900, 1270, 1700, 2650	
AstroFlight	Astro 5	114	3.17	2600, 2666, 4000	
NeuMotors	1110	114	2.3 or 3.2	1900, 2500, 3000, 3500, 4700, 5600	
Lehner	1520	115	3.17 or 4	1072-7147	Delta mode x1.7Kv
Kontronik	Kora 10	118	?	1050, 1250, 1360, 1750	
Astro	Astro 19	120	3.17	1375	
Cyclon	Cyclon Heli 4000	120	3.17	3742	
Cyclon	Cyclon Turbo 4000	120	5	3742	
Cyclon	Cyclon CAR 4000	120	3.17	3742	
Cyclon	Cyclon CAR 5000	120	3.17	4753	
Aveox	27/26	123	3.17	1288, 1724,	

Manufacturer	**Motor**	**Weight grams**	**Shaft Size mm**	**Kv range**	**Notes**
				2544, 3363, 4962	
MPJet	AC 26/45-20	123	4	3000	
HB Elektronik	HB 12-25	124	3.17	2300	delta x1.7 kv
Hacker	B40-S	125	3.17	1429-7531	
NeuMotors	1902	125	5	2050, 4350	
Lehner	1525	135	3.17 or 4	857-5713	Delta mode x1.7Kv
Plettenberg	Orbit 10	135	5	1050, 1280, 1410	
Mega Motor	RC 600/20	136	5	885, 1160, 1370	
Himax	HA2825	138	3.17	2300, 2700, 3600, 4400, 5500	
Himax	HB3615	138	5	1600, 2100, 3200	
Kontronik	Fun480-xx	140	3.17	2800, 3300, 4200, 5500	
Actro	Actro C	140	5	890, 1170, 1470, 1900	
Cyclon	Cyclon 25	140	5	1500	
Hyperion	Z3019	142	5	900, 1070	
Lehner	BASIC	145	3.17	2100, 2400, 2700, 3100, 4200, 5300	
Hacker	C40-S	147	3.17	1429-7531	
Cyclon	Cyclon 30	150	5	960	
Kontronik	Kora 15	150	?	690, 790, 920, 1133	
Model Motors	AXI 2820	151	5	990, 1200, 1500	
Lehner	1530	155	3.17 or 4	714-4760	Delta mode x1.7Kv
Hacker	B40-L	158	3.17	2029-7100	
Kontronik	Twist	160	3.17	3300, 3700, 4200, 4750, 5500	
Medusa Research	MR-028-056	160	3.17	900, 1400, 1900, 2800	
Cyclon	Cyclon Heli 2000	160	3.17	2093	
Cyclon	Cyclon Turbo	160	5	2093	

Manufacturer	Motor	Weight grams	Shaft Size mm	Kv range	Notes
	2000				
Cyclon	Cyclon Turbo 2500	160	5	2611	
Cyclon	Cyclon CAR 2500	160	3.17	2611	
Cyclon	Cyclon CAR 2000	160	3.17	2093	
Aveox	27/39	161	3.17	855, 1134, 1693, 2257, 3305	
Mega Motor	ACn 22/20	168	5	1480, 1850, 2875, 4050, 5500	
AstroFlight	Astro 25	170	5	2044	
Lehner	1920	170	3.17 or 4	784-7838	Delta mode x1.7Kv
MPJet	2820-7 Mk2	170	5	950	
Plettenberg	HP 220/20/A2 S P6	175	5	3030	
Plettenberg	HP 220/20/A3 S P6	175	5	1930	Heli +20 grams
Plettenberg	Orbit 15	175	5	940, 960, 1080, 1210	
Cyclon	Cyclon 40	175	5	1000	
Hacker	A30-XL	179	5	1000, 1185	
Hacker	A30-XL	179	?	770, 900, 1100	
NeuMotors	1506 (finned)	180	5	1700, 3400, 5200, 5500, 6800, 9500	
Plettenberg	HP 220/20/A3 S P4	180	5	3084?	
Plettenberg	HP 220/20/A4 S P4	180	5	2315	Heli +20 grams
Plettenberg	HP 220/20/A5 S P4	180	5	1780?	
Model Motors	AXI 2826	181	5	760, 920, 1130	
NeuMotors	1905	182	5	720, 864, 1035, 1440	
Hyperion	Z3025	186	5	664, 815, 987, 1365	
Himax	HA3618	187	5	2300, 3000, 4500	

Manufacturer	Motor	Weight grams	Shaft Size mm	Kv range	Notes
Hacker	C40-L	187	3.17	1988-6942	
Actro	Actro CL	190	5	600, 800, 1000, 1240	
HB Elektronik	HB 20-10	190	3.17	2310	delta x1.7 kv
HB Elektronik	HB 20-13	190	3.17	1900	delta x1.7 kv
Mega Motor	RC 600/30	195	5	640, ???, 1080	
Aveox	36/15	196	5	1495, 1979, 2947, 3873, 5603	
Hacker	B50-S	198	5	1375-7380	
Kontronik	Fun500-xx	200	5	1940, 2140, 2400, 2700, 3200, 3800, 4800	
Lehner	BASIC XL	210	3.17	1200, 1600, 2000, 2400, 2800, 3100, 4200, 5200	
Plettenberg	Orbit 20	215	5	640, 720, 810, 950, 1130	
Mega Motor	ACn 22/30	220	5	940, 1050, 1270, 1770, ???	
NeuMotors	1509 (finned)	225	5	1820, 2400, 2700, 3600, 4500, 6700	
Kontronik	Kora 25	225	?	420, 480, 550, 650	
Himax	HB3630	230	5	780, 1000, 1500	
Lehner	1930	230	3.17 or 4	523-5225	Delta mode x1.7Kv
Cyclon	Cyclon 60	235	5	800	
NeuMotors	1907	235	5	483, 580, 690, 966	
Aveox	36/24	236	5	983, 1313, 1956, 2633, 3724	
HB Elektronik	HB 30-13	245	3.17	1200	delta x1.7 kv
Hacker	C50-S	249	5	2843	

Manufacturer	Motor	Weight grams	Shaft Size mm	Kv range	Notes
Kontronik	Fun600 -xx	250	5	1150, 1300, 1500, 1630, 1800, 2530, 3200	
Plettenberg	Orbit 25	250	5	520, 590, 670, 770, 930	
AstroFlight	Astro 40	253	5	1363	
Hacker	B50-L	255	5	929-6038	
Aveox	36/30	268	5	729, 1011, 1466, 1945	
Cyclon	Cyclon Heli 1600	270	5	1245	
Kontronik	Tango	285	5 ?	392-3919	
NeuMotors	1910	289	5	360, 432, 525, 680	
Lehner	1940	290	3.17 or 4	1400, 1900, 1700, 2000, 2600, 3200, 4875	Delta mode x1.7Kv
NeuMotors	1512 (finned)	290	5	1400, 1900, 1700, 2000, 2600, 3200, 4875	
Mega Motor	ACn 22/45	303	5	1380	
Plettenberg	Orbit 30	305	5	550, 650, 780	
Hacker	C50-L	314	5	1353-4060	
Model Motors	AXI 4120	320	6	515, 660	
Cyclon	Cyclon 90	320	5	430	
HB Elektronik	HB 40-13	322	3.17	980	delta x1.7 kv
Aveox	36/38	323	5	574, 765, 1172, 1681	
Hacker	B50-XL	340	5	607-3945	
NeuNotors	1912	345	5	270, 324, 405, 540, 825	
Actro	Actro 24 heli	350	5	435, 570, 740	
Lehner	1950	355	3.17 or 4	314-3135	Delta mode x1.7Kv
NeuMotors	1515 (finned)	360	5	1100, 1360, 1500, 1700, 2200, 2700, 3450	
Lehner	2230	380	5	493-3944	Delta mode x1.7Kv

Manufacturer	**Motor**	**Weight grams**	**Shaft Size mm**	**Kv range**	**Notes**
Model Motors	AXI 4130	409	6	305, 385	
Hacker	C50-XL	420	5	773-2707	
Koehler	Actro 32 heli	430	5	330, 415, 555	
Aveox	46/30	455	5	886	
Lehner	2240	465	5	296-2368	Delta mode x1.7Kv
NeuMotors	1521 (finned)	480	5	780, 1050, 1577, 1860, 2800	
HB Elektronik	HB 40-22	520	5	660	Delta mode x1.7 kv
Lehner	2250	570	5	185-1480	Delta mode x1.7Kv
Aveox	46/43	680	5	222, 266, 333, 444, 670	
Lehner	2280	800	5	185-1480	Delta mode x1.7Kv
Lehner	3060	1200	10	196-1570	Delta mode x1.7Kv
Lehner	3080	1600	10	147-1178	Delta mode x1.7Kv

1. Normal Plettenberg motors e.g. "A3 P6" have cooling fins.

2. Boat Plettenberg motors e.g. "A3 S P6" have a smooth case?

3. Heli Plettenberg motors have a built-in fan.

30.4. Pinion selection guide

30.4.1. Pitch to module conversion

Here is a the conversion from English to metric.

module = 25.4 / pitch

30.4.2. Common pitch equivalents

Here is a table with approximate conversions from pitch to module.

There will be extra wear and some inefficiency due to not having an exact match, however this is good enough for most purposes.

- 32 pitch = about 0.8 module (actually 0.793 module)
- 48 pitch = about 0.5 module (actually 0.529 module)
- 64 pitch = about 0.4 module (actually 0.396 module)

Pinions are sometimes labeled as "metric 48 pitch which is actually 0.6 module.

30.4.3. Shaft sizes

There are about six different shaft sizes used in electric helicopters today: 1mm, 1.5mm, 2mm, 2.3mm, 3.17mm, and 5mm.

The 1mm shafts are used by the "N20" style tail motors used in micro helicopters. Wes-Technik stocks 0.5 module brass pinions with 6-15T for this shaft size.

The 1.5mm shafts are used by the GWS IPS-style "performance" tail motors used in micro helicopters. Wes-Technik stocks 0.5 module brass pinions with 7-12T for this shaft size.

The 2mm and 2.3mm (3/32 inch) shafts are used by main motors on the micro helicopters, such as the Piccolo, Dragonfly, Hummingbird, etc. The 2mm bore pinions are easy to find, but the 2.3mm bore pinions are much more difficult to find.

30.4.4. Pinion notes

The standard Hacker B20-series motors have a 2.3mm shaft, but Aircraft World carries some B20-S motors with a standard 2mm shaft, which makes pinion selection much easier.

Precision Model Products modifies the Team Losi Micro RS4 pinions bored out to 2.3mm for Hacker B20 series motors. These pinions work but are not the best because they are very noisy.

Sparrow Products now sells a pinion adapter (bore reducer) which allows you to use a 3.17mm pinion with a 2mm or 2.3mm motor shaft. This is available from their website.

If you know of another source for 0.5 module metal pinions for 2mm and 2.3mm shafts with setscrews, then please send me a message at RC Groups , because these pinions are difficult to find.

The 3.17mm (1/8 inch) and 5mm shafts are used for nonmicro helicopters. Tower Hobbies carries a wide range of 1/8 inch pinions in both 32 and 48 pitch sizes which are usable in electric helicopters.

Kawada makes 48 pitch 3.17mm pinions up to 40T. RCmart carries a full selection of Kawada pinions.

Please note the Duratrax Mini Quake pinions are NOT 0.5 module and will not work on most micro helicopters. The teeth are too big and the pitch may be 0.6 module, but haven't verified this.

The press-on pinions for GWS EPS gearboxes are 0.4 module and have a 2mm bore. These are usable for the Hornet, but they do not have a setscrew.

If noise is a concern, then the smallest pinions should be avoided because they tend to be noisier then the larger pinions.

The Team Orion Elite Micro Modified motor has a very short shaft, and works best with a tall pinion such as the Align 2.3mm pinions.

30.5. Pinion selection tables

Pinions are available from several after-market suppliers. The following tables list them grouped by bore-size.

Table 30.8. Pinions 2mm bore 0.5 module

Manufacturer	Teeth	Part No.
HPI Racing Micro RS4 steel pinions w/ss	old 8T	48005
	old 9T	48006
	old 10T	48007
	old 11T	48008
	old 12T	48009
	old 13T	48010
	old 14T	48011
	new 9T	48050
	new 10T	48051
	new 11T	48052
	new 12T	48053
	new 13T	48054
	new 14T	48055
	new 15T	48056
	new 16T	48057
Duratrax Micro Street Force aluminum pinions w/ss	9T	Tower Hobbies LXFNC5
	11T	Tower Hobbies LXFNC6
	13T	Tower Hobbies LXFNC7
Team Integy pinions w/ss	8T, 9T, 10T	T4027
	11T, 12T, 13T, 14T	T4023
Trinity pinions w/ss	9T, 10T, 11T, 12T	34066
	13T, 14T, 15T, 16T	34067
Xray M18 composite pinions	13T, 14T, 15T, 16T	385701
	17T, 19T, 21T, 23T	385700
Kyosho @12 steel pinion w/ss	7T	Kyosho AZW002-07
	7T	Tower Hobbies LXGPF2
	8T	Kyosho AZW002-08

Manufacturer	Teeth	Part No.
	8T	Tower Hobbies LXGPF3
	9T	Kyosho AZW002-09
	9T	Tower Hobbies LXGPF4
Team Losi Mini-T plastic press-on pinions	12T, 14T, 16T	LOSB1069

Table 30.9. Pinions 2.3mm bore 0.5 module

Manufacturer	Teeth	Part No.
ARK/Helimax MX400 brass pinions w/ss	11T	Tower Hobbies LXLBN2
	12T	Tower Hobbies LXLBN1
	13T	Tower Hobbies LXLBN0
	14T	Tower Hobbies LXLBM9
AlignRC T-rex metal pinions w/ss	9T, 10T, 11T	HZ020

Table 30.10. Pinions 3mm bore 0.5 module

Manufacturer	Teeth	Part No.
Stock Drive Products pinions w/ss	12T	A 1Y 2MY05012
	15T	A 1Y 2MY05015
	16T	A 1Y 2MY05016

Table 30.11. Pinions 3.17mm bore 0.5 module

Manufacturer	Teeth	Part No.
AlignRC T-rex metal pinions w/ss	11T, 13T, 15T	HZ021
ECO 8 pinions	10T	67108
	11T	67109
	12T	67611
	13T	67612
	14T	67613
	15T	67614
	16T	67615
	17T	67616
GPM Racing Titanium pinions w/ss	11T	MH011TT-B, -S
	12T	MH012TT-B, -S
	13T	MH013TT-B, -S
	14T	MH014TT-S

Manufacturer	Teeth	Part No.
	15T	MH015TT-B

Table 30.12. Pinions 5mm bore 0.5 module

Manufacturer	Teeth	Part No.
Stock Drive Products pinions w/ss	25T	S10T05M025S0505
	26T	S10T05M026S0505
	28T	S10T05M028S0505
	32T	S10T05M032S0505
	36T	S10T05M036S0505
ECO 8 pinions	13T	M2813
	14T	M2814
	15T	M2815
	16T	M2816
	17T	M2817
	18T	M2818
	19T	M2819
	20T	M2820
	21T	M2821
	22T	M2822
	23T	M2823
Mikado Logo 10 pinions	13T	2813
	14T	2814
	15T	2815
	16T	2816
	17T	2817
	18T	2818
	19T	2819
	20T	2820
	21T	2821
	22T	2822
	23T	2823

Table 30.13. Pinions 5mm bore 0.7 module

Manufacturer	Teeth	Part No.
Mikado Logo 20/24 pinions (new)	10T	3010
	11T	3011
	12T	3012
	13T	3013

Manufacturer	Teeth	Part No.
	14T	3014
	15T	3015
	16T	3016
	17T	3017
	18T	3018

Table 30.14. Pinions 5mm bore 1.0 module

Manufacturer	Teeth	Part No.
Century Swift pinions	9T	CNMG509
	10T	3010
	11T	3011
	12T	3012
	13T	3013
	14T	3014
Mikado Logo 16/20 pinions (old)	8T	2508
	9T	2509
	10T	2510
	11T	2511
	12T	2512

30.6. Servo selection guide

There are 10 main criteria to consider when selecting a servo:

30.6.1. Electrical characteristics

30.6.1.1. Servo deadband

The servo deadband is measured in microseconds, and is an indicator of the "electrical slop" of the servo's electronics. This term is rather technical, but the simplified explanation is that it measures the resolution of the servo.

For example, the standard R/C servo control pulse width varies from 1 millisecond to 2 milliseconds wide, so there is about 1 millisecond of electrical resolution.

The Hitec HS-81 analog servo has a deadband of 8 microseconds. So, the resolution of this servo is about 180 degrees * 8 microseconds / 1000 microseconds or about 0.72 degrees.

The Hitec HS-5245 digital servo has a factory default deadband of about 2.9 microseconds. So, the resolution of this servo is about 90 degrees * 2.9 microseconds / 1000 microseconds or about 0.261 degrees.

30.6.1.2. Current draw

Digital servos will have a much higher current draw than analog servos, especially when used for tail control with a heading hold gyro. You may need to use an external switching BEC to avoid overloading the built-in BEC of the ESC, which will add to the weight of the heli.

Also, some servos which have high torque will have a correspondingly high current draw. For example, the GWS Naro HP BB has the nickname of "current hog" because it draws a large amount of current for its size.

30.6.2. Physical characteristics

30.6.2.1. Size

There are four servo sizes which are tyically used on electric helis: Standard, mini, micro, and submicro.

The standard servos are usually 40mm x 20mm x 40mm, and are typically used on helis which heavier than 2.5 kgs, such as the Swift and Logo 20.

Mini servos are about 30mm x 12mm x 30mm, such as the Hitec HS-81 and HS-85. These servos are typically used on helis between 1kg and 2.5kgs, such as the Viper 90, ECO 8, Logo 10, and Robbe Spirit.

Micro servos are about 23mm x 12mm x 24mm, such as the Hitec HS-56. These servos are typically used on helis between 500 and 800 grams, such as the Zoom 400, T-rex 450XL, and Viper 70.

Submicros vary in size, but the Hitec HS-50 and HS-55 are in this category. These servos are typically used for helis under 400 grams, such as the Piccolo, GWS Dragonfly, Century Hummingbird, etc.

30.6.2.2. Mounting lugs

Some helis which use micro servos have four holes for mounting, and some have two.

30.6.2.3. Servo weight

Some servos are very heavy. This weight may be undesirable for a heli which is optimized for duration flight.

30.6.2.4. Speed and Torque

Speed and torque are dependent on the gearing inside the servo. Often there will be two servos from the same manufacturer which be visually identical but have different speed and torque specifications, such as the HS-85 and Hs-81. This difference is due to the difference in gear ratios inside the servo.

Torque is usually more important for swashplate servos because it is important to hold the swashplate position accurately. Speed is more important for tail servos when used with a heading hold gyro which requires fast servo response.

30.6.2.5. Gear type

There are two main types of gears used in servos: plastic and metal.

The advantage of plastic gears is they wear slowly. However, they are easily damaged in a crash. Metal gears are more durable and are more resistant to crash damage. However, they wear much faster and develop mechanical slop.

Therefore, it is best to use metal geared servos for swashplate control, where the crash resistance is desirable. The plastic geared servos work better for tail control because tail control slop will cause tail wag with a heading hold gyro.

30.6.2.6. Replacement gear availability

Servo gears are sometimes destroyed in heli crashes, so you should consider the availability of replacement servo gears when selecting a servo.

30.6.2.7. Geartrain slop

Slop is undesirable for both swashplate and tail control servos. SOme servos, such as the HS-50, have excessive amounts of mechanical slop, which make them undesirable for helicopter use.

30.6.2.8. Overall quality

The two best servo manufacturers are probably Volz and Multiplex. They have a history of manufacturing servos with extremely good geartrains and very tight deadbands.

The next best servo manufacturers are probably Futaba, JR, and Hitec. All three manufacture good quality servos.

30.7. Electronics modification guide

30.7.1. Adding a brushless motor to a brushed 3-in-1 controller

You may want to use a brushless motor with an existing 3-in-1 controller without converting the helicopter to separate electronics. There are a few different ways to do this.

Note: A 4-in-1 controller is the same as a 3-in-1 controller with a receiver, so these techniques will work with a 4-in-1 controller as well.

30.7.1.1. Using a Y-lead

A brushless main motor ESC can be added to an brushed 3-in-1 controller by simply using a Y-lead servo connector on the throttle channel. This will allow both the 3-in-1 and brushless motor controller to receive the throttle signal. This will not work for a brushless tail motor because a Y-lead on the rudder channel will bypass the revo mixing capability of the 3-in-1 controller.

30.7.1.2. Using a PowerZone adapter board

A PowerZone adapter board converts a brushed motor signal back into a servo signal (variable width pulse) so the brushless ESC can plug into the PowerZone. This works for a brushless main and tail motors, although a Y-lead is much cheaper for a brushless main motor. However, if the 4-in-1 board has both the receiver and controller on a single board, then using a PowerZone may be easier than trying to trace the receiver's throttle channel to connect a servo connector.

Search the RCgroups micro heli forum for more info on the PowerZone.

30.7.1.3. Use transmitter mixing to slave channel 5 to the throttle channel

If you are using a six or more channel transmitter, then channel 5 should be unused when using the 4-in-1 board. You can slave the unused channel 5 to the throttle channel (usually channel 3) and connect the brushless motor ESC to channel 5 on the receiver.

30.7.2. Adding a heading hold gyro to a brushed 3-in-1 controller

You can add a heading hold gyro to a brushed 3-in-1 controller by using a heading hold gyro (without remote gain), and a tail ESC. You will need to rewire the electronics as follows:

1. The throttle channel will go to the 3-in-1 board, and the main motor will still be controlled by the 3-in-1 board.
2. The rudder channel will now go to the heading hold gyro, and the tail motor ESC will plug into the heading hold gyro.

Basically, you will only use the 3-in-1 board as a main motor ESC, and all other functions will be handled by the other components.

30.7.3. Brushed tail motor to brushless conversion

If you are using a brushed 3-in-1 controller, then you can use a PowerZone board to convert the brushed tail motor output into a servo signal, then you can plug a brushless motor controller into the PowerZone board.

Otherwise, if you are already using separates, then just replace the brushed tail motor ESC with a brushless tail motor ESC.

If you are using a heading hold gyro and you replace a brushed tail motor with a brushless tail motor, then the tail will probably wag very badly because the brushless tail motor will generate more thrust than the brushed tail motor.

If this occurs, you will need to trim the tail rotor to reduce the tail rotor thrust. You should trim the tips of the tail rotor instead of the trailing edge of the tail rotor, because this will create a more efficient tail rotor (smaller rotor with more pitch is more efficient at generating static thrust than a larger rotor with less pitch).

Be sure to trim the tail rotor in small steps and test the tail rotor thrust by flying the heli to ensure you do not trim too much from the tail rotor.

30.8. Battery info

30.8.1. Battery terminology primer

LiPo batteries are usually described as something like "5S2P 4200 maH 10C". This can be a bit confusing to understand.

30.8.2. Battery pack series/parallel rating

The xSxP parameter descdribes describes the arrangement of cells in the battery pack.

The "5S2P 4200 maH" means there are 5 batteries in series, with 2 sets of these in parallel for a total of 10 cells. The capacity of the entire pack is 4200 maH and there are two sets of batteries in parallel, so the capacity of each individual cell is 2100 maH.

Alternatively, you can think of the battery pack as each cell is doubled up in parallel, then 5 of these doubled cells are connected in series. Either way, the pack will behave identically.

30.8.3. Battery capacity rating

Imagine a jug which holds one gallon. If you drain this jug at one gallon per hour, then the bottle will be empty in one hour. If you drain the jug at half a gallon per hour, the jug will be empty in two hours, and if you drain the jug at two gallons per hour, then the jug will be empty in half an hour.

Similarly, a 2100 maH battery can supply 2100 ma of current for one hour, or 1050 ma of current for two hours, or other combinations.

30.8.4. Internal resistance/discharge rate

Each battery has an internal resistance which determines the maximum continuous discharge rate.

For NiCad/NiMH batteries, the internal resistance is measured in milliohms. The lower the reistance (milliohms), the more current the battery can supply.

A good rule of thumb is to estimate the maximum discharge capacity at 125 divided by the milliohms of internal resistance. For example, the Sanyo RC2400 cells which have about 4.5 milliohms of internal resistance can supply about 125 / 4.5 or about 27 amps of continous discharge current.

For LiPo cells, the maximum discharge rate is usually given as a C-rating, such as 10C or 12C. In the RC world, the C-rating specifies the current rating as a mutiple of the battery capacity. So a 2100 maH battery pack would be able to supply 2100 ma * 10 or 21000 ma (21 amps) of current. Note that this 21 amps can be either a maximum continous dicharge rate or a maximum burst discharge rate.

Note that reputable companies rate their cells conservatively for maximum current and their batteries will last hundreds of cycles at the maximum current rating. Less reputable companies will aggressively over-rate their cells, and if you continously draw the maximum current from the battery, it will only last for twenty or thirty charge/discharge cycles. Therefore, if you buy the cheapest batteries, you will spend more on batteries over the long term.

30.9. Battery care and maintenance

Different types of batteries have different requirements for care and maintenance. In order to ensure maximum battery usability, you should carefully follow the recommendations for each battery type.

30.9.1. Nickel-cadmium (NiCad) batteries

Nickel-cadmium batteries are generally the most robust of all the battery types. They're the oldest and most reliable battery type, (often over 200 charge/discharge cycles) and are fairly resistant to overcharging, vibration, and other forms of abuse.

NiCad batteries can be charged at a maximum rate of 2C.

NiCad batteries should be left discharged at the end of the flying day. When stored long-term (over two months) they should be stored in a cool storage area. After storage, you should do a formatting charge (which overcharges the pack slightly) to ensure the battery pack is properly balanced.

Warning

NiCad batteries contain cadmium which is toxic and can cause lung and kidney damage. Be sure to wash your hands after handling nicad batteries. Also, nicad batteries MUST be disposed of properly. See Section 30.9.4, “NiCad/NiMH/LiPo Battery disposal”.

30.9.2. Nickel-metal-hydride (NiMH) batteries

Nickel-metal-hydride batteries are a newer battery type than nickel-cadmium. They have a higher energy capacity than nicad, but have a much shorter life (about 100 charge/discharge cycles), and they are more easily damaged by overcharging and vibration.

NiMH batteries can be charged at a maximum rate of 1C, however, some people claim the Sanyo HR2600SC can be charged at 2C rates. This warms up the cell for maximum performance prior to flying. Chargers will fail to properly terminate the charge when NiMH cells are charged at rates less than 0.4C, so slow charges must be carefully timed to avoid overcharging the cells.

NiMH batteries can be left either charged or discharged at the end of a flying day. When stored long-term they should be stored in a cool storage area. After storage, they should be cycled a few times to restore capacity.

30.9.3. Lithium-Polymer (LiPo) batteries

Lithium polymer is the newest battery type. They have up to four times the battery capacity of nicad batteries, but they are very fragile. They contain lithium which is a metal which ignites on contact with air, so if the battery balloons and the covering pops or the covering of the battery is punctured, it will ignite and explode.

LiPo batteries can be charged at a maximum rate of 1C.

LiPo batteries are very sensitive to overcharging. They should *NEVER* be overcharged, and *ALWAYS* be charged in a fireproof container and should *ALWAYS* be attended because they have been known to ignite in some circumstances.

LiPo batteries should not be discharged below 3 volts per cell because they can be damaged by overdischarging. A LiPo battery should not be discharged below 80% capacity if possible because this stresses the cell and reduces the cell lifetime (number of charge/discharge cycles before cell capacity degrades significantly). They should not be fully discharged at the end of the day; you should leave some charge in them. Thunder Power recommends long-term storage with about a 40% charge left in the cell; this minimizes cell deterioration and prevents the cell's voltage from dropping too low. They should be stored in a cool place in a fireproof container.

LiPo batteries are fairly fragile. You should avoid dropping them (especially onto concrete or asphalt) because this can cause cell damage. LiPo batteries have beeen damaged in a crash and have spontaneously ignited up to 30 minutes later. Any LiPo batteries which have been in a helicopter that has crashed should be kept in a fireproof container for a few hours for observation.

Do not attempt to charge or discharge a ballooned battery pack. The proper way to dispose of a bad lipo cell is to take a container and fill it with water, then keep adding salt and stirring until no more salt will dissolve (reached saturation). Drop in the cell and leave for at least *TWO WEEKS*. Also, please search for "lipo disposal" in the RC Groups forums for the latest safety information on this technique.

30.9.4. NiCad/NiMH/LiPo Battery disposal

All battery types, especially NiCad and LiPo battery packs, must be disposed of properly. In the US, go to www.rbrc.org to find the nearest battery disposal site.

More information on R/C batteries can be found at Red Scholefield's R/C battery clinic at www.rcbatteryclinic.com and also at www.batteryuniversity.com..

30.9.5. Solderless power tube (SPT) battery packs

The endcaps of the solderless power tubes can be damaged in hard crashes when the battery pack is ejected from the helicopter. These endcaps can be purchased separately from MEC.

My experience with the SPT battery packs is the battery terminals tend to oxidize as the batteries are heated and cooled. This oxidation results in increased resistance and the battery pack may appear to be weak.

I recommend disassembling the SPT battery packs about once a year and inspecting the battery terminals. If the positive terminal has a thin film of white residue on it, then this is a sign the cell has vented. This indicates the cell is probably weak. You should clean the terminal and write a mark on the cell to indicate it has been cleaned. If this cell requires cleaning more than once, it should probably be replaced.

30.10. Maintenance and crash repair

30.10.1. Brushed motors w/carbon brushes

After every ten flights or so, the carbon dust should be blown out of the motor with compressed air and the commutator checked to see if it is clean. If the motor is assembled with screws and the commutator is dirty, disassemble the motor and burnish the commutator with some extra fine steel wool or 1000-1200 grit sandpaper.

30.10.2. Main rotor shaft bearings

Some helicopters (ECO, etc) have open-faced bearings. These bearings are not sealed, and because the ball-bearings are exposed, they can become contaminated with dirt and grit.

If you notice the main rotor shaft bearings grinding or not rotating smoothly, then they should be removed and cleaned in some good solvent or cleaned with compressed air. If they still sound or feel funny, they should be replaced.

30.10.3. Tail rotor shaft bearings

The tail rotor shaft bearings may incur damage if the tail blades touch the ground, especially on the ECO 8/16. They should also be checked periodically and cleaned or replaced if necessary.

30.10.4. Tail belt tension

Tail belts tend to loosen over time especially if the tail boom mount is loose. They should be checked and retensioned periodically.

30.10.5. Battery retaining o-rings

O-rings will last longer if they are unhooked from the battery mounts when not in use. If they are left under tension continously, they will develop cracks over time. The o-rings should be checked periodically and replaced if necessary.

30.10.6. Main rotor blades

If the main rotor blades appear damaged do NOT fly with them. They can explode in flight which is very dangerous. You should replace any blades which appear damaged.

30.10.7. Ball links

Ball links (especially above the swashplate) will wear out and require replacement as they become loose.

30.10.8. Servo wear

Servos may start to jitter as they wear. This may be caused by two problems:

- Worn potentiometer. This requires the servo to be replaced or sent to the manufacturer for repair.
- Chipped gear teeth. This can be fixed by replacing the servo gear set.

30.10.9. Ball bearings

Ball bearings should be checked periodically for wear.

- Insert a shaft through the ball bearing and push on the shaft at right angles to the bearing while rotating the shaft. If the bearing does not rotate smoothly (feels "notchy"), then it should be replaced.

30.10.10. Corona specific maintenance

- If you have a boom strike, the tail boom can be straightened by pushing a 3/8" dowel through the tail boom.
- If you let the Corona come down too fast it may "bounce" off the ground and break a main gear tooth and/or trash a bearing. So, the main gear should be checked periodically for missing teeth and the main rotor shaft bearings should be checked for smoothness.
- Be sure to check HS-81s for broken gear teeth after each hard crash. They may rotate properly through the whole rotation, but they may have a broken tooth somewhere.

  I consider the HS-81 gears a "sacrificial" part...they break to prevent other things from being broken, and at $3-$5 a set they are fairly cheap.

30.10.11. Piccolo specific maintenance

- There isn't much maintenance required on a Piccolo. The stock brushed motor (the 280 or 310) should last 300 flights or more without maintenance if properly broken-in.
- If the antirotation pin breaks off the swashplate but the stub is left, then it can be fixed with a small nylon tiewrap. Cut the tip from the tie-wrap and lash it the remnants of the antirotation pin by using several loops of cotton thread. After tying, put a drop of thin CA on the thread to harden it.

30.10.12. ECO 8/16 specific maintenance

- The one-way bearing in both plastic and aluminum autorotation hubs has been known to become loose. Usually when this happens, the one-way bearing can be pushed out of the hub with firm finger pressure.

  This can be easily fixed by roughing up the bearing and autorotation hub mating surfaces with 200 grit sandpaper and using thick CA to reassemble the unit.

- The tail blade grips (67542) should be checked periodically to make sure they are not too loose. If they are, be sure to unscrew them from the tail rotor hub and apply fresh loctite to the screw before reassembling.
- The main rotor shaft bolt (67599) is rather soft and can become bent in a hard crash. Be sure to check this bolt if the main rotor blades have hit anything. If the bolt is bent, be sure to replace it and do not fly with it.
- The battery holder O-rings (67587) will need to be replaced about once a year because they will start to crack. These can be replaced with the stock Ikarus parts or you may be able to find the O-rings(30mm ID x 3mm thick) cheaper elsewhere.

30.11. Useful equations

This is a section with various bits of math which are useful for calculating various parameters of helicopters.

30.11.1. Calculating headspeed

There are three steps to calculating the headspeed:

1. Calculate the motor rpm
2. Check the motor's maximum rated RPM.
3. Calculate the gear ratio

In order to calculate the motor RPM, you need to know two things: the motor Kv constant, and the battery voltage.

The Kv constant is the no-load RPM/V, or basically the RPM of the motor at a given voltage with no load. If you multiply this value by the voltage, then the result is the motor speed at the voltage with no load.

As the helicopter takes off, the load on the motor will increase, so the motor RPM will drop by about 15%. So this unloaded RPM should be multiplied by about 0.85 to calculate the loaded motor RPM.

For example, a Hacker B50-18S has a Kv of 2006, so the no-load motor speed on 8 cells (9.6 volts) is: 2006 * 9.6 = 19257.6 RPM. Under load the motor RPM will drop to about 19257.6 * 0.85 = 16369 RPM.

The second step is to check the motor's maximum rated RPM. For the Hackers this is about 60,000 rpm, so 19257.6 RPM is well below the motor's maximum rated RPM.

The third step is to calculate the gear ratio. The ECO 8 has a 180 tooth main gear and if the motor pinion is 18 tooth, then the gear ratio will be 180:18 or 10:1.

The final headspeed will be the motor RPM multiplied by this gear ratio, multiplied by about 0.85 to simulate the loading effect of the main rotor blades.

So: 2006 (motor Kv) * 9.6 (battery voltage) * 0.85 = 16369 RPM motor speed

16369 * 18 (motor pinion) / 180 (main gear teeth) = 1636.9 RPM head speed

For a fixed pitch helicopter, you should plan to have double the hovering headspeed at full throttle so the helicopter will hover at approximately half stick.

Note

The 0.85 multiplier is the speed drop under load, which is a rough estimate. It is NOT an efficiency factor. If a motor is inefficient, it will usually consume more current rather than dropping RPM.

30.11.2. Estimating power consumption

R/C helicopters need about:

- 100 watts/kg for hovering
- 150 watts/kg for entering/exiting forward flight
- 200 watts/kg for light aerobatics (loops/rolls)
- 300+ watts/kg for serious 3D flight

(add up to 50% for higher headspeeds)

Since watts = voltage * current, we can divide the watts by voltage to estimate the amps required. For example, an ECO 8 weighs about 1.5 kg. From this, we can estimate the power at hover:

100 watts/kg * 1.5 kg = 150 watts

For a 10 cell nicad pack, this would be:

150 watts / 12 volts = about 12.5 amps

Note that the 100 watts/kg value is an average power draw during hovering. It is not safe to hover a heli with a 100 watt/kg power system, because extra power will be required to recover the heli safely if a gust of wind blows, etc. A realistic minimum power system would be about 150-200 watts/kg.

Power consumption is very dependent on motor and headspeed. For example:

- ECO 8 w/Mega 16/25/3 at 1400 rpm HS: 105 watts/kg to hover
- ECO 8 w/Mega 22/20/3 at 1600 rpm HS: 174 watts/kg to hover

Chapter 31. Glossary

Glossary

120 CCPM
: A type of CCPM using three servos arranged at equal 120 degrees from each other. The advantage of 120 CCPM is the load of the swashplate is evenly distributed across all three servos resulting in more precise control. 120 CCPM requires a special transmitter ("computer radio") which supports this mode.

90 CCPM
: A type of CCPM using three servos arranged at 90 degrees to each other (and one spot empty). On an ECO 8/16 using 90 CCPM there is a servo at the left, right, and front positions of the swashplate.

3D flying
: A maneuver which requires the constant harmonized input of three or more controls simultaneously during the maneuver.

  There is a good discussion of this at runryder.com/helicopter/t6270p1

A

Advancing blade
: The rotor blade which is moving into the wind created by helicopter motion, thus increasing its effective airspeed.

  See also Retreating blade

Aileron
: Airplane equivalent of left/right cyclic. Although a helicopter can provide cyclic movement in all directions around the mast,not just left/right roll, this can still be a useful concept for pilot orientation.

Airfoil (Aerofoil)
: The shape of a wing (or a rotor blade) which produces lift. Different airfoils may be better for different styles of flying.

Armature
: See Rotor

Angle of Attack
: The difference in angle between the direction of the chord of the rotor blades and the direction of the wind.

ARF or ARTF
: Almost Ready to Fly. A pre-built helicopter which only requires installation of electronics.

AR Pin
: Antirotation pin.

AR Arm
: Antirotation arm.

Autorotation
A controlled, unpowered helicopter descent (and landing). A helicopter is a brick with a rotor, so it doesn't glide well when unpowered. The autorotation is the closest to gliding possible. The autorotation consists of a steep descent using negative pitch to keep the rotor blades spinning followed by a slight flaring performed with positive pitch to convert the momentum of the blades into lift to soften the landing.

Autorotation Gear
Autorotation gear. A gear with a one-way bearing so the motor can only drive the main shaft in one rotational direction. Required for performing autorotations.

AR Gear
See Autorotation Gear

ATV
Adjustable Travel Volume. This is the amount of servo travel from one servo endpoint to the other. This can be reduced or increased by changing the servo endpoints. This is also used to avoid binding.

See also EPA

AUW
All Up Weight. The weight of the heli when ready to fly, including batteries.

AVCS
Angular Vector Control System. Basically Futaba's own terminology for "heading hold". Their website describes it as "an advanced version of heading hold which doesn't have the temperature related drift problems of most of the older HH gyros."

B

Backlash
The play in the mesh between two gears. Too much backlash and the gears can slip or break the teeth, too little backlash can cause excess friction, heat and wear. The common guideline is to allow the thickness of a sheet of paper between gears to achieve the correct amount of backlash.

Balance Charger
A charger which automatically equalizes the amount of charge in each cell of a multi-cell battery pack. This is particularly important for lithium-polymer battery packs to prevent cell bloating or cell ignition.

Ball Link
A connection that allow for adjusting controls using a ball on one end, and a link that "snaps" onto the ball on the other.

Ball-Link Pliers
A special plier made especially for handling ball links. It can quickly remove the ball joint from a ball link without damaging either part. One jaw has a U-shaped cut in it and the other jaw has a small cup on it to hold the ball joint.

Ball Link Pliers

Base Loaded Antenna
: A rigid short antenna used to replace the longer wire receiver antenna.

BEC
: Battery Eliminator Circuit.

On a nitro helicopter, there is a 4.8 volt "receiver pack" that powers the receiver, gyro,and servos. On an electric helicopter, we already have a very large battery which powers the main motor. However, the voltage of this main motor battery pack is typically more than 4.8 volts. So, the BEC will take the voltage of the main battery pack and regulate it down to 4.8 volts to power the receiver, gyro, and servos, This eliminates the need for a separate 4.8 volt receiver pack.

There are two types of BECs: linear BECs and switching BECs.

A linear BEC reduces the main battery voltage to about 4.8 volts by applying a resistive load and wasting the excess power as heat. This has two important implications: First, the current capacity of a linear BEC drops quickly as the input voltage rises. A typical 1 amp linear BEC can dissipate about 3 watts, so it can handle a load of 1 amp at 8 volts, but can only handle half this current, or 0.5 amps, at 11 volts. Second, a linear BEC is usually only about 50% efficient (or less) since it discards excess power as heat. If a linear BEC becomes too hot, it will thermal shutdown and you will lose control of the model.

A switching BEC functions by rapidly pulsing the main battery voltage to create an average filtered output of 4.8 volts. This method of regulating voltage is more efficient than a linear BEC, so a typical switching BEC is 80 to 90% efficient. Also, it can handle much higher input voltages than a linear BEC (up to 35 volts or more), and the current capacity does not drop at higher voltages.

Note: Most BECs are rated for 5 volts of output. The extra 0.2 volts will not harm the electronics equipment. From an electronics point of view, a 5 volt regulator is easier to build than a 4.8 volt regulator since the parts are more easily available, so most BECs output 5 volts instead.

Bell-Hiller Mixer
: The seesaw arm on the head of a CCPM helicopter which isolates the height component of the swashplate position and controls the main blade pitch.

Binding
: A bad condition where the control adjustments can not move as far as the maximum servo travel. This puts extremely high torque on the servo and as well as consuming excessive current and will eventually destroy the servo.

BL
: Brushless, usually in the context of brushless motors.

Boom Strike
: A type of helicopter crash where the main rotor blade hits the tailboom. This may dent/bend the tail boom and damage the main rotor blades. This is a frequent mistake made by beginners.

Brain Fade
: A mental lapse where the person flying the heli, suddenly forgets which way to move the controls, or which control to move at all.

Buddy Box
: Two similar transmitters that are wired together with a "trainer cord" or buddy-lead This is most useful when learning to fly, it is the same as having dual controls. The instructor can take over control at any time by using the "trainer switch" on his transmitter.

C

C-rate (1C, 2C, etc. charging & discharging rate)
: This refers to a charging or discharging rate in terms of the capacity of the battery pack. For example, a 2C rate for a 2400 maH battery pack would be 4800 ma or 4.8 amperes. A 1/10 C rate for a 2400 maH battery pack would be 240 milliamperes.

CA Glue
: Cyanoacrylate A form of glue, commonly called "super glue" often used in model building. You should treat with extreme caution: always have debonding agent close by, in case your components or parts of your body become bonded in an unanticipated way. Avoid breathing the fumes, as they are toxic.

Collective Pitch Compensator
: The assembly with two seesaw arms directly above the swashplate

CCPM
: Cyclic/Collective Pitch Mixing. A type of control system where the swashplate controls both main blade pitch and flybar pitch. The swashplate relative tilt controls the pitch of the flybar as the main rotor rotates, and the absolute height of the swashplate controls the pitch of the main rotor blades.

: See also Mechanical Mixing

: See also Electronic Mixing

Chicken dance
: When a helicopter crashes and flails wildly on the ground due to the main rotor still spinning.

Cyclic/Collective Pitch Interaction
: A problem on CCPM control systems when cyclic input causes an unintended collective pitch change, or vice versa.

: See also CCPM

Carbon Fiber
: A carbon composite material usually used for rotor blades, helicopter frames, tail booms, and other areas where high strength and light weight are required.

CG, CofG, Center of Gravity
: The point at which an object's center of mass appears to be; its balance point

Channels
: A measure of the number of separate signals that can be handled by a Tx and/or Rx. This usually refers to the number of separate control surfaces or servos/speed controllers a Tx can control, so typically a simple helicopter will need at least four channels.

Cogging
: A *bumpy* effect noticed as the shaft of a iron core rotor (non-coreless) motor is rotated. This is due to internal magnets are attracted to the iron core of the motor windings.

Coning Angle
: Some helicopters like the FP Piccolo are designed so the rotor blades are flexible and will bend upwards in flight. The amount which the blade bends upwards is called the coning angle. The coning effect is good for beginner helicopters because it makes hovering more stable, but is bad for forward flight because it makes the helicopter pitch up which makes forward flight difficult.

CP
: Collective Pitch. A helicopter that adjust vertical lift by changing the pitch of the main rotor blades.

D

Disc Loading
: The weight of the helicopter divided by the rotor disc size

  Similar to the "wing loading" figure for airplanes. "High disc loading" means the helicopter is heavy for its rotor size, or conversely, the main rotor blades are short for its weight.

Dissymmetry of Lift
: The advancing side of the rotor disk moves faster than the retreating side and thus produces more lift. This causes the helicopter to bank in forward flight. This is usually dampened by flapping or seesawing blades.

  For further information see Section 30.1.6.1, “Dissymmetry of lift”

Drag
: The friction experienced by a object moving through the air.

Dual Rates
: A feature of some Tx models which allows you to flip a switch to make the controls more or less sensitive. Usually set as some % of the normal rate.

Dual Conversion
: A type of receiver which converts the incoming frequency through two intermediate stages. This type of receiver rejects interference better than single-conversion receivers, but with a size and weight penalty. This type of receiver uses a different crystal than single-conversion receivers.

E

eCCPM
: See CCPM

See Electronic Mixing

eHeli
: Electric Helicopter - hard to figure out, isn't it?

Electronic Mixing
: A control system where the radio transmitter controls the mixing between the roll/pitch servos and the main rotor pitch servo. Also called colloquially eCCPM.

  See also CCPM

  See also eCCPM

EPA
: EndPoint Adjustment. This is the same as ATV.

  See ATV

Elevator
: Airplane equivalent of fore/aft cyclic The elevator is what pitches a plane forward or back, to dive or climb.

ESC
: Electronic Speed Control. Basically, the motor controller for brushed and brushless motors.

  There are two basic types of ESCs: brushed motor ESCs and brushless motor ESCs.

  A brushed motor ESC is basically a switching voltage regulator connected to the motor. It outputs a variable voltage which is proportionally relative to the throttle value. A brushless motor ESC is basically a three-phase AC motor controller. It electrically commutates the three phases of a brushless motor at a frequency proportional to the throttle value.

ESD
: Electrostatic Discharge. This usually refers to the static electricity which builds up on the tail belt, most often on Logo 10s. Some people have reported "ball lighting" shooting away from Logo 10s on humid days.

Exponential
: A programmable nonlinear response curve associated with a particular transmitter control. This allows either less or more sensitivity near the center of a transmitter joystick. Often useful for beginners to allow better control of helicopter movement.

F

Failsafe
: A default setting for a receiver channel to be used when the transmitter signal is lost, usually associated with PCM receivers. This is useful for airplanes to allow the model to glide when the signal is lost, but is less useful for helicopters.

Feathering
: The rolling motion of a rotor blade along its long axis which changes its angle of attack.

Feathering Shaft
: The shaft which allows the blade grips to pivot to change the angle of attack (feather). A flapping head has two feathering shafts (one for each blade) and a see-saw head has one feathering shaft (running through the head)

Flybar
: The metal or CF rod which holds the smaller paddles to the main rotor head

Flybar Paddles
: The smaller blades (not the main rotor blades) on the main rotor of a helicopter.

FF or FFF
: Forward Flight or Fast Forward Flight

FP
: Fixed Pitch. Usually refers to a helicopter which has rotor blades at a fixed pitch, and climbs and descends by changing the speed of the main rotor blades. This type of helicopter is more durable and easier to maintain but have some disadvantages such as more sluggish altitude changes and the inability to perform autorotations.

Flapping
: A type of rotor head. (See Section 30.1.5, “The rotorhead” of Section 30.1, “How helicopters work”)

Flare
: Mostly used when talking about airplanes and landing. The end of an autorotation maneuver which eliminates the forward motion of the helicopter.

G

Gain
: Gyro sensitivity to motion.

  See also Section 30.1.7, “How gyros work”

Gasser
: The slang term which describes a R/C heli that has a motor which runs on gasoline.

GE
: Ground Effect. When a helicopter is hovering at less than approximately one rotor length above the ground, the heli will become a little more skittish, as though it is trying to balance on a ball. This is the ground effect. Near the ground your blades produce more lift, but also more turbulence.

GF
: Glass fiber (fiberglass) usually in the context of rotor blades.

Glitch
: Momentary uncontrolled operation of control servos or motor speed caused by electronic interference or equipment malfunction. Rearrangement of the electronic components and/or re-routing of wires can often cure this.

Governor, Govenor Mode
: A feature of an ESC, for an explanation see Section 30.1.10.3, “Governor mode”

Ground Resonance
: The phenomena that can make a helicopter almost shake itself to bits on the ground, even when it is perfectly balanced in the air. This is more common in seesaw type heads which aren't as dampened as flapping heads, and is also more common on pavement or hard surfaces which don't absorb vibrations.

GRP

Glass Reinforced Plastic. A type of plastic material often used in helicopter chassis.

Gyro
A device used to help stabilize the yaw of a helicopter by adjusting the tail rotor pitch.

Mechanical gyros use a real spinning disk inside a small enclosure measure the yaw due to the torque of the main rotor blades. Solid-state gyros achieve the same measurement without using moving parts, but can still be easily damaged by impact.

Gyroscopic Precession
A tendency of a rotating body to translate an external force into a a new force occuring 90 degrees later in its rotation.

H

Heading Hold Gyro
A gyro which attempts to "lock" the heading of the gyro and keep the helicopter pointed in the same direction until you choose to turn it via the rudder.

See also Yaw-Rate Gyro

HH
Heading Hold (gyro)

HS Head Speed
The RPM of the main rotor. Most nonmicro helicopters need between 1200-2000 RPM of headspeed to fly. If the headspeed is too low, then the heli will not lift off or will require extra pitch to fly, which will make the heli very unstable. For aerobatics, most people raise their headspeed to about 1800-2000 RPM. Most helicopter rotor hubs are only rated for a maximum of 2000 RPM. If you exceed 2000 RPM, this places excessive stress on the main rotor hub and the heli is likely to throw a blade.

Hunting
See Wag

I

Idle-up Mode
A transmitter mode which has a different throttle and pitch curve than the regular mode. For electric helicopters, we normally use the "normal" mode to arm the ESC and spool up the helicopter, and use an idle-up mode with a flat throttle setting for regular flying.

Some transmitters have multiple idle-up modes. For example, the Futaba 9C has idle-up1, idle-up2, and idle-up3 modes. The additional idle-up modes can be programmed for a low headspeed for duration flight, high headspeed with full negative pitch range for aerobatics, etc.

This feature can be used to lock the throttle to a specified value so the throttle stick only controls the collective pitch, which is required for inverted flight.

Io
The no-load current rating for a motor. This is the electrical current used by the motor when the motor is running at full speed with no mechanical load on the rotor.

J

Jesus Bolt
The bolt which holds the rotor head onto the main rotor shaft.

K

Kv
The no-load RPM per volt of the motor. For example, if a motor is rated at Kv = 3000 and is being run on a 10 cell (12 volt) battery, then the motor will spin at 36,000 rpm. The head-speed can then be calculated by calculating the gear reduction ratio of the pinion/main gear combination. This is very important because a helicopter only flies well in a certain range of headspeed.

L

Lead/Lag bolt
The bolt which allows the main rotor blades to swing horizontally so it can either lead (swing ahead) or lag (swing behind) the main rotor head.

LHS
Local Hobby Shop

Loctite
A threadlocking adhesive used to ensure screws do not unscrew themselves. Technically, it is an anaerobic adhesive.

Loctite 242 (blue) is removable and used for screws which may require removal later to repair crash damage.

Loctite 262 (red) is permanent and used for screws which will never require removal. If you wish to disassemble parts which have been loctited, then you should weaken the adhesive first by heating the metal parts to about 212F/100C. This can be easily done by touching the metal parts with a hot soldering iron or a hair dryer.

LVC
The low-voltage cutoff point of the ESC, if it has one. For a heli, you want an ESC with no or very low LVC

When the battery voltage drops down to the low-voltage cutoff point, the ESC will either stop or throttle down the main motor, which is undesirable for a helicopter. For a heli, you want an ESC with no or very low LVC.

M

mCCPM
See also Mechanical Mixing

Mechanical Mixing
A type of control system where the roll/pitch and main blade pitch are not mixed at the transmitter but are instead mixed mechanically at the helicopter. JR transmitter manuals refer to this as mCCPM.

See also CCPM

Micro Helicopter
This is a rather subjective term, but in this guide it refers to any helicopter under 800

grams AUW. This includes the Ikarus Piccolos, MS Hornets, Century Hummingbird, Feda, GWS Dragonfly, MIA Housefly, Wes-Technik Helistar LH35, etc.

N

Nose-In
: Hovering or maneuvering with the nose of the helicopter pointed at the pilot. This is a advanced step in the learning stages of flying a helicopter because both roll and pitch controls are reversed relative to the pilot.

O

Outrunner motor
: A motor where the outside of the can rotates. This is also called "rotating can" or "external rotor" by some distributors.

P

Paddles
: These are the shorter stubby blades on the end of the two rods opposite the rotor blades. These aid in pitching the main rotor blades for quicker responses and less servo stress.

PCM
: Acronym for Pulse Code Modulation A generic term for digitally encoded data.

PPM
: Acronym for Pulse Position Modulation. Same as FM. An analog form of encoding data.

Pirouette
: A spinning maneuver where the helicopter yaws around the main mast one or more times.

Pitch Curve
: A transmitter feature which allows adjustment of the translation from throttle stick position to the collective pitch position so the mapping is not linear. Most transmitters have a three-point or five-point pitch curve which allows you to set the collective pitch at the 0%, 50%, 100% or 0%, 25%, 50%, 75% and 100% stick positions. When the throttle stick position is between two points, the transmitter will linearly interpolate between the two nearest pitch curve points.

  See also Throttle Curve

Pitch Meter (or Gauge)
: A measuring device used to check the varying pitch settings of your rotor blades and paddles. You need the pitch of the corresponding blades to be very close or they will not track evenly.

Pod-and-Boom
: A style of helicopter model that derives its name from the appearance of its short fuselage and tail-support boom. This is the usual style for most R/C helicopters, since it is easier to fly and maintain than one with a scale fuselage.

Pusher tail rotor
: A tail rotor that pushes air away from the tail boom. Most helicopters including the Corona, ECO 8, Logo 10 use a pusher tail rotor.

See also Tractor tail rotor

R

Retreating blade
: The rotor blade which is moving with the wind created by helicopter motion, thus decreasing its effective airspeed.

  See also Advancing blade

Retreating blade stall
: A situation in forward flight where the effective airspeed of the retreating blade approaches zero. This can result in loss of helicopter control.

Revo mix/Revo mixing
: A mixer which adds a percentage of the main rotor throttle to the tail rotor throttle to prevent the heli from spinning. This is only used with yaw rate (non-heading hold) gyros because the yaw rate gyro only dampens tail movement and cannot maintain the direction of the tail. If using a heading hold gyro, this option should be DISABLED on the transmitter

RFI
: Radio Frequency Interference. RFI causes little "glitches" in your control and the heli will twitch abruptly in one direction or another and/or the tail may suddenly jerk around.

Rotor
: The rotating part of a motor. For a brushed motor, this includes the motor windings; for a brushless motor, this includes the magnets.

  See also Stator

Rudder
: On an airplane, the vertically hinged plate which controls the course of the airplane. This is equivalent to a helicopter's tail rotor.

Rudder Offset
: A transmitter function that lets you specify an additional amount of rudder trim for idle-up modes which usually have a higher RPM or different blade pitch curve and thus different amounts of torque compensation. This function should be inhibited if using a heading hold gyro.

Rx
: Abbreviation for receiver. The portion of the radio system that is mounted in the helicopter and adjusts the servos and speed controller(s) according to the signals from the Tx.

  See also Tx

S

See-Saw Head
: A form of rotor head where the two rotor blades are "connected" through a feathering shaft so that when one pitches up the other pitches down. This makes for a more stable helicopter an a simpler design, but does not handle as well as a flapping head type.

Settling with Power
: A dangerous condition when descending during a hover where the helicopter's rotor blades descend into their own downwash. This can cause a crash if not handled properly.

Model helicopters have a better power-to-weight ratio than full-size helicopters, so this is usually not a huge problem, however, it does occur.

Slop
: The amount of "free play" in a control system. A common example of this is a door knob. If you gently twist the doorknob back and forth, you can feel a few degrees of looseness before the internal mechanism engages. These few degrees of looseness is the sloppiness or "slop" in the mechanism. Slop can make the helicopter more unpredictable and less responsive to control input.

Stabilizers
: Small plates affixed to a helicopter's tail to force the tail to weathervane and improve forward flight characteristics. Helicopters usually have a vertical stabilizer (to prevent the tail rotor from touching the ground) and may have a horizontal stabilizer. Aerobatic models will often have stabilizers with cutouts to reduce the weathervaning effect.

Static tail rotor compensation
: Multiplex's term for revo mix.

See also Revo mix/Revo mixing

Stator
: The stationary part of a motor. For a brushed motor, this includes the magnets; for a brushles motor, this includes the motor windings.

See also Rotor

Swashplate
: The control mechanism component which mechanically joins the non-rotating control portions to the rotating control portions of the main rotor.

Switchless inverted
: An inverted helicopter flying technique (mostly pioneered by Mike Mas) where inverted flying is done without using a transmitter switch to invert the flight controls. Modern 3D helicopter aerobatics are based on the switchless inverted style of flight.

Most modern helicopter transmitters do not have an invert switch. However, some older transmitter still sold today such as the JR XP8103 and the Futaba 9Z WCII have an invert switch.

Sub-trim
: An auxiliary trim adjustment on many transmitter models which allows trim of controls with the joystick trim centered. This allows full trim adjustment while flying.

T

Threadlock
: See Loctite

Throttle Curve
: A transmitter feature which allows adjustment of the translation from throttle stick position to the throttle channel output so it is not linear. Most transmitters have a three-point or five-point throttle curve which allows you to set the channel values at the 0%, 50%, 100% or 0%, 25%, 50%, 75% and 100% stick positions. When the throttle stick position is between two points, the transmitter will linearly interpolate between the two nearest throttle curve points.

See also Pitch Curve

Throttle Hold (switch)
A switch used to force a zero throttle setting regardless of the throttle stick position or idle-up switch position. This is useful as a safety feature when connecting or disconnecting the battery and also to quickly kill the motor when a helicopter crash is imminent.

Throw a Blade
A slang term describing a main rotor blade detaching from the rotor head and being flung at high speed. This is very, very dangerous.

TL Translational Lift
The extra lift produced by the main rotor when a helicopter is moving horizontally or when hovering in windy conditions. When a helicopter stops moving horizontally it tends to drop, because it loses the extra lift.

TR
Tail rotor

Tractor tail rotor
A tail rotor that pulls air towards the tail boom. The Hummingbird Elite series uses a tractor tail rotor.

See also Pusher tail rotor

Trickle Charge
A continuous charge rate of C/20. This is a safe level for continuous charging of NiCd cells. Cells of other types, such as NiMH and Lipo should NOT be trickle charged.

Tracking
The path of a rotor blade as it spins. See also Section 13.6.1, “Blade tracking - CP helicopters”

Training Gear
A landing gear with a wider stance so the likelihood of tipping the helicopter on takeoff or landing is reduced. Often used by beginners while learning to hover and they typically are made of two crossing sticks with whiffle balls on the ends.

Transitional Lift
A corrupted form of translational lift.

See TL Translational Lift

Tx
Abbreviation for Transmitter

See also Rx

W

Washout
For a rotor blade, this references the area of the rotor blade where the leading edge has less pitch than the trailing edge. Also, the collective pitch compensator is sometimes referenced as a "washout unit".

See also Collective Pitch Compensator

Weathervane
The tendency of the helicopter to point into the wind like a windsock. The amount of

weathervaining is determined by the aerodynamic properties of the helicopter, primarily the size of the vertical stabilizer.

Wag
: A rhythmic back-and-forth tail movement that will not stop. This may occur with heading hold gyros when the setup is not correct. In this case, the gyro overshoots the correct tail position, so it constantly keeps moving the tail.

Woodies
: Wooden main rotor blades

Y

Yaw-Rate Gyro
: A type of gyro which dampens but not eliminates unwanted yaw rotation. If a gust of wind blows the tail of a helicopter with a yaw-rate gyro, the gyro will make the tail rotor 'push back' against the wind to reduce the amount of unwanted tail movement, but since it does not accumulate of total tail movement, it cannot return the tail back to its original position.

See also Heading Hold Gyro

Z

Z-Bend
: A Z-shaped bend in the wire of a pushrod which is commonly used on airplanes to absorb the impact of crashing. These should not be used in model helicopters because it will create slop in the control system.