Dragonfly Pro

Tandem Rotor R/C Electric Helicopter

Assembly/Flight Manual

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1.0. Introduction

The Dragonfly project began in the spring of 2002. Our goal was to create a micro electric tandem rotor R/C helicopter. We decided to use proven "Off the shelf" rotor and drive components to make the project affordable. Our research found that the MS (Hornet) helicopter was the perfect choice. The CP rotor heads perform well and the parts are widely available. We based the motors and gear drive components on Hornet parts as well. A belt and pulley system was chosen to couple the front and rear rotor shafts and a centrally located roller was added to allow a 180 degree twist in the drive belt to provide counter rotating rotors. The KISS principle was our guide and overseer for all of the design decisions. Only the best ideas and design concepts floated to the top. The design needed to be light but strong, simple to construct, and easy to maintain and repair.

Several months into the project, we realized there wasn't a viable way to control the model. Even the most advanced radios could not perform the mixing functions needed. Mechanical solutions would be heavy and too complex. We started with a clean slate and drafted a set of requirements for this new control system which is based on the flight control laws of full scale tandem helicopters, and named it the TH-1. We then began the TH-1 development in "tandem" with the Dragonfly. Test flight after test flight the improvements and breakthroughs came and every minute of it was fun. We enjoyed the need to test fly the helicopter to gather data or test/verify something new.

The Dragonfly Pro tandem helicopter released in 2004 is the next step in the evolution. It has a new main frame design to operate with the new driveshaft created and manufactured by Walt Ferar. The driveshaft allows the Dragonfly Pro to use much more powerful motor and battery combinations for enhanced flight performance.

Micro electric tandem helicopters are here to stay. It can only get better. Hang on....

1.1. Specifications

Body length	21 inches
Main rotor length (combined)	35.5 inches
Distance between rotor shafts	16 inches
Weight RTF without battery	474 grams (16.7 ounces)
Servos required	6
Control system	TH-1
Radio	Helicopter 6 channel
Gyros	2 (yaw and pitch)
ESC	12 amp motor, 1 amp BEC
Motor	Twin Speed 300
Battery	10 cell NiMH or 3s Li-Poly

1.2. Kit Contents

See the "Parts list" section for a complete list of each part and photos.

1.3. Rotor and drive parts needed (not in this kit)

The following parts are not included in this kit and are needed to complete the assembly of the Dragonfly Pro. These parts can be purchased from your Dragonfly Pro dealer.

MS Hornet parts (qty)

- (2) MS-CP Collective upgrade kit
- (1) MS-E230 Main gear and one-way kit
- (1) MS-E067 3mm shaft collar or equivalent
- (2) MS-E018 10 tooth pinion gear or equivalent
- (2) MS-E010 Speed 300 motor or equivalent

Dragonfly Pro parts (qty)

- (1) D203 SS one-way sleeve (Note: This part is only needed if the MS-230 is used)

1.4. Information sources and upgrade parts

1. **Information sources**

   a) Your dealer
   b) Our web site www.tech-mp.com
   c) Internet bulletin boards
      - www.rcgroups.com
      - www.runryder.com
      - www.hornet-heli.com (Non Hornet section)

2. **Upgrade parts**

   We recommend adding a swashplate ball mod to both stock Hornet swashplates.
   This will improve the handling characteristics of the model.
   This upgrade can be purchased from your dealer or from www.rigoleth.ch.

3. **Swashplate epoxy upgrade** - The stock Hornet swashplates must be disassembled and the upper and lower sections epoxied with "JB WELD" epoxy to the swashplate bearing. All surfaces must be cleaned to remove all grease and oil and the surfaces roughed up with sandpaper for best adhesion. **WARNING: Failure to perform this upgrade will likely result in the loss of control of the model, possible injury and a crash.**

2.0. Assembly

The Dragonfly Pro tandem rotor helicopter is not a toy and must be assembled correctly to operate properly and safely. Failure to assemble the model as stated in the instructions may compromise safety. When in doubt, seek help. See section 1.4 for information sources.

Read each section completely and study the applicable figures before performing the assembly.

2.1. Main body section

Tools/Materials Required: #1 Phillips head screwdriver
1.5mm Allen wrench
Needle nose pliers
30 minute epoxy
Medium thread locking compound

Parts Required:
D100p Main body assembly
D101 Main lower body assembly
D102p Front bearing block
D103p Rear bearing block
D902 (4) 3x6 flanged bearings
D800 Driveshaft
D802 (2) Horizontal gear
D804 (2) Gear retainer clip
D805 (2) Driveshaft bearing 5x10 flanged
D604p Front rotor hardware - (1) M2x6 PPH screw
D706p Rear rotor hardware - (1) M2x6 PPH screw
D106 Main body hardware - (6) M2 washer, (4) M2x6 SH screw, (2) M2x10 SH screw, (6) M2 nuts

Overview: The main body section assembly involves installing the driveshaft into the main body assembly, attaching the lower body section, and epoxying the main shaft bearings into the front and rear bearing blocks.

1. **Driveshaft and bearings -** Press a 5x10 bearing (D805) into the outside of the front Delrin frame block. Secure the bearing with a M2x6 PPH screw. Tighten the screw gently. Slide the driveshaft (D800) through the frame from the rear into the front bearing all the way. Press the second 5x10 bearing into the outside of the rear Delrin frame block. Secure the bearing with a M2x6 PPH screw. Tighten the screw gently. See Figure 2.1a.

2. **Horizontal gears -** Slip the horizontal gears (D802) onto the driveshaft with the teeth facing out. Secure each gear to the driveshaft using a gear retainer clip (D804). Center the driveshaft within the frame such that there is equal play between the driveshaft's shoulders and the front and rear bearings. See Figure 2.1b.

3. **Main and lower body sections -** Join the main and lower body sections such that the lower section (D101) mates with the front sides of the main body section bulkheads. Secure the four outer bulkheads with (4) M2x6 SH screws and M2 nuts. The threads should face the front of the model, use a washer under each screw head, use thread locker and tighten the M2 nuts. Secure the two inner bulkheads with (2) M2x10 SH screws the same way. Be sure the two sections are mated completely and without any twisting. Use thread locker and tighten the M2 nuts. See Figure 2.1c

4. **Front and rear bearings** - Use a solvent (Acetone, Alcohol, etc) to clean around the bearing mounting holes for each bearing block. Carefully clean just the flange area for each of the (4) 3x6 flanged bearings (D902). It helps to hold the bearing with a pencil tip while cleaning it. Mix a small batch of 30 minute (or longer) epoxy and apply a small amount, with a pin, only to the underside of the bearing flange. Insert the bearing completely into a bearing block hole. Be sure the bearing flange sits flat on the surface of the bearing block. Repeat for all four bearings. Put the assemblies aside and allow the epoxy to cure. See Figure 2.1d.

2.2. Bearing blocks and shafts

Tools/Materials Required: Needle nose pliers

Parts Required:

D601 Front rotor shaft
D701 Rear rotor shaft
D905 (2) Nylon shaft spacer
D906 (2) Brass shaft spacer
D903 (2) Main rotor shaft retainer pin
D801 (2) 3mm sleeve
D803 (2) Vertical gear
D804 (2) Gear retainer clip

Overview: The rotor shafts and vertical drive gears are mounted to the bearing blocks.

1. **Mount sleeves to gears -** Slide the vertical gears (D803) onto the 3mm sleeve (D801) so that the 1mm holes line-up and the long side of the sleeve exits the tooth side of the gear.

2. **Mount front rotor shaft -** Slide the front rotor shaft just through the top bearing on the front bearing block. Slip the vertical gear with sleeve onto the rotor shaft such that the gear teeth are facing down towards the bottom bearing. Continue sliding the rotor shaft through the bottom bearing. Secure the gear to the rotor shaft using a gear retainer clip (D804).

    - Slide the brass shaft spacer (D906) followed by the thin Nylon shaft spacer (D905) onto the bottom of the front rotor shaft. Install the shaft retainer pin (D903). Check that the brass spacer rides against the inner race of the bottom bearing when the shaft is all the way up. A small amount of space should be between the 3mm sleeve and the top bearing. If not, then use the thicker Nylon spacer (D905). See Figure 2.2a.

3. **Mount rear rotor shaft -** Repeat step 2 for the rear rotor shaft. See Figure 2.2a.

2.3. Bearing blocks and motor mount

Tools/Materials Required: #1 Phillips head screwdriver
tweezers
hobby knife
Thin CA
Medium thread locking compound

Parts Required: D604p Front rotor hardware - (4) M2x6 PPH screw, (1) M2x4 PPH screw
D706p Rear rotor hardware - (5) M2x6 PPH screw, (2) M2x4 PPH screw
D704 Motor mounting plate

Overview: The front and rear bearing blocks are mounted to the main frame and the driveshaft gear mesh is adjusted. The rear rotor shaft support struts add rigidity to the rear rotor support assembly. It is important that the position of the rear bearing block is finalized at this point. Once the struts are installed, the gear mesh can then only be adjusted by moving the front bearing block.

The front and rear rotors must be set to a 90-degree phase angle relative to each other (perpendicular). This is required to prevent the rotor blades from colliding. This should be checked before each flight.

1. **Mount rear bearing block -** Verify that the driveshaft is centered within the frame such that there is equal play between the driveshaft's shoulders and the front and rear driveshaft bearings. Position the rear bearing block onto the main frame such that the slots are just past the screw holes (farthest outward). Loosely install the (2) M2x6 PPH screws into the top of the rear bearing block and (2) M2x6 PPH screws into the bottom rear slots.

2. **Rear gear mesh** - Adjust the gear mesh by moving the bearing block inward gently until it stops (full gear mesh achieved) then slowly back it out while rotating the rotor shaft. Be sure not to upset the centered position of the driveshaft. The goal is to get the gears to mesh as much as possible while running smooth. Tighten the bearing block screws when you are satisfied with the gear mesh.

3. **Motor Mount -** Attach the dual speed 300 motor mounting plate (D704) to the rear bearing block with (1) M2x6 PPH screw in the slotted hole and (2) M2x4 PPH screws. Use thread locker for the M2x4 screws and tighten. See Figure 2.3a.

4. **Mount front bearing block -** Position the front bearing block onto the main frame such that the slots are just past the screw holes (farthest outward). Loosely install (2) M2x6 PPH screws into the top of the front bearing block and (2) M2x6 PPH screws and (1) M2x4 PPH screw into the bottom. The M2x4 screw belongs in front under the driveshaft bearing. The driveshaft should spin freely at this point with the gears disengaged.

Setting the 90 degree phase angle - Rotate the front shaft so that the rotor head mounting holes (1mm) are 90 degrees out of phase (perpendicular) with those on the rear rotor. Now slide the front bearing block towards the rear so the gears engage. The goal is to get the gears to mesh as much as possible while running smooth. Tighten the bearing block screws when you are satisfied with the gear mesh.

2.4. Servo mounting tray and shaft supports

Tools/Materials Required: #1 Phillips head screwdriver
Thin CA
30 minute epoxy
Medium thread locking compound

Parts Required:
D901 (2) Servo mounting tray assembly
D902 (2) 3x6 flanged bearings
D602 Front rotor shaft support tube
D702 Rear rotor shaft support tube
D703 (2) Rear rotor support strut w/Nylon wrapping, (2) M2x2 PPH
D604p Front rotor hardware - (2) M2x4 PPH screw
D706p Rear rotor hardware - (2) M2x4 PPH screw
D501 Canopy mounting pin w/M2x4 PPH screw
MS-E067 3mm collar

Overview: The canopy mounting pin is installed first since it would be more difficult later. The front and rear servo mounting trays attach to the main body section on top of the bearing blocks with two screws. The shaft supports are glued with thin CA to the servo trays and the top bearings are epoxied into place. The shaft collars are temporarily installed to keep the rotor shafts in place. Finally, the support struts are screwed into the rear rotor shaft support tube (D702) and secured to the main frame with nylon wrapping thread soaked with thin CA.

1. **Canopy mounting pin** - Attach the canopy mounting pin (D501) to the top front side, of the front bearing block, with the M2x4 PPH screw. Use thread locker and tighten.

2. **Front servo mounting tray** - Remove the 3mm collar (MS-E067). Position a servo mounting tray assembly onto the front bearing block such that the mounting holes line up and the shaft hole is aligned with the center of the bearing. Add the (2) M2x4 PPH screws. Be sure the tray is sitting completely flat on the bearing block. Use thread locker and tighten.

    - Use a solvent (Acetone, Alcohol, etc) to clean both ends of the front rotor shaft support tube (D602). Insert the support tube into the servo tray (D901) (the tray hole may need to be lightly sanded for proper fit). Be sure the tube is all the way down onto the tube support plates. Align the tube so that it is centered around the rotor shaft. Glue the front rotor shaft support tube using thin CA. Be sure to apply the glue to all of the joints.

    - While the CA is curing, carefully clean just the flange area of the 3x6 flanged bearing (D902). It helps to hold the bearing with a pencil tip while cleaning it. Mix a small batch of 30 minute (or longer) epoxy and apply a small amount, with a pin, only to the underside of the bearing flange. Slip the bearing onto the rotor shaft and insert the bearing completely into the support tube.

    - Be sure the bearing flange sits flat on the surface of the tube and the shaft is all the way up with the brass spacer riding against the inner race of the bottom bearing . Install the 3mm collar (MS-E067) on the shaft so that it sits on top of the bearing with the reduced side down. Gently tighten. The collar will be removed in a later assembly step. Allow the epoxy to cure. See Figure 2.4a

3. **Rear servo mounting tray** - Remove the 3mm collar (MS-E067). Position the other servo mounting tray assembly onto the rear bearing block such that the mounting holes line up and the shaft hole is aligned with the center of the bearing. Add the (2) M2x4 PPH screws. Be sure the tray is sitting completely flat on the bearing block. Use thread locker and tighten.

    - Use a solvent (Acetone, Alcohol, etc) to clean both ends of the rear rotor shaft support tube (D702). This tube has two threaded holes for the strut supports. The holes must be towards the top of the tube and aligned such that they are perpendicular to the main body section. Insert the support tube into the servo tray (D901) (the tray hole may need to be lightly sanded for proper fit). Be sure the tube is all the way down onto the tube support plates and the strut holes are aligned. Align the tube so that it is centered around the rotor shaft. Glue the rear rotor shaft support tube using thin CA. Be sure to apply the glue to all of the joints.

    - While the CA is curing, carefully clean just the flange area of the 3x6 flanged bearing (D902). It helps to hold the bearing with a pencil while cleaning it. Mix a small batch of 30 minute (or longer) epoxy and apply a small amount, with a pin, only to the underside of the bearing flange. Slip the bearing onto the rotor shaft and insert the bearing completely into the support tube.

    - Be sure the bearing flange sits flat on the surface of the tube and the shaft is all the way up with the brass spacer riding against the inner race of the bottom bearing . Install the 3mm collar (MS-E067) on the shaft so that it sits on top of the bearing with the reduced side down. Gently tighten. The collar will be removed in a later assembly step. Allow the epoxy to cure. See Figure 2.4b.

4. **Rear rotor shaft support struts** - Attach each strut (D703) to the rear rotor shaft support tube (D702) with the (2) M2x2 PPH screws. Be sure they are resting against the outer notches in the rearmost bulkhead. Use thread locker and tighten. See Figure 2.4c.

    - Apply several wraps of the Nylon wrapping thread around each strut and the bulkhead notches. Soak with thin CA after each wrap. See Figure 2.4d.

    - Apply several wraps of the Nylon wrapping thread in a figure eight pattern around the each strut and the main frame 3mm carbon rods. Soak with thin CA after each wrap. See Figure 2.4d.

2.5. Landing gear

Tools/Materials Required: 1.5mm Allen wrench
Needle nose pliers
Hobby knife
Thin CA
30 minute epoxy
Medium thread locking compound

Parts Required: D300 (2) Landing gear skid
D301 (2) Landing gear skid tip
D302 (4) Landing gear leg
D304 (4) Landing gear leg mounting tab
D305 Silicone rubber skid grip
D105 (4) 4" Tywrap
D106 Main body hardware - (2) M2 nuts

Overview: The landing gear consists of two main assemblies, a left and a right. They are attached to the main body frame with two screws and four Tywraps.

1. **Landing gear assemblies** - Mix a batch of 30 minute (or longer) epoxy and apply to both ends of a landing gear leg (D302). Insert the leg into a landing gear leg mounting tab (D304) all of the way in. Insert the other end of the leg into the landing gear skid (D300) all of the way in. Remove any excess epoxy.

    - Repeat for the other three legs.

    - Put the assemblies aside while the epoxy cures. Be sure the legs are perpendicular to the skid top surface and that the mounting tabs are oriented properly. Also, check that the distance from the mounting tab hole to the top of the skid is the same for each leg. Adjust if necessary. See Figure 2.5a.

2. **Attaching the landing gear to the body** - Slide the right landing gear assembly onto the M2x10 SHS against the nut. Slide the left landing gear assembly on next. Secure with a M2 nut. Use thread locker and tighten. Be sure the legs are resting against the 3mm carbon rods of the main lower body assembly (D101). See Figure 2.5b.

    - Attach the legs to the main lower body assembly with a Tywrap. Be sure the Tywraps are positioned as shown in Figure 2.5c.

3. **Completing the landing gear** - Insert the landing gear skid tips (D301) into the end of each skid. Adjust the tip such that the point is at the top of the skid. Secure with a small drop of CA. See Figure 2.5d.

    - Cut four equal lengths about 0.20 long from the rubber skid grip material (D305). Slide each piece onto the front and rear of each skid. The grip should rest against the leg attachment tubes. See Figure 2.5d.

2.6. Front rotor assembly

Tools/Materials Required: 1.5mm Allen wrench
Needle nose pliers
Small flat blade screwdriver
Thin CA
30 minute epoxy
Medium thread locking compound

Parts Required: MS-CP kit

Overview: The Dragonfly Pro uses the "MS Hornet" rotor system for both the front and rear rotors. The front rotor head is built exactly as if used on a Hornet. Follow the assembly instructions that came with the MS-CP kit for the details on how do build the front rotor head. **The stock Hornet swashplate requires the upper and lower sections to be epoxied to the bearing. See section 1.4.3**. Also, we recommend adding a swashplate ball upgrade. See the Upgrades section 1.4.

1. **Anti-rotation arm and pin** - Remove the collar (MS-E067) and put aside for now. Rough up the inner surface of the mounting hole in the AR arm (MS-E008). Glue into place on the front support tube (D602) using thin CA. Next, glue the AR pin (MS-E009). Allow the CA to cure. Mix a small batch of 30 minute (or longer) epoxy and apply to the underside of the AR arm and the front support tube forming a fillet. Remove any excess epoxy.

2. **Front shaft collar** - Install the 3mm collar (MS-E067) on the shaft so that it sits on top of the bearing with the reduced side down. Be sure the shaft is up as far as it will go. Do not compress the Nylon shaft spacer. Use thread locker and tighten. See Figure 2.6a.

3. **Front rotor head** - Install the swashplate and front rotor head parts except for the rotor blades. Use the instructions that came with the MS-CP kit as a guide. The servos and links will be added in a later step.

2.7. Rear rotor assembly

Tools/Materials Required: 1.5mm Allen wrench
Needle nose pliers
Small flat blade screwdriver
Thin CA
30 minute epoxy
Medium thread locking compound

Parts Required: MS-CP kit

Overview: The Dragonfly Pro uses the "MS Hornet" rotor system for both the front and rear rotors. The rear rotor head is built a little different than the front rotor since it rotates counter-clockwise (CCW) instead. Follow the assembly instructions that came with the MS-CP kit for the details on how do build the rear rotor head except for the differences outlined below in step 3. **The stock Hornet swashplate requires the upper and lower sections to be epoxied to the bearing. See section 1.4.3**. Also, we recommend adding a swashplate ball upgrade. See the Upgrades section 1.4.

1. **Anti-rotation arm and pin** - Remove the collar (MS-E067) and put aside for now. Rough up the inner surface of the mounting hole in the AR arm (MS-E008). Glue into place on the rear support tube (D702) using thin CA. Next, glue the AR pin (MS-E009). Allow the CA to cure. Mix a small batch of 30 minute (or longer) epoxy and apply to the underside of the AR arm and the rear support tube forming a fillet. Remove any excess epoxy.

2. **Rear shaft collar** - Install the 3mm collar (MS-E067) on the shaft so that it sits on top of the bearing with the reduced side down. Be sure the shaft is up as far as it will go. Use thread locker and tighten. See Figure 2.7a.

3. **Rear rotor head** - There are four (4) differences with the assembly of the rear rotor head. It must be modified so that it will operate correctly when rotating in a CCW direction.

    - The blade grips (MS-E076) must be installed upside down.
    - The stabilizer dome (MS-E072) must be installed upside down.
    - The flybar paddles (MS-E048) must be installed upside down.
    - The rotor blades must be installed upside down. Only fully symmetrical blades will work in this case

Install the swashplate and rear rotor head parts except for the rotor blades. Use the instructions that came with the MS-CP kit as a guide. The servos and links will be added in a later step. See Figure 2.7b.

2.8. Servos and linkages installation

Tools/Materials Required: Small Phillips head screwdriver
Needle nose pliers
Servo mounting tape
Hobby knife
#58 (0.042 inches) drill bit

Parts Required: (6) HS-50 servos or equivalent
(2) servo links sets (from MS-CP kits)
D705 Threaded M2 pushrods

Overview: The front and rear rotor servos are mounted with identical layouts. Double sided servo tape is used to attach them to the servo mounting trays (D901). All six servos and servo arms must be of the same type. The front rotor linkages are added first and then the rear linkages are added and adjusted so that rotor head stabilizer bed (MS-E073) sits in the same relative position for both rotor heads.

1. **Upper head ball links** - The upper ball links (connects MS-E072 to MS-E076) for both the front and rear rotor heads should all be about the same length with a space of about 0.05 inches between the links and have the threaded rod centered between each link. We recommend marking the center of the rod by gently squeezing it's midpoint between the jaws of a pair of small wire cutters.

2. **Servo arms** - The servo arms must be attached to the servos before they can be mounted to the servo tray. Select the servo arm you plan to use. We recommend using the shorter

arm from a cross shaped arm that has the other three arms removed. See Figure 2.8a. Enlarge the link hole of each servo arm with a #58 drill bit (by hand). Attach the servo arms to each servo such that the arm is centered or biased slightly upward. Each servo should be connected to an operating radio during the arm installation so that it will be centered properly.

3. **Front and rear rotor servos** - Remove the rear mounting tab for each servo. This can be done by slicing it away with a hobby knife. Mount the servos to the servo mounting trays (D901) with double sided servo mounting tape. See Figure 2.8b.

4. **Front rotor servo linkages** - The three linkages should all be about the same length with a space of about 0.05 inches between the links and have the threaded rod centered between each link. We recommend marking the center of the rod by gently squeezing it's midpoint between the jaws of a pair of small wire cutters.
Attach the clevis type links to servo arms and the ball links to the swashplate balls. With the servos centered the swashplate should be sitting level. See Figure 2.8c.

5. **Rear rotor servo linkages** - The three linkages should all be about the same length with the same number of turns into the upper and lower links. Attach the clevis type links to servo arms and the ball links to the swashplate balls. With the servos centered, the swashplate should be sitting level. Also, the length of the linkages should be adjusted such that the rotor head stabilizer bed (MS-E073) sits in the same relative position as the one on the front rotor head. That is, the gap between the bottom of (MS-E073) and the top of (MS-E074) should be the same for both the front and rear rotor heads. See Figure 2.8d.

2.9. Motors and main drive gear

Tools/Materials Required: #2 Phillips head screwdriver
1.5mm Allen wrench
Soldering iron
Electronics solder
Hobby knife
Electronics cutting pliers
Medium thread locking compound

Parts Required: MS-E230 Main gear with one-way
(2) MS-E018 10 tooth pinion gears
(2) MS-E010 Speed 300 motors
MS-E067 3mm shaft collar
D704 (4) M3x4 PPH screws
D107 Motors wiring accessories
D203 SS one-way sleeve

Overview: The 10 tooth pinion gears are trimmed and pressed onto each motor shaft. The wires and capacitors are added to each motor which are then attached to the motor mounting plate. The SS sleeve, main gear with one-way are mounted to the rear rotor shaft and a 3mm collar is added to hold the main gear in place. Finally, the motors are adjusted for the proper gear mesh.

1. **Motor pinion gears** - Trim about 0.05 inches off the solid end of each pinion gear (MS-E018). This is needed in case the main gear wobbles. It should always contact the teeth of the pinion gears. Press a pinion gear onto the shaft of each motor so that the motor shaft is

aligned with the end of the gear.

2. **Motor wires and capacitors** - To each motor, solder three capacitors and a red (+) wire and a black (-) wire to the motor terminals. A capacitor is connected between the terminals, and from each terminal to the motor case. Cut the wires long for now, about 12 to 14 inches will work well. **Do not "Y" connect the motor wires.** Run separate wires from each motor to the ESC. The Teflon tubing (part of D107) can be used to prevent shorts between the capacitor leads and the motor case.

3. **Mounting the motors** - Each motor is mounted to the top side of the motor mounting plate (D704) using (2) M3x4 PPH screws. Leave the screws loose for now.

4. **Main gear and SS sleeve** - Slip the SS sleeve onto the rear rotor shaft. The slots in the sleeve should engage the shaft retainer pin (D903). Slip the main gear with one-way assembly (MS-E230) onto the rear rotor shaft so that the SS sleeve (D203) slides all the way into the one-way bearing. Finally, slide the 3mm shaft collar (MS-E067) onto the rear rotor shaft with the reduced side up. Use thread locker and tighten. See Figure 2.9a.

5. **Motor gear mesh adjustment** - Adjust each motor by sliding it towards the main gear such that the pinion gear meshes with the main gear. The pinion gear must be set at a point where there is no binding between it and the main gear around its full circumference. A mesh of about 85% of the teeth between the gears is about right. Check this by fully rotating the main gear for each pinion gear being adjusted. Use thread locker and tighten the motor screws.

2.10. Canopy

Tools/Materials Required: 30 minute epoxy
Thin CA
Hobby knife
Straight scissors
Curved scissors
Rotary tool with sanding drum
Grinding wheel for rotary tool
#47 (0.078 inches) drill bit
Pin vise (hand drill)
Binder clip clamps

Parts Required: D500 Dragonfly stock canopy
D502 Canopy mounting block
D503 Canopy attachment rod
D504 (2) Canopy attachment magnets

Overview: The canopy halves are rough trimmed and joined together with thin CA using either of two methods, flanged or overlapped. Either method requires a fair degree of patience. After joined, the canopy is shaped for finishing using a rotary tool with a sanding drum running at low speed. The canopy is then painted and detailed. The balsa mounting block is trimmed and epoxied into place and the attachment rod is epoxied to the main body section. A hole is drilled into the balsa mounting block so that it mates with the mounting pin. Finally, the mounting magnets are glued to the canopy.

The pin and magnets do a fairly good job holding the canopy onto the model. For aggressive flying, a simple rubber band can be added which wraps around the top sides of the canopy and hooks onto the lower frame section.

1. **Initial canopy trimming** - Trim the two canopy halves using a straight scissors on the flat flange area and a curved scissors for the top and bottom areas. See Figure 2.10.a.

2. **Joining the canopy halves** - For the flanged method, position the two halves together so they line up, and use binder clip clamps on the flange about 8 to10 clamps are needed. For the overlapped method, Use tape to hold the two halves together. Wick thin CA into the seam. Only glue one small section at a time and allow to cure. After the entire seam is glued and cured, cut 6 or 7 tabs about 0.5x0.75 inches, from the scrap canopy material and glue these in place across the main seam (perpendicular). Place one at the start and end of the seam and the rest spaced equally. This will help to reinforce the canopy structure.

3. **Final canopy trimming** - Using a rotary tool with a sanding drum set to low speed, trim and shape the canopy. Take your time with it. When completed, use a sharp hobby knife to remove any flash.

4. **Painting the canopy** - The canopy is made of PVC plastic and should be painted with a paint that is suitable for this material. Check with your dealer. We recommend painting the canopy a bright color such as while or yellow and avoid dark colors since they make flying the model more difficult since it is harder to see.

5. **Mounting the canopy** - Trim the balsa mounting block (D502) so that the angle matches the canopy front. Mix up a small batch of 30 minute epoxy and glue the mounting block into place. Also, epoxy the canopy attachment rod (D503) to the top of the first main body bulkhead forward the center bulkhead. Allow the epoxy to cure.

    - Grind the top surface of the canopy attachment rod flat with a rotary tool and grinding wheel. This will allow the mounting magnets to hold stronger.

    - Slide the canopy onto the body. Position it such that the top flat surface is about 0.02 to 0.03 inches below the bottom surface of the servo mounting tray (D901). The canopy mounting pin (D501) should sit approximately in the middle of the balsa mounting block. Gently mark the block by indenting it with the mounting pin. Remove the canopy and drill a hole with a #47 dill bit (by hand with a pin vise) into the mounting block where it was marked. Now soak the hole area of the mounting block with thin CA and let it cure.

    - Slide the canopy onto the body and mounting pin. Move it to its final position on the model. Mark the canopy where the attachment rod makes contact with it. Remove the canopy, and glue a magnet to each side of the canopy, at the center of each mark with thin CA.

2.11. Radio components and TH-1 installation

Tools/Materials Required: 30 minute epoxy
Thin CA
Hobby knife
Soldering iron
Electronics solder
Electronics cutting pliers
Hobby knife
Electrical tape
Servo mounting tape
Velcro mounting tape (hook and loop)

Parts Required: D104 Gyro and Rx mounting plates
D105 4" Tywrap
Receiver, Gyro(s), TH-1, ESC, Battery, Connectors

Overview: The gyro and receiver mounting plates are glued in place. The gyros are mounted with servo tape and the receiver is mounted with Velcro. The TH-1 is mounted to the frame with Tywraps and a connector is added to it and the ESC for connection to the battery.
A second connector is added to the ESC for connection to the motors. Finally, the servos are connected to the TH-1. The gyros, ESC and TH-1 are connected as required to the receiver.

1. **Gyro and receiver mounting plates** - Place the gyro mounting plate (shorter plate) into the notches of the two support ribs. The plate should be aligned flush with the forward rib. Glue with thin CA. Glue the receiver mounting plate to the bottom of the two most forward main lower body bulkheads with thin CA. The plate should be centered between the two bulkheads. Mix up a small batch of 30 minute epoxy and for each joint, create a fillet between the mounting plate and the body. Allow the epoxy to cure.

2. **Mounting the gyros** - The pitch gyro is mounted to the bottom of the gyro mounting plate with servo tape and may need an extension cable. The yaw gyro is mounted with servo tape to the front side of the forward rib that the plate is mounted to.

3. **Mounting the receiver** - The receiver is mounted to the top side of the mounting plate using Velcro tape. The antenna should be routed as far away as possible from the main body since it is made from carbon fiber rods. We recommend using a base loaded whip antenna mounted to the front of the model.

4. **Mounting the battery** - We recommend mounting the battery with either a Tywrap or a Velcro strap. The general location is forward and below the receiver. The exact position is determined by the adjusting the battery position such that the model balances on its **center of gravity** which is located at the center bulkhead.

5. **Mounting the TH-1** - The TH-1 is mounted to the main body frame with two Tywraps. Run the front and rear servo ribbon cables inside of the lower body bulkheads and attach the Tywraps to the center two lower bulkheads such that the TH-1 circuit board is suspended and not touching the frame. This will provide maximum cooling for the dual BEC's. **Caution: The TH-1 circuit board must not contact the conductive carbon fiber rods.**

6. **ESC and TH-1 power connector** - Solder the connector that mates with the battery connector to the power leads of both the TH-1 and ESC. Be sure to observe proper polarity. Refer to the TH-1 and ESC operator's manuals for more information.

7. **ESC and motors connectors** - Solder the connector that mates with the motors connector to the motor leads of ESC. Solder the mating connector to the motor wires added in a previous step. Both motors are wired in parallel to the ESC. Be sure to observe proper polarity. Refer to the ESC operator's manuals for more information.

8. **Final connections** - Plug the front servos into the TH-1 front header and the rear servos into the rear header. Refer to the TH-1 operator's manuals for more information.

    - Plug the pitch axis gyro connector into the receiver's elevator header.
    - Plug the yaw axis gyro connector into the receiver's rudder header.
    - Plug the ESC's signal connector into the receiver's throttle header.
    - Plug the TH-1's aileron connector into the receiver's aileron header.
    - Plug the TH-1's pitch (CH6) connector into the receiver's pitch (CH6) signal pin.
    - Plug the TH-1's elevator connector into the pitch axis gyros output signal pin.
    - Plug the TH-1's rudder connector into the yaw axis gyros output signal pin.

    Secure all connections with high quality electrical tape. This must be done with care to prevent a future loose connection. Use the remaining Tywraps to secure the wires and leads to the main body frame. Be sure to secure any wires or leads located near the drive components. See Figure 2.11.a.

3.0. Setup

This section will guide you through the setup process.

3.1. Initial radio settings

1. **Transmitter setup** - Refer to the TH-1 manual for servo reverse settings and ATV (adjustable travel volume) settings. Follow the instructions that came with the ESC for proper setup. The initial throttle curve should be set to (0, 25, 50, 75, 100) and the pitch curve set to (30, 40, 50, 60, 70). These settings are approximate and you may need to adjust them for your particular installation and equipment. We recommend setting up the "Throttle hold" switch such that it will kill power to the motor when switched on. This can be used as a safety switch to prevent accidental motor activation. All other features (TX mixing) should be turned off for now, and the trim controls centered. Set the swashplate to SWH1 (no TX CCPM mixing).

2. **Exponential rates** - We recommend using exponential rates for channels aileron, elevator, and rudder. Use a value of about -30 for each channel.

3. **Gyros gain and centering** - Adjust the "centering" control for each gyro. Follow the instructions that came with the unit. For now set the "gain" of both gyros to zero (0).

4. **TH-1 settings** - For now set the "yaw compensation gain" control to zero (0).

3.2. Initial spin-up

Caution: This procedure requires eye protection.

With the main rotor blades and canopy removed, connect the battery, arm the ESC, and slowly spin-up the rotor shafts to about 25% of full. Do not over-speed the drive system. The flybars should be flying level and there should be little or no vibration. Correct any vibration problems before proceeding.

3.3. Main rotors setup

Caution: This procedure requires eye protection.

Front rotor setup - Install only the front rotor blades. They should be tightened such that they can swing when spun-up but not loose enough to flop around.

- The blades must first be tracked by spinning the blades and observing if they are rotating in the same plane or not. It helps to paint the tips different colors to tell them apart. Make adjustments to the upper linkages that connect the blade grips to the stabilizer dome. If more than a half turn is needed on a linkage, then both linkages should be adjusted one up, and the other down a half turn each. Be sure to keep the threaded rod centered within the linkage.

- The blades must now be balanced. It is assumed that the blades you have are reasonably matched and only a final dynamic balance is required. If your blades need further balancing then see section 1.4 for information sources.

Balancing is done by spinning the blades and observing the level of vibration. A small piece of tape or a rubber band is moved around on each blade and the effect is observed. The goal is to have no vibration throughout the entire rpm range (0 to 2200 rpm).

Rear rotor setup - Remove the front rotor blades and install the rear rotor blades. Be sure they are oriented to spin CCW. The screws enter from the bottom of the blade grip. They should be tightened such that they can swing when spun-up but not loose enough to flop around. Follow the above steps to track and balance the blades.

Pitch balancing - The goal of this procedure is to balance the pitch load of both the front and rear rotors so that they are the same. Install the front blades as described above.

- Rotate the front rotor by hand counter-clockwise and check that the phase angle of the front and rear rotor blades is approximately 90 degrees. The blade tip of a rotor blade should line up with the flybar paddle of the other rotor blade. Make corrections if needed before proceeding.

- Spin-up the rotors to achieve liftoff (a turntable fixture or "lazy Susan" is ideal for this procedure) and observe any yaw rotation. A pitch imbalance will cause a yaw axis torque moment, so it is very easy to correct by direct observation**. If the yaw is clockwise then the front rotor has less pitch than the rear rotor and visa versa.** The rotor with the greater pitch should be adjusted by lowering its pitch with the upper linkages or a combination of the upper and lower linkages. Avoid making adjustments by making the linkages longer since it reduces the amount of threads holding the link. Using this method will get the pitch balanced to within a half turn of the linkage.

Yaw compensation - The Dragonfly Pro uses differential collective pitch (DCP) and a blend of cyclic for pitch axis (elevator) control. The DCP causes an imbalance in the torque between the front and rear rotors and needs to be compensated. This can be done with two methods, by the TH-1 or by the transmitter if it has programmable mix capability. A turntable fixture (lazy Susan) is ideal for this procedure.

- **TH-1 yaw compensation** - Adjust the yaw compensation gain pot on the TH-1 so that little or no yaw occurs when a pitch command is applied.

- **Transmitter yaw compensation** - Be sure to disable the yaw compensation feature in the TH-1 by installing the jumper. Setup a programmable mix between elevator (master) and rudder (slave). An initial value of about +30% is in the ballpark. Adjust as needed so that little or no yaw occurs when a pitch command is applied. The only drawback to this method is that the pitch gyro will not have yaw compensation applied to its corrected output. Our testing has shown that the effects of this are almost unnoticeable.

3.4. Final setup

- **Gyro gains** - Adjust the gain on the yaw gyro to about 50%, and the gain on the pitch gyro to about 70%. Check the centering adjustment regularly since vibration can change it.

- **Center of gravity** - The (CG) for this model is at the center bulkhead, This will cause the model to hover level when both rotors are generating the same lift. The battery placement is

used to set and adjust the CG. The actual CG range is quite large as with the full scale tandem machines. This can be used to take advantage of some characteristics that only tandem helicopters possess.

- **Swashplate pitch axis bias** - The front and rear swashplates can be biased along the pitch axis to enhance the flying characteristics for hovering or forward flight. Enhancing one will generally reduce performance in the other. It all depends on how you like to fly the model. Initially, we recommend keeping the swashplate level until you gain some experience with flying the model. After you feel comfortable flying the Dragonfly Pro, you may want to experiment with different bias settings. Whatever you decide to do, do it gradually, make changes to the settings in small increments and change only one setting at a time if possible.

- **Hovering enhancement** - To enhance the model for hovering, the front swashplate is tilted back and the rear swashplate is tilted forward. This is called dihedral, and only a few degrees is needed to make a noticeable difference. The tilt is accomplished by adjusting the linkages that connect the servos to the swashplate. The swashplate rear links move equal amounts opposite of the swashplate front link.

- **Forward flight enhancement** - To enhance the model for forward flight, both the front and rear swashplates are tilted forward. Only a few degrees is needed to make a noticeable difference. The tilt is accomplished by adjusting the linkages that connect the servos to the swashplate. The swashplate rear links move equal amounts opposite of the swashplate front link. The CG can be biased rearward to compensate (by shifting the battery location rearward). This will allow the model to hover without holding back stick or by requiring trim.

3.5. Pre-flight Checkout

- Check all hardware and linkages.
- Check all connections between radio components.
- Check the main drive belt tension.
- Check the front and rear rotors phase angle
- Check the rotor heads and swashplate components.
- Check the main drive components.
- Check the gyro centering.
- Range check the radio with and without the motors running.
- Check your surroundings.
- Happy flying.

4.0. Flying the Dragonfly Pro

If you are not a member of the AMA then please join. Always follow the AMA safety code when operating the model. When in doubt use common sense and err on the side of safety.

There are three basic flight modes - Happy flying

- **Hovering** including slow forward flight where the forward airspeed is not great enough for the front rotor vortex to interfere with the rear rotor lift.

  We have found that this helicopter is very tame in this flight mode as compared to single rotor machines. During the early test flights, there was no body/canopy, just a truss frame that offered a poor visual reference. This caused disorientation on a number of occasions and this was when it was discovered that the hovering flight characteristics were so tame. The model would hover around by itself when the transmitter sticks were released. The controls were released because the pilot was disoriented and didn't know what inputs to command. The helicopter didn't have the tendency to roll towards the ground a few seconds later as some single rotor machines do. It seemed happy just floating around.

- **Hover to forward flight transition** where the forward airspeed is great enough for the front rotor vortex to interfere with the rear rotor lift. This flight condition is a characteristic of all tandem rotor helicopters.

  This region of the flight envelope can be tricky, but with knowledge and the understanding of how problems can occur and how to deal with these problems, it's not a big deal.

  At a certain airspeed, and when the fuselage attitude is near level, the front rotor vortex will begin to interfere with rear rotor lift. This will cause the nose of the helicopter to pitch up and eventually stop the forward airspeed. The recommended recovery maneuver is to apply both power and forward stick at the same time. The sooner you detect this flight condition, the easier it is to recover from it. In many cases only some forward stick will be needed. We recommend practicing entry and recovery until you become proficient. As you gain experience, recovery will become second nature and will be hardly noticeable that this flight condition even occurred. It should be noted that full forward flight is possible without entering this flight condition at all, this is what the full scale tandem rotor machines do.

  Problems can occur when the battery becomes weak and there is not enough control power to recover. Keep this in mind, and avoid this flight condition when the battery is low. In most cases, as long as you level the aircraft, when it enters ground effect it will bounce up a little allowing you to land safely. Again, practice really helps to sharpen your reactions.

- **Full forward flight** where the forward airspeed varies from low to maximum and the front rotor vortex is not interfering with the rear rotor. Both vortices remain separate and the fuselage attitude is angled nose down. To enter forward flight, apply both power and forward stick and watch it get up and go. When entering a turn, apply left or right roll, and just ease back on the stick (pitch axis) to complete the turn. Add yaw as needed. Resist the feelings to pull back on the stick as you would do if you were flying a single rotor helicopter. To fly forward the tandem helicopter needs a fair amount of forward stick full time.