

Introduction

In 1988 I started looking for information about the use of electronic controls for Control Line Scale Model Airplanes. At that time I was building a Sterling Corsair with a 36" wing span. I first built the model without any throttle system. I would start the engine at full bore and let her go. I am amazed I did not pile the little plane into the concrete. After surviving those flights I wanted to add throttle control so I got hold a 3-line handle and bellcrank. A photo of this model can be found in the Photo Gallery section (Plate #10). In the back of my mind I always knew there was some slick way to using some of the technology that Radio Control used on a daily basis to improve the throttle control system. I never was able to find anyone who could tell me what equipment to buy and how to set it up. Letter after letter came back with the standard answer "I don't know".

I knew that it was possible to use Electronic Controls so I decided to figure it out for myself. I pulled out my Ace 3 Channel radio that I used once in a RC glider. I called up ACE and asked a few questions and told them what I wanted to do. After a few weeks I was modifying the ACE radio for CL electronics use.

Then I met two other CL pilots who also wanted to use the electronics and had also been looking for information without much luck. Grant Hiestand, Merle Mohring and myself teamed up to come up with the information that is being presented here. This is everything that we have learned to date with the numerous models we have built and flown over the years. By 1991 we had finished the development and testing of two major systems, Single and Mutli Channel controls. DSC with the use of JR radios came later in 1997.

This is intended to provide the newcomer to Control Line Scale, Carrier and general sport flying an alternative to the normal fixed throttle, fly until you are out of gas model airplane. All of the techniques shown here have been tested many times by others and myself. We continue to develop new ideas and test them. Just because we do something one way does not mean that it can't be done slightly differently.

For those who maintain that the 3-line handle and bellcrank should not be replaced with all these wires, batteries and servos consider this actual case. When I first met Virgil Wilbur he like myself started with the 3-line bellcrank and handle. For several years we flew together, I had my electronics and Virgil had his 3-line setup. Then one summer he decided to try electronic controls. He wasn't real sure if he was going to like the system, but he was going to give it a try. After his first test flight with electronic controls he came back to the pits real excited. By the next weekend all of his models had been converted to electronics and he never looked back. He never built a model with a 3-line bellcrank again. Until you have actually flown and set up a model with electronics you have no idea what you are missing.

Good luck and keep your wings level

Fred Cronenwett

- Notes -

Section 1

Electronic Controls

- Notes -

Chapter 1 - System Overview

Electronic Controls operate one or more functions on a CL model with two flying lines. The handle can be adjusted for neutral elevator without affecting the throttle setting. The model with electronic controls results in smoother operation of the throttle and other features. The servo can make very small changes that would be difficult to accomplish with a mechanical system that has multiple points of friction which reduce the sensitivity of the 3-line setup.

The Electronic Control system uses equipment that was designed for a Radio Control (RC) model. The equipment is used in such a way that no frequency is ever transmitted. The signal and ground are transmitted through the two flying lines (no power is transmitted). This signal and ground is generated by the transmitter or Servo Driver hanging from the pilots belt or handle and then communicated to the receiver or servo in the model through two insulated flying lines, since Electronic Controls are not based upon line tension like the older 3-line system. If you lose line tension with electronic controls you still have control of the throttle and other features.

The use of electronic controls has been growing steadily since 1991. Single Channel was used at the 1992 Scale World Championships with great success. Electronic controls have been very popular with the United States FAI CL scale team over the last decade. The top three finishers at the 2000 Scale CL World Championships used electronic controls. As the electronic controls improved over the years we have adapted a system called "Direct Servo Connection" or DSC. The radio control systems that use the DSC functionality (JR for example) have given us a huge leap forward in capability. In 1999 Bill Young designed a specially built CL electronics handle that eliminates the transmitter or Servo Driver that hangs off of the pilot's belt. All of these systems permit the application of Electric motors with proportional throttle control. Other electronic items designed for Radio Control airplanes can also be used.



Picture 1.1 -Wide selection of Scale modeling is possible, small to large, fun to Precision Scale, CL Precision Semi-scale, Profile Scale

- Notes -

Chapter 2 - Flying Line Construction

The flying lines are built the same way regardless of the system that you choose to use in your plane. We demand a lot out these two thin steel lines and we should not take anything for granted. The entire system from handle to bellcrank will be discussed here.

There is a lot more to our lines than just two steel cables. Lets start with the handle. When you look through any catalog with CL accessories you will notice that two types of handles are sold, 3-line and handles designed for Precision aerobatics. The specialized handles used for Rat Racing or Speed could also be used, however I find the Stunt handles to work just fine for our application. Take a good look at your new handle and make sure all of the crimping, wire, bolts and nuts are tight and will not fail under load. I have seen the results of handles failing during a flight and the damage to the model is almost always substantial.

The flying lines serve two purposes; 1) to fly the model airplane and 2) transmit the electronic signal to the model. The actual line itself is nylon coated fishing leader used for salt water fishing. It is identical to the flying lines you are currently using except it is coated with a thin layer of nylon to insulate the electronic signal. At each end of the flying lines is a connector that transmits the electronic signal. Details on how to assemble the lines can be found starting on page 9.

The flying lines are normally available at your local fishing store. You will have to special order 300 or 1000 foot rolls in the size line you require since the length of our flying lines ranges from 55 to 70 feet. Each 300 foot roll can make two sets of flying lines. Fishing stores normally have 30 foot sections for sale so you can check out the actual wire size, use this material for your leadouts. Below is the recommended wire diameter for a typical model. Remember to check the actual wire diameter after removing a section of the nylon coating.

Chart 2.1 Surflon* Brand Wire data

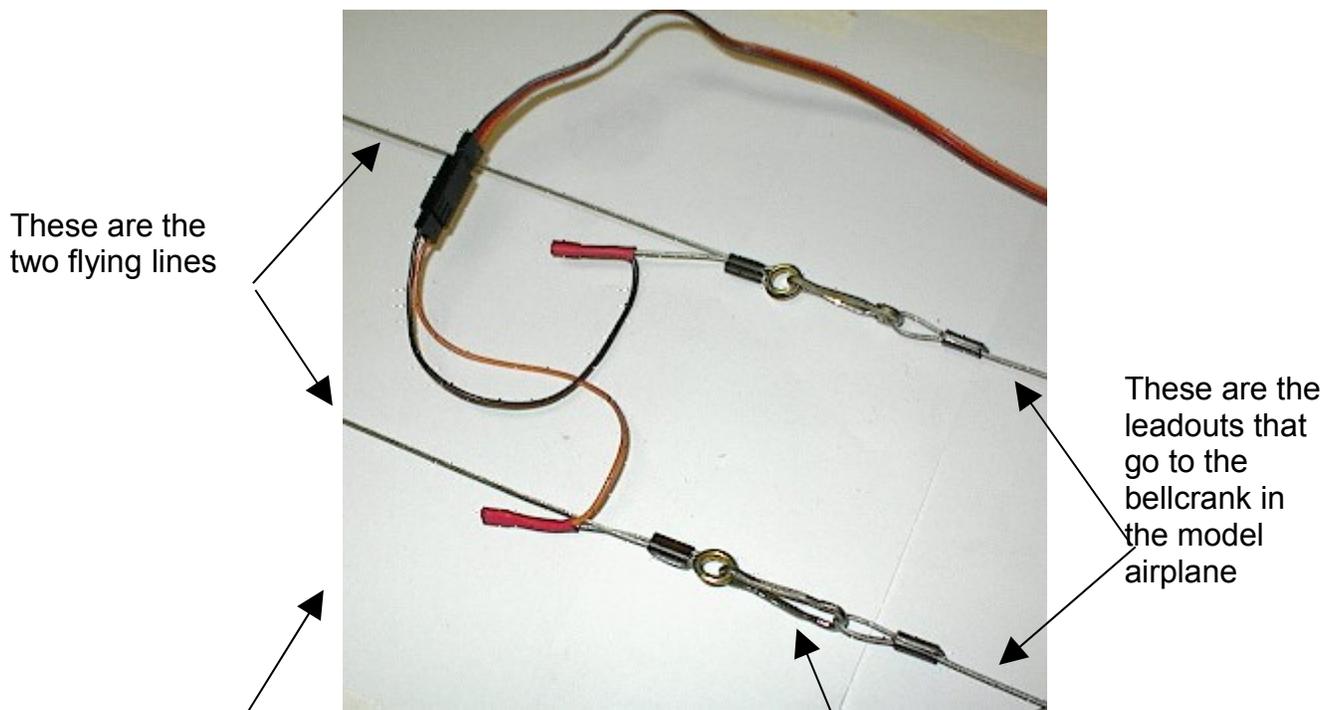
Pound Test	Outside Diameter	Wire Diameter
140	.040	.028
80	.038	.025
60	.032	.021
45	.027	.018
30	.025	.017
20	.026	.012
15	.020	.016
10	.019	.010

Recommendations:

0 - 4 lbs model:	30 lbs test
4 - 8 lbs model:	60 lbs test
8 - 20 lbs model:	140 lbs test (due to AMA rules for line dia)

* Surflon is a Brand name available in some fishing stores. Sevelon is another brand available. Overall Outside diameter and actual wire diameter will vary with each manufacturer. Surflon is available from **tacklemania.com** and other outfits that sell fishing products.

Photograph 2.1 - completed line connection with electronic wire plugged in



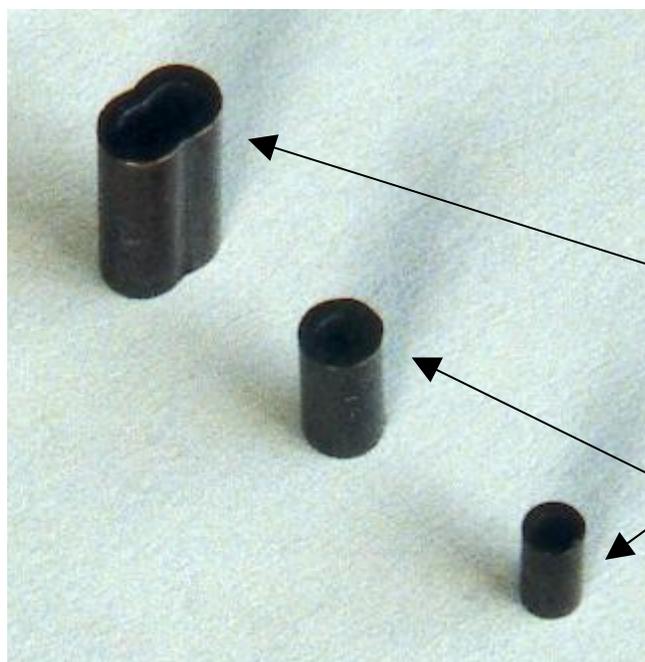
These are the two flying lines

These are the leadouts that go to the bellcrank in the model airplane

This is the final product that we are after. Flying lines that can pass an 80 lbs pull test and transmit the electronic signal down the flying lines. The next three pages will show you how to do just that.

These line clips can be found in Hobby Shops and Fishing stores

Photograph 2.2 - These are typical line connectors that I buy from my local fishing store. The top left one is a double connector that allows a total of three lines to pass thru side by side. I use these double connectors for the main line crimp tube.

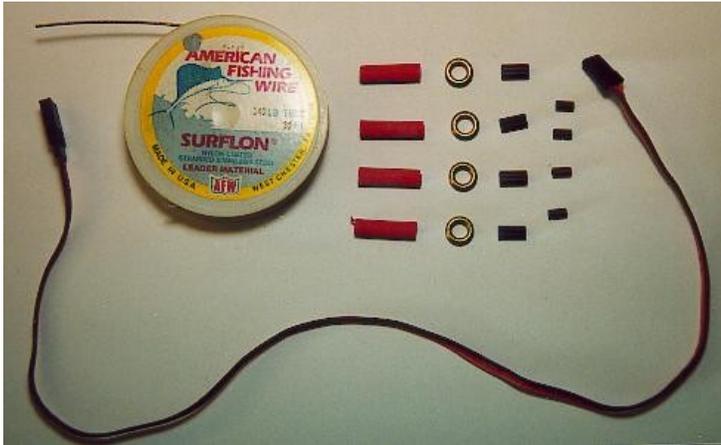


Double or "Binocular" Connectors

These smaller round connectors I use for the electronic connector and then cover with heat shrink tubing.

Round "Single" Connector

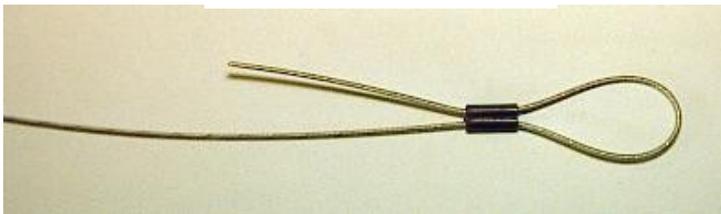
Step by Step how to build lines



Photograph 2.3

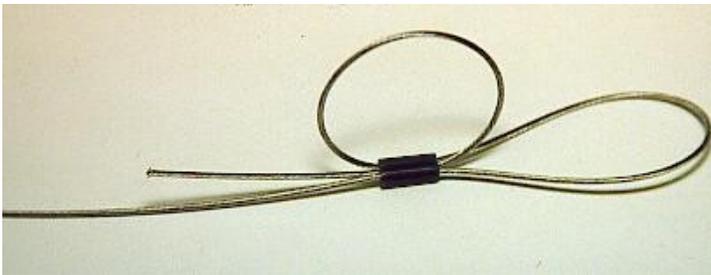
You will need these following parts
(left to right as shown):

- 1) Flying line (as needed)
- 2) Heat shrink tubing (4 pieces)
- 3) Brass ring or Thimble (4 total)
(available thru Brodak)
- 4) Double crimp tube (4 total)
- 5) Round crimp tube (4 total)
- 6) Electrical connector wire
(Servo extension cut in half)



Photograph 2.4

Slip the line thru the Double crimp tube connector

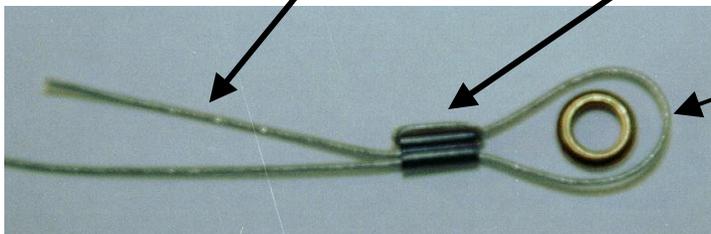


Photograph 2.5

Loop the line around the crimp tube and double back thru the crimp tube as shown.

Excess wire for electronic wire attachment

Pull the loop tight around the double crimp tube as shown. Make sure you have enough excess for the electronic wire attachment

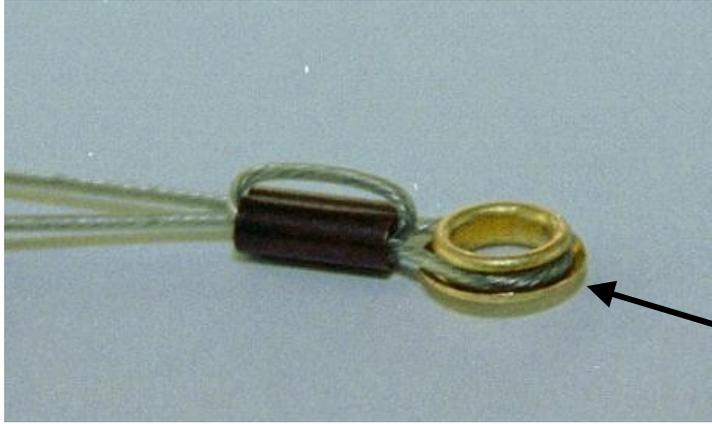


The thimble will go into the loop as shown

Photograph 2.6

Step by Step how to build lines

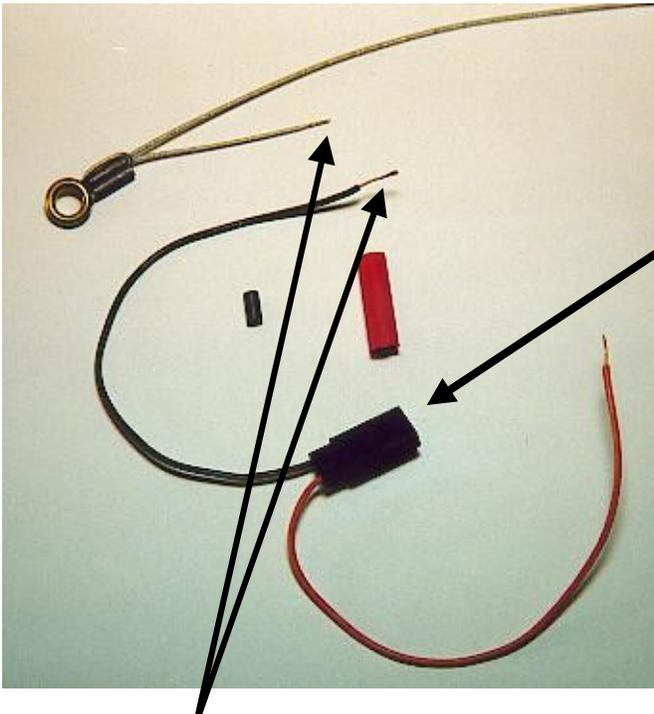
Photograph 2.7



Pull the wire loop around the brass thimble tight as shown. Crimp the tube with standard pliers to keep the loops from moving. This style of line assembly has been pulled tested to 80 lbs during competition without failure. The brass Thimble shown is from a Sig package but is also available from Brodak Manufacturing.

Do not crimp the brass thimble, a short will result in the lines. The line that wraps around the inside of the thimble still has the nylon coating (see figure 2.2)

Photograph 2.8



Take the end of the excess flying line wire and strip the nylon coating off with a lighter or sharp knife to expose the wire underneath

Cut the servo extension in half and strip the end of the wires as shown. Notice the third wire has been removed from the JR servo extension

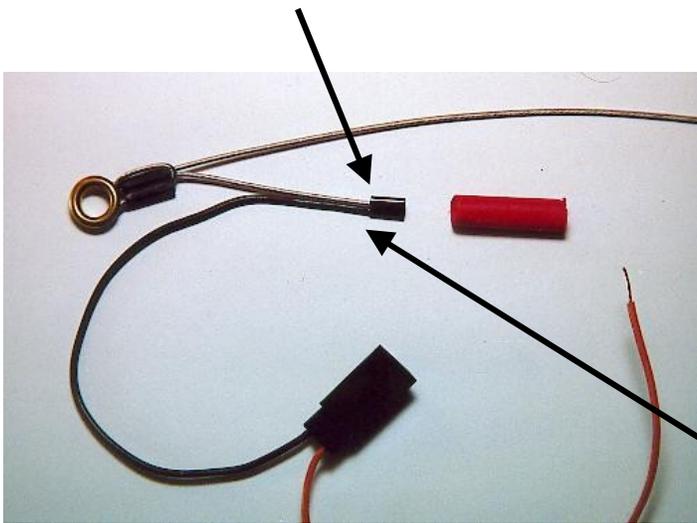
This Orange wire goes to the other flying line that is built the same way

Slip the end of the excess flying line, electronic wire thru the round crimp tube. Crimp the round tube with a pair of pliers. Cover section with heat shrink tubing.

The only exposed wire, either on the flying lines or the electronic hookup is located here. The Orange wire will go to the other flying line as seen in photo 2.1.

Slip the end of the excess flying line and electronic wire thru the round crimp tube. Crimp the round tube with a pair of pliers. And then cover that section with heat shrink tubing.

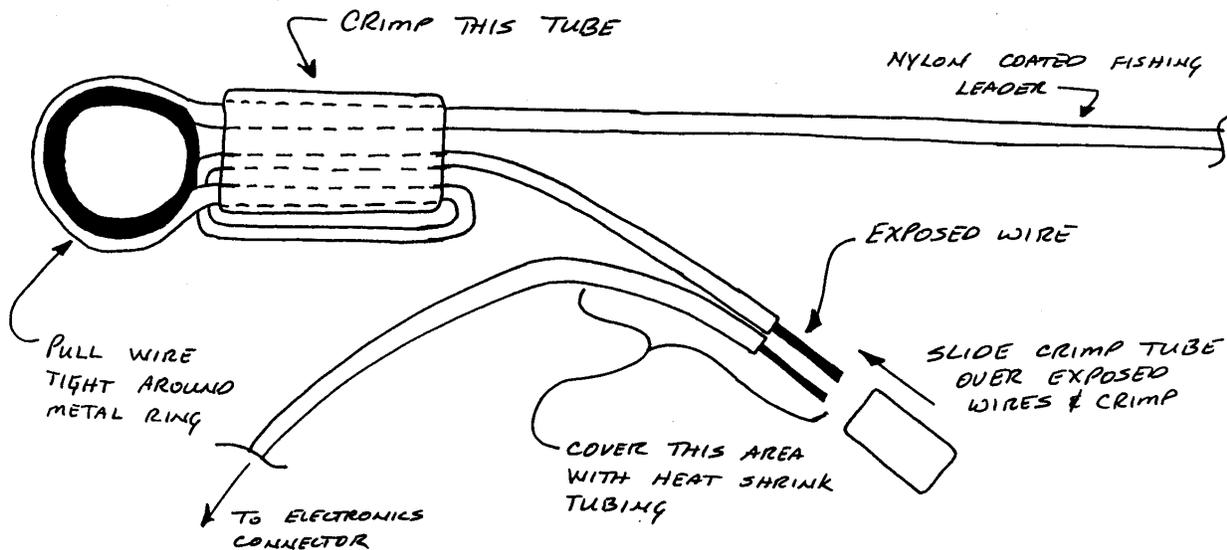
This is what the line assembly looks like prior to putting the heat shrink tubing over the connection. The electronic joint between the flying line and wire connector is not soldered. The heat shrink tubing is important because it keeps the wire underneath from breaking due to wear. Remember these wires will be moving around during normal use and will eventually break if not protected by the heat shrink tubing.



Wire will break here if not covered with Heat Shrink tubing during normal use at the flying field

Photograph 2.9

Figure 2.1 - Line Construction Detail



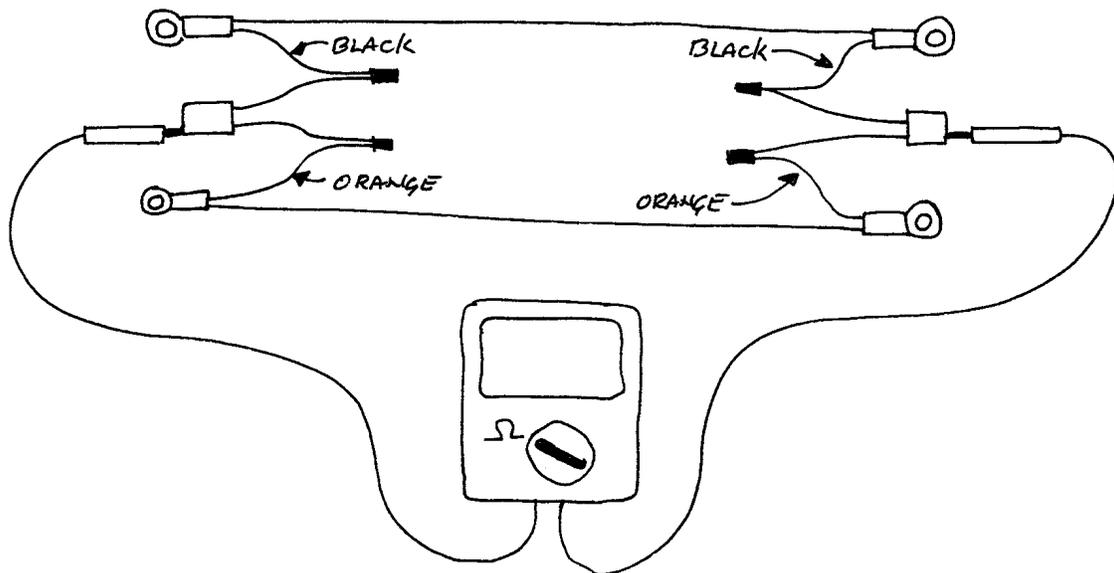
HOW TO TEST PROPER LINE ASSEMBLY WITH CONNECTORS

After the flying lines are assembled the following test locates problem areas or confirms lines were assembled properly. Measure the resistance of the lines from pin to pin at the connector (see figure 2.2). The resistance will vary, but generally the larger the wire diameter the smaller the resistance. The resistance will vary from approximately 90 Ohms to 200 Ohms per line. Consult the Trouble Shooting Chapter for more ideas on isolating problem areas. Make sure you don't transpose the pin to pin connectors, this is common mistake.

Sometimes the flying lines will not work under tension, but work just fine when they are slack. The following problem actually happened at the Nationals. The electronics would work correctly in the pits but soon after takeoff the lines stopped working and the electronic signal was lost. The problem was traced to a crimped tube that was failing only when the lines were under tension. To test this, the airplane end of the lines was tied to a large object and then while tugging on the lines the ohmage was measured from pin to pin. As expected, the lines failed under tension. In this case we had to re-assemble the lines and re-crimp the electrical connector.

The only section of the flying lines that are exposed are the ends where the electronic hookup wire is attached. If the brass thimble is crimped it creates a short and makes the system inoperable. This is difficult to detect with a multi-meter. Often times we just re-assembled the lines and they work just fine. To isolate the problem we sometimes try another set of lines to determine if the lines themselves were the problem.

Figure 2.2



Measure Ohmage from pin to pin, or some multi-meters measure continuity. Determine if pin to pin connection is complete and the wires are not transposed

Chapter 3 - Single Channel

The information presented here shows an electronic control system for a CL model as an alternative to the widely accepted 3-Line system used today. The assembly of the commonly available hardware into an integrated system will be discussed. This control system has been successfully used in both Carrier and Scale models. In the Carrier models, the plane used a normal two line bellcrank and it worked like a champion.

This electronic system is designed to operate a single function on a control line model with the use of a servo mounted in the model airplane. It can be an alternative to the 3-line system, or, it can supplement the 3-line system to operate other functions such as flaps, bomb drop or retracts. This system will result in a more precise throttle control since all of the points of friction normally associated with 3-line system have been eliminated. It also eliminates the need for the third line, so if for any reason the flying lines should go slack the electronics will still work. This is especially comforting when the model ground loops towards the pilot or has lost line tension.

All of the hardware used is available in most hobby shops, electronic and fishing stores and does not require any major modification, unless you wish to customize it to your purposes. To assemble this integrated system you will need a good soldering iron with flux and solder. Locate the following items:

- Servo Driver with Joy stick manufactured by "CUSTOM ELECTRONICS"
- Servo Driver battery; normally requires "N" cells
- Micro or Standard Servo
- Red, Black and White braided wire (not solid)
- ON - OFF switch from electronics store
- Flight pack battery (4.8 volt Nicad, four AAA, or four AA batteries)
- 3-pin connectors ("DEANS" connectors are recommended)
- Heat shrink tubing - multiple colors
- Flying lines (see section on flying lines)

The servo driver basically is a 555 timer circuit, which produces a pulse train that the servo understands and moves accordingly to the movement of the joystick. The servo driver comes with 3 wires exiting the case. You will only use the orange and black wire, and the red wire can be clipped. The red wire is power for the servo, but since an external battery will be used, this wire is not required. The orange wire is the signal and the black wire is the ground. Remember to install a battery in the Servo Driver. The normal N cell batteries can be replaced by four AA or a 4.8 volt Nicad pack if so desired.

When the model is being flown with the single channel system we normally clip the servo driver to our belt. If you are right handed you will most likely operate the servo driver with your left hand and fly the model with your right hand. The wire exiting the case of the Servo Driver must be long enough so that the unit does not become unplugged from the handle when your arm reaches full extension. The belt clip can be made from sheet metal or you can use a prefabricated clip normally found on tape measures available in hardware stores. See Picture 3.1 for a photograph of the Servo Driver and Plate #10 (see Photo Gallery) to see how the Servo Driver plugs into the airplane.

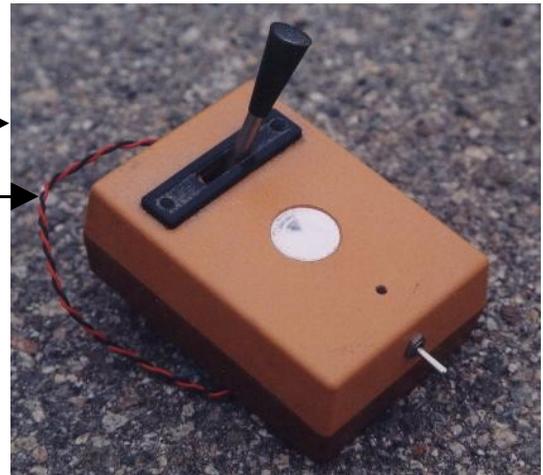
We have made several modifications to the servo driver that has improved the usefulness of the unit for control line flying. Our first modification was the 500 ohm trim pot wired in series with the joystick to act as a fine trim. We have also used larger cases so that we can install larger more commonly available batteries such as AA or AAA. The servo driver currently is configured for N cells, which are difficult to find in most stores. Another modification has been the use of a JR servo reverser to accommodate different servo installations. The trim pot and the servo reversing have been used in radio control for years. One Servo Driver can be used for multiple models.

The flight pack is the other half of the system and is carried by the model to operate the throttle or other function selected. The flight pack consists of a servo, battery, on-off switch, deans connectors and wires. The ground between the servo driver and the flight pack must be common. If the grounds are not common, the system will not work. The schematics shown in this chapter maintain the common ground. The flight pack is to be assembled as shown on the figures in this chapter for dry cell operation (Figure 3.3) or the Nicad operation (Figure 3.2). It is possible to assemble, test and install a flight pack in less than 2 hours into a model that is already configured for 3-line operation (assuming you have easy access).

The batteries required for this system will vary based on your model and the number of servos. We have tested both dry cell and NICAD batteries with great success. I prefer to use the dry cells since they can easily be replaced at the field. In cases where weight is critical, the 6.0 volt dry cell photo battery (PX28 or A544) available from electronic stores is a good choice. This dry cell is extremely small and lightweight and will power a single servo for about 40 flights. AA or AAA dry cells (four required) will provide power for a long time and are very dependable. If you are not concerned about the weight of the batteries the AA are your best choice. Be sure to install the batteries in such a way that they can not shake loose during flight (this actually happened to me - it took 20 minutes to fly the 12-ounce tank dry with a 9-LB scale model with Fox .60 running!). I used a PT-19 model as a prototype for this control system (See photo Gallery, Plate #11)

Custom Electronics Servo Driver shown with the joystick. →

Notice the two wires, Orange & Black →



Photograph 3.1

CONTACTS:

Custom electronics
Box 123B
Higginsville, MO 64037
(888) 584-6284
FAX (888) 584-6285

If you hobby shop does not carry this item call Custom Electronics directly and order the Servo Driver. We tested the servo driver with the dial and joystick, I prefer to fly with the joy stick version. **This servo driver is out of production and no longer available.**

Figure 3.1 - Overall single Channel configuration

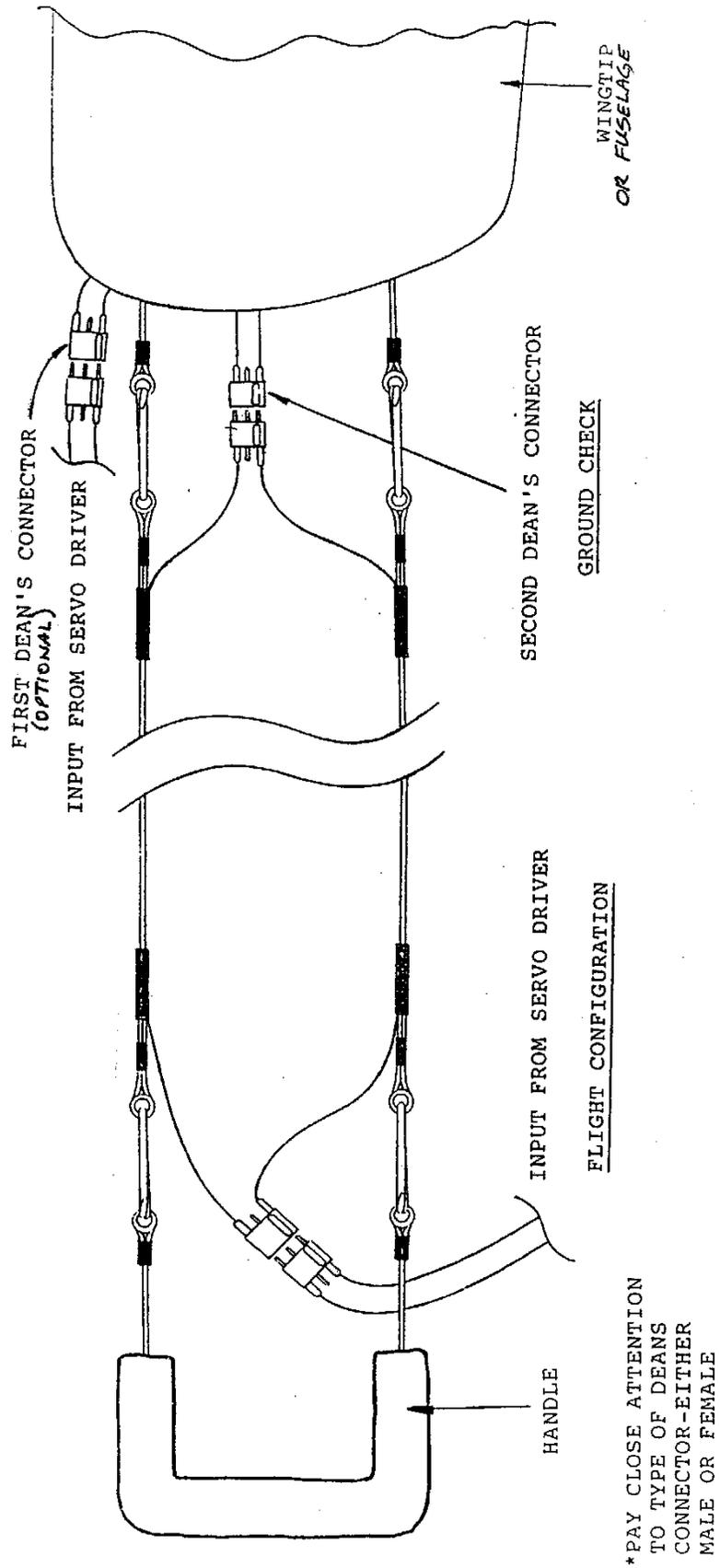


Figure 3.2 - Flight Pack – Nicad configuration

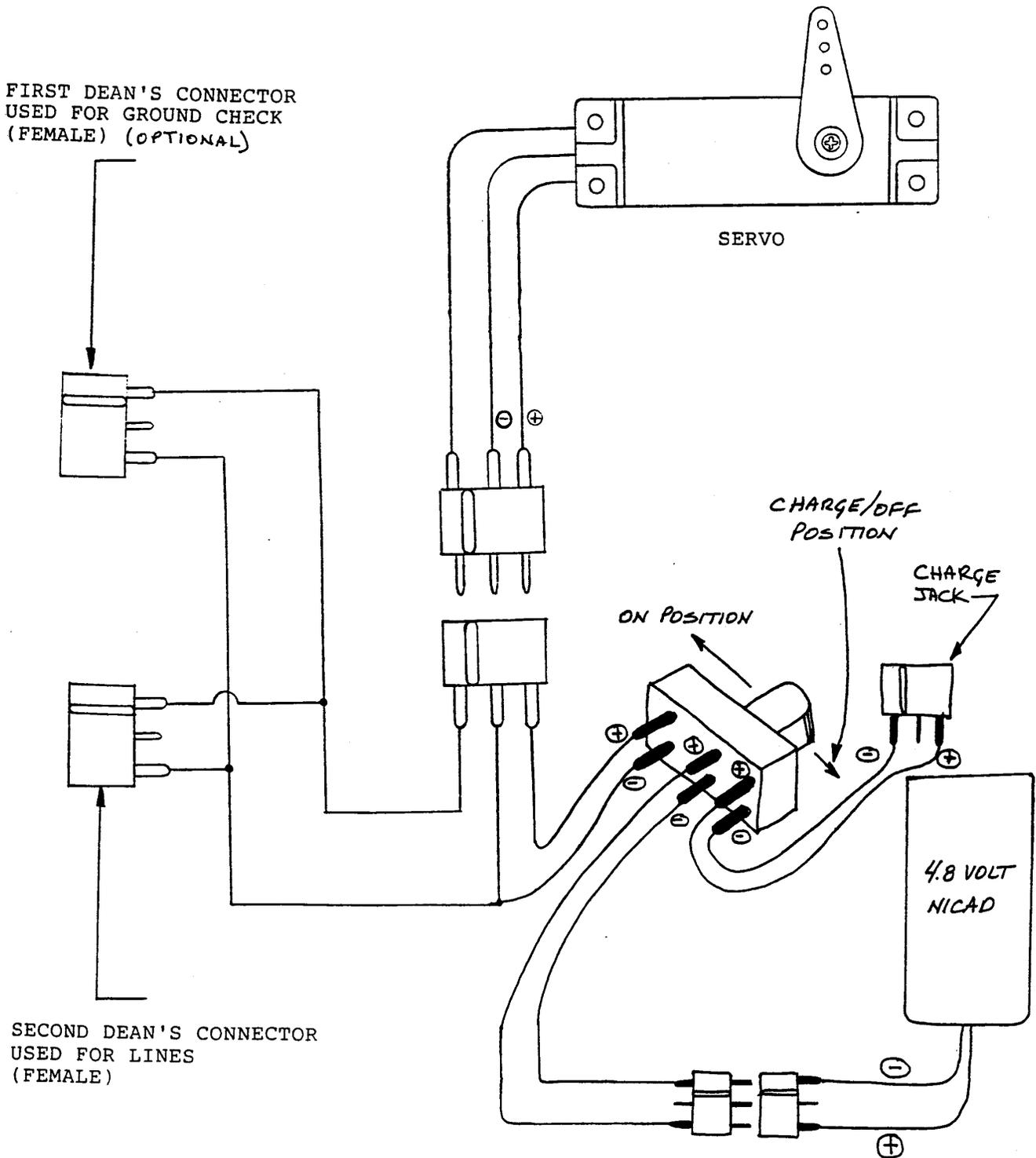


Figure 3.3 - Flight Pack – Dry cell configuration

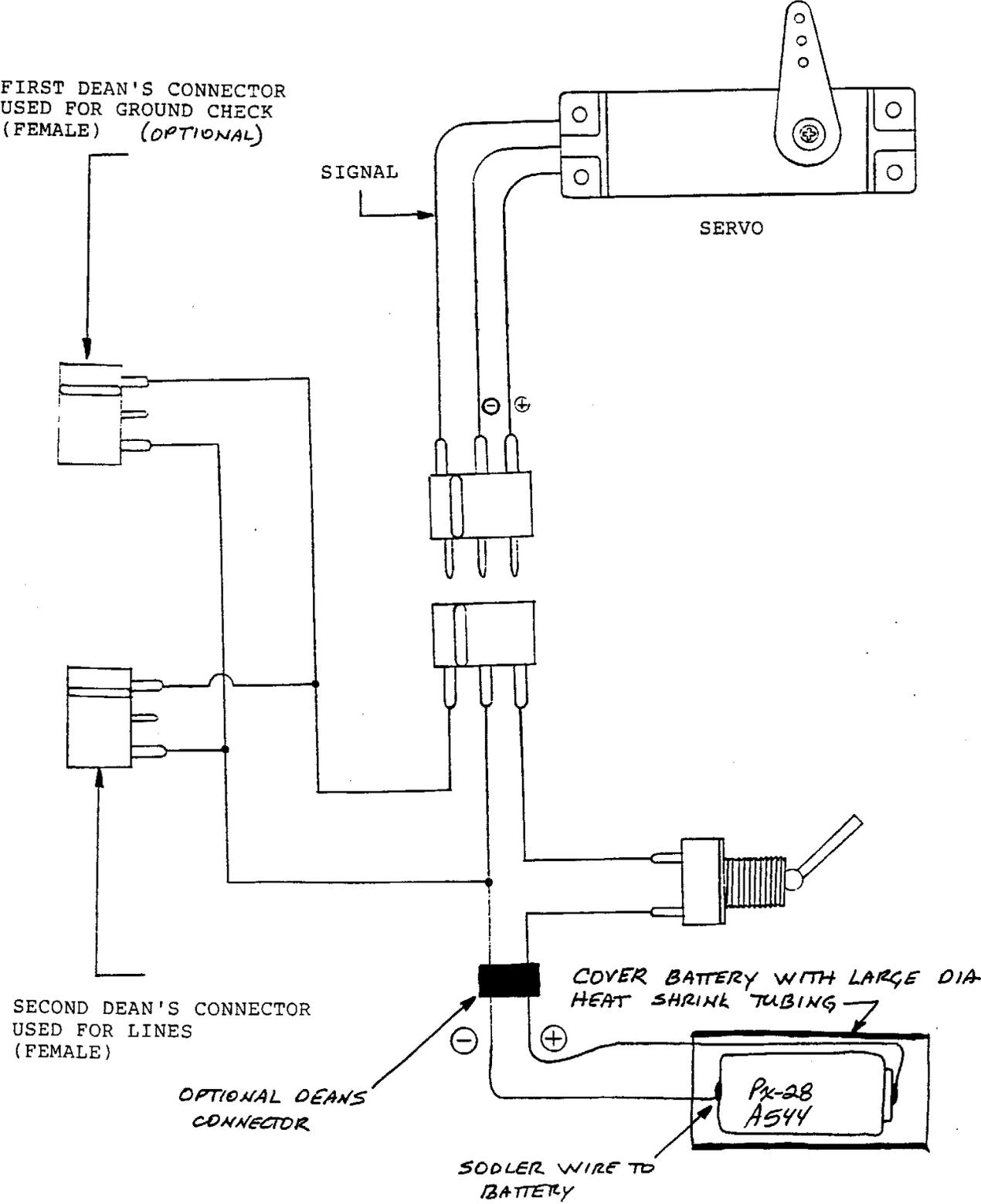
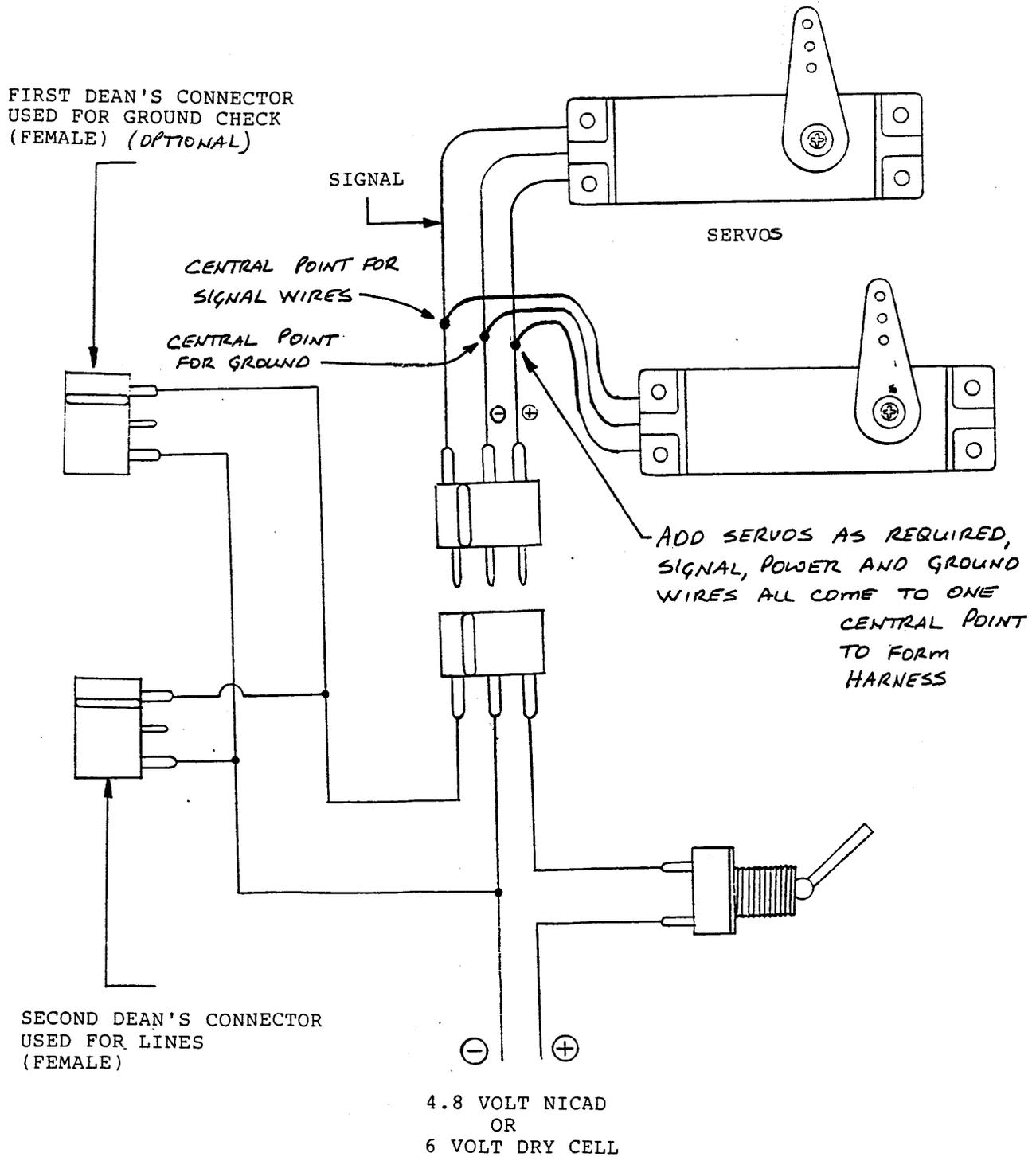


Figure 3.4 - Flight Pack – Multi Engine configuration



Chapter 4 - MULTI-CHANNEL

This section discusses an electronic control system for CL models to operate more than one feature independently by the use of a receiver and servos. The modification of a typical Radio control transmitter and receiver will be discussed.

All of the hardware used is available in most hobby shops, electronic and fishing stores and requires the modification of the RC transmitter and receiver. Any FM or AM radio control system can be converted for CL use. The conversion process removes the RF decks from the transmitter and receiver. The transmitter is hard wired to send a signal and ground to the receiver through the two flying lines. After your transmitter and receiver are converted for CL use it can be installed much like a typical RC model installation. There are currently two sources who specialize in this conversion process. See the end of this chapter for details.

The installation for a typical scale model has the receiver, battery and other hardware in the fuselage. Take advantage of the battery weight to correct a tail heavy condition. Servo extensions are required for servos located in the wing. Try to locate as much of the equipment in one location as possible, this will make servicing the model much easier later on. The receiver can be attached with velcro. The foam is not necessary since the crystal has been removed. The input lead replaces the antenna and is placed at the wing tip or fuselage side.

When the model is being flown with the multi-channel system we normally clip the transmitter to our belt. If you are right handed you will most likely operate the transmitter with your left hand and fly the model with your right hand. An extension is required so that the unit does not become unplugged from the handle connection if your arm reaches full extension. The belt clip can be made from sheet metal or you can use a prefabricated clip normally found on tape measures available in hardware stores.

The batteries used for this system are the typical Nicad batteries that come with the RC transmitter and receiver. We have not tried using dry cells for this system because the receiver was designed for the 4.8 Volt Nicad. Some receivers may be capable of handling the 6.0 Volt dry cells, but we have not tested that configuration. We have had the best luck using the standard Nicad battery normally supplied by the Radio's manufacturer.

Multi-Engine operation is a subject matter that we have been experimenting with. We have tried the torque tube method, flexible nyrods & individual servos to operate the throttle. One model was tested with a single servo mounted on the profile fuselage driving a torque tube that went to both engines. The second test was to mount a servo at each nacelle. The flexible Nyrods were found to be the least desirable choice. Properly installed; the Nyrods will work but we have found the installation of a servo in each nacelle to be the best solution. An Y-harness can be purchased from your hobby shop to operate more than one servo from one channel. This Y-harness can be expanded to drive up to 4 or more servos. A simple 2-56 threaded pushrod is used to link the servo to the throttle arm on the carburetor. Solder a clevis on one end of the pushrod and use a threaded pushrod on the other end. Locate the threaded pushrod at the servo or engine, whatever is the most accessible for adjustment.

Radio Conversion

Currently there are two sources that can convert your radio over for CL use. If you have enough tools and knowledge you can probably do the job yourself. I prefer to spend time building model airplanes and letting someone else do the radio conversion for me.

Calvin Wollitz **(Out of production)**

8996 Barco Lane
Jacksonville, FL 32222
(904) 771-0613

Bill Young Designs **(Out of production)**

4403 E. Rustic Knolls Lane
Flagstaff, AZ 86004
(520) 522-0155

Photograph 4.1 - Typical Multi-Channel setup



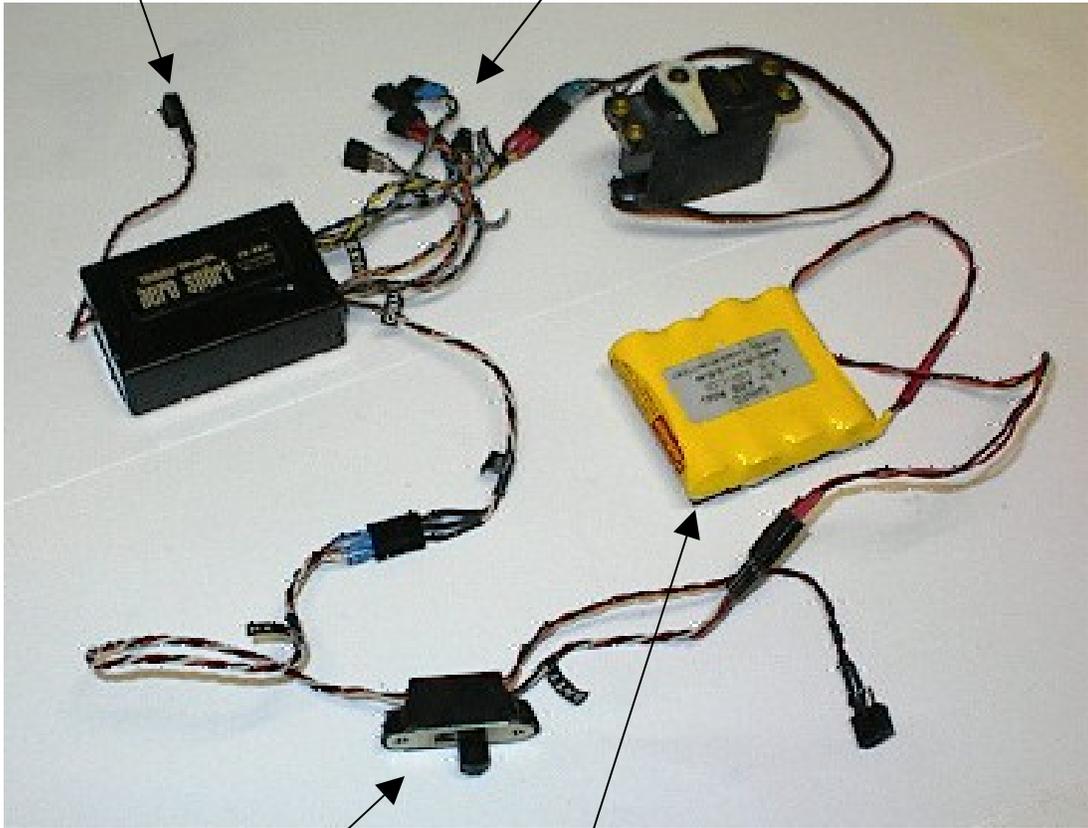
This is a typical radio control unit that has been converted for CL use. The wire plugged into the top of the transmitter carries the signal and ground out to the two flying lines. This unit happens to be a 6-channel unit with only one servo shown.

This is a good example of an older radio that is no longer legal for radio control purposes that can easily be converted for CL use. Typically these older radios can be purchased for a good price.

Photograph 4.2 - Typical Multi-Channel setup

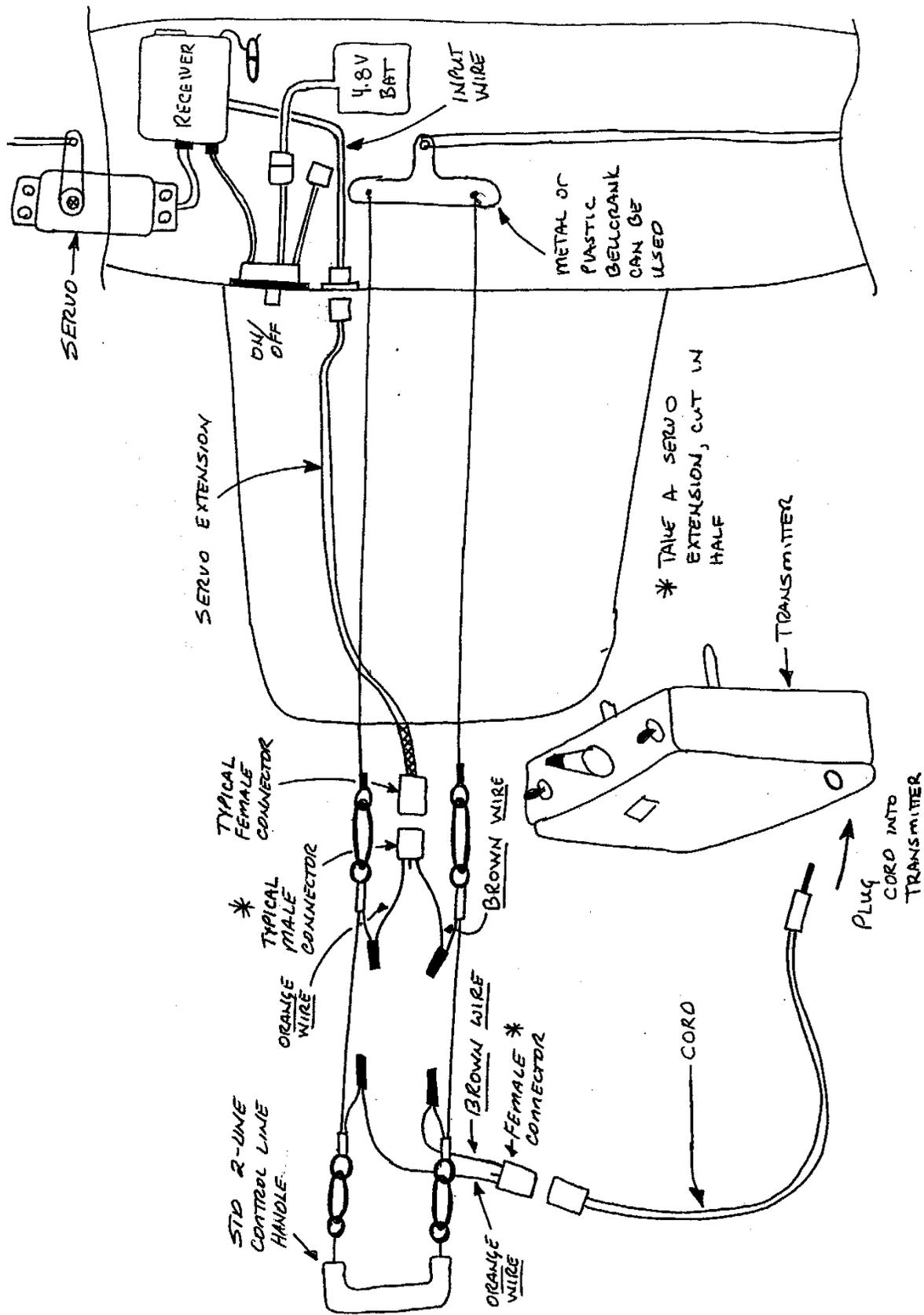
Electronic input from lines,
Signal and Ground

Servo wires



Standard On – Off switch and battery that came with radio

Figure 4.1 - Overall Multi-Channel Configuration



Chapter 5 - Direct Servo Connection - DSC

Up till now all of the equipment we have been using, either the converted radios or the servo driver required some modification. JR radios currently on market (F400, XP642, XP8103 and others) have a feature that we can use for CL. These radios can be used on a CL model without any special conversion; purchase one day, install into the airplane, and then fly CL style.

Next time you are in your local Hobby Shop take a good look at the JR line of radios. On the back of the transmitter there is a jack with the letters DSC next to it. DSC stands for DIRECT SERVO CONNECTION. When you start digging thru the instruction manual you find that the DSC function is designed to allow the RC pilot to flight check the model in the pit area. It allows the pilot to check the operation of the servos without transmitting any kind of radio signal. The DSC function basically hard wires the transmitter to the receiver bypassing the RF decks. This chapter will show how the DSC function can be used on a CL model and how it's advanced features makes this radio a real plus.

The figure pages at the end of the chapter show how the radio is set up to be used in DSC mode for RC use in the pit area and for CL. One special note, the normal switch harness that comes with the 6 channel radio needs to be replaced with the deluxe switch harness that has three wires for each bundle. The DSC function will not work with the normal switch harness that comes with the radio. The DSC cord also needs to be purchased. The DSC cord is about 6 feet long and it plugs into the back of the transmitter and the charge jack on the receiver switch harness. If the transmitter is turned ON with the ON / OFF switch on the front of the transmitter then you will be transmitting a radio signal. To turn on the transmitter for DSC mode, simply plug the DSC cord into the back of the transmitter. You will notice the transmitter turns ON, yet the ON / OFF switch is still in the OFF position. Turn on the receiver as you normally would.

Notice that the radio works the same as if you where transmitting a radio signal. The 6-channel radio has four spring loaded sticks for normal elevator, rudder, aileron and throttle control operation (if used for RC operation). Two additional toggles can be used to operate two other functions such as flaps and retracts. The radio has some other features such as 4 model memory, end point adjustment and servo reversing. We have been flying with these JR radios since 1997 and use the end point adjustment and the multi-model memory the most.

One of the models that I fly with the DSC system is a Sig Kadet Seniorita. I built the kit per Sig's instructions except I made the airplane into a tail dragger, added flaps and changed the nose section. I have a total of six (6) servos in this model. I have one servo each for the throttle, rudder, elevator and camera shutter release. In the wing there are two servos, one for each flap.

Remember when we had the radio working in DSC mode on the workbench and we had the DSC cord plugged into the Transmitter and the switch harness? Now all we need to add is a set of flying lines between the DSC cord and the switch harness to make this setup complete. Basically we are extending the 6-foot long DSC cord to 70 feet with the flying lines.

This computer radio has two features that makes setting up a CL model in DSC mode extremely easy; servo reversing and end point adjustment. While servo reversing is nothing new, this feature is standard on this radio. This allows the direction of the servo arm rotation to be reversed allowing any orientation for installation of the servo inside the airframe.

End point adjustment changes the amount of travel of the servo arm. This comes in handy when you are hooking up a servo to an air valve or flaps. Often times you have to use a really short servo arm to reduce the amount of throw for flaps. Normally a toggled servo will result in about 160 degrees of throw. With servo reserving you can limit the amount of throw from 0% to 150%. When I set up the flaps on the Seniorita I used end point adjustment to line up the trailing edge of the flap with the trailing edge of the wing. Then I used the other end point to adjust the amount of flap that is deployed. Changes can be made at the field in a matter of minutes. This way you can use a normal servo arm and never adjust the clevis hooked up to the flaps. This can be used on all of the other channels resulting in the exact amount of throw required for the job.

Since this radio has 4 model memory you can store up to 4 different settings for each channel including end point adjustment and servo reversing. You can have one transmitter and purchase additional receivers, switch harnesses, battery and servos for each additional model. Other JR radios have even more model memory if four does not suit your needs.

My Seniorita can be flown as a RC or CL model since I have installed an elevator and rudder servo. Remember that the only difference between operating this radio in DSC mode and normal RC mode is that we plugged in the DSC cord between the airplane and transmitter. We have the same transmitter and receiver and if they have the crystal installed then we can fly this model as an RC plane. So if we left the flying lines at home, moved the elevator pushrod to the elevator servo, removed the wing tip weight and line guide, this model can be flown RC style. Then with another 5 minute conversion it can be a CL model again using the same radio and transmitter. The Seniorita is not a CL or RC model airplane, it is a MODEL AIRPLANE that can be flown in either mode, RC or CL with a simple 5 minute conversion.

When flown as a CL model the transmitter is attached to the pilot's belt and operated all by touch. A few minutes of practice are all that is required to get used to the setup. The DSC cord that is available from JR is the perfect length to go from the transmitter to the handle during flight. JR also makes other radios such as the F400 (4 channel) and the ultimate XP8103 eight channel radio. JR is always discontinuing and replacing the radios with updated versions. As long as the radio has the DSC functionality it can be used for CL. Even the F400 has the DSC function, however the instruction manual does not show you how to use this feature. To date we have flown CL models with the F400, XF622, XP642 and the XP8103. Any JR radio with a DSC jack on the back of the transmitter can be used for CL flying without any special modification. Remember that you need the DELUXE SWITCH HARNESS and the DSC CORD to make the system work properly. The 8-channel XP8103 automatically comes with the deluxe switch harness while the XP652 and F400 do not. Pick the JR radio that best suites your needs, including number of channels, model memory and other features. At the time of printing this book the XP652 was currently available at your local hobby shop or retailer.

Parting Thoughts:

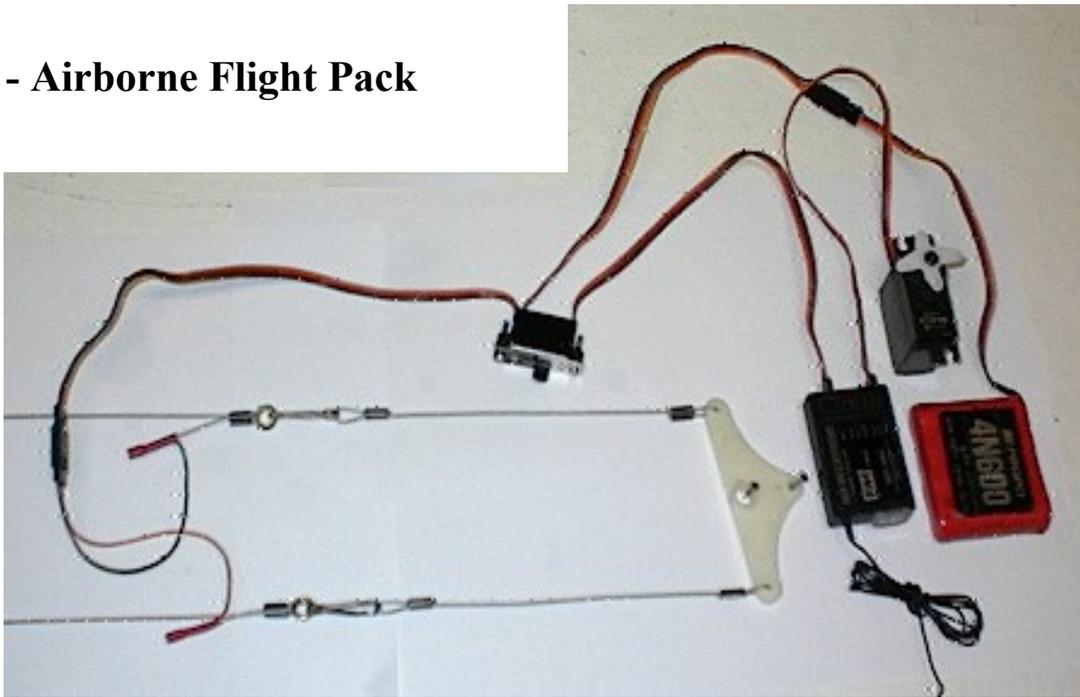
When we first discovered this system both Grant and myself had some of our models flying with the converted radios. Within 2 months we had converted our models over to the DSC radios. The computer radio along with end point adjustment made the decision very easy. Given the choice, I would choose the JR DSC radio over a permanently converted radio (See Multi-Channel Electronics chapter). Once you set up a plane with end point adjustment you will be spoiled and consider it mandatory when setting up a complex scale model. Both systems work great, but the DSC radios have three major advantages: End Point Adjustment, Multi-model memory and the units do not require any special conversion.

Typical DSC Set-up before going into the model airplane

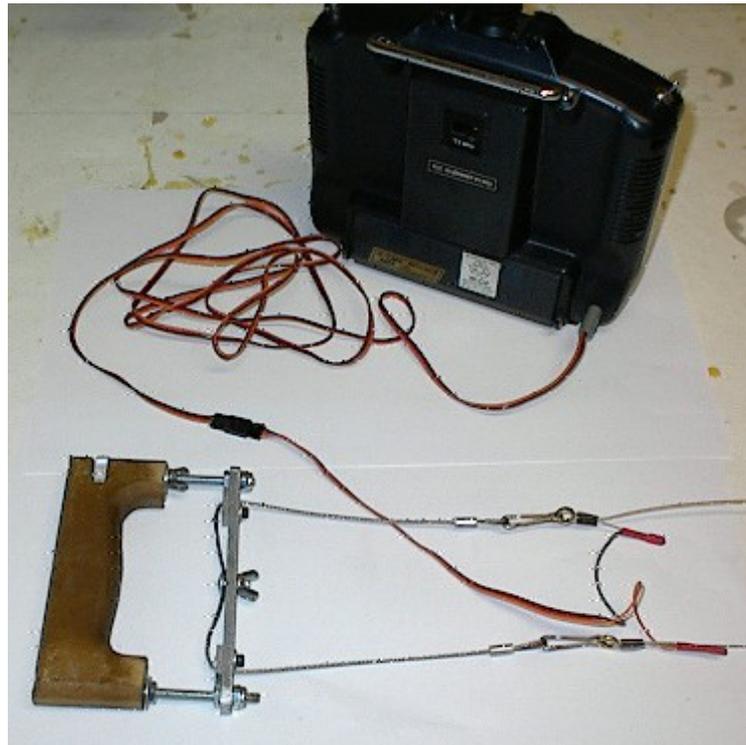


Photograph 5.1 - Shown here with one servo plugged into receiver and deluxe switch harness, this system will not work with standard switch harness

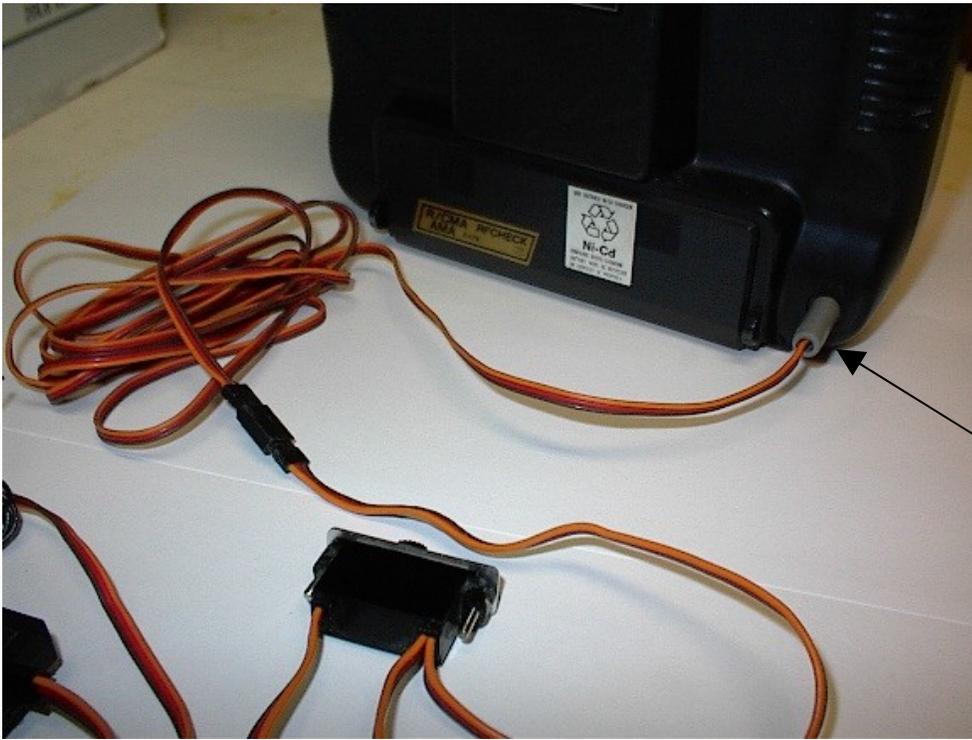
DSC - Airborne Flight Pack



Photograph 5.2 - This is what goes into the model airplane, shown here with one servo, receiver, battery, on-off switch, and bellcrank with leadouts.

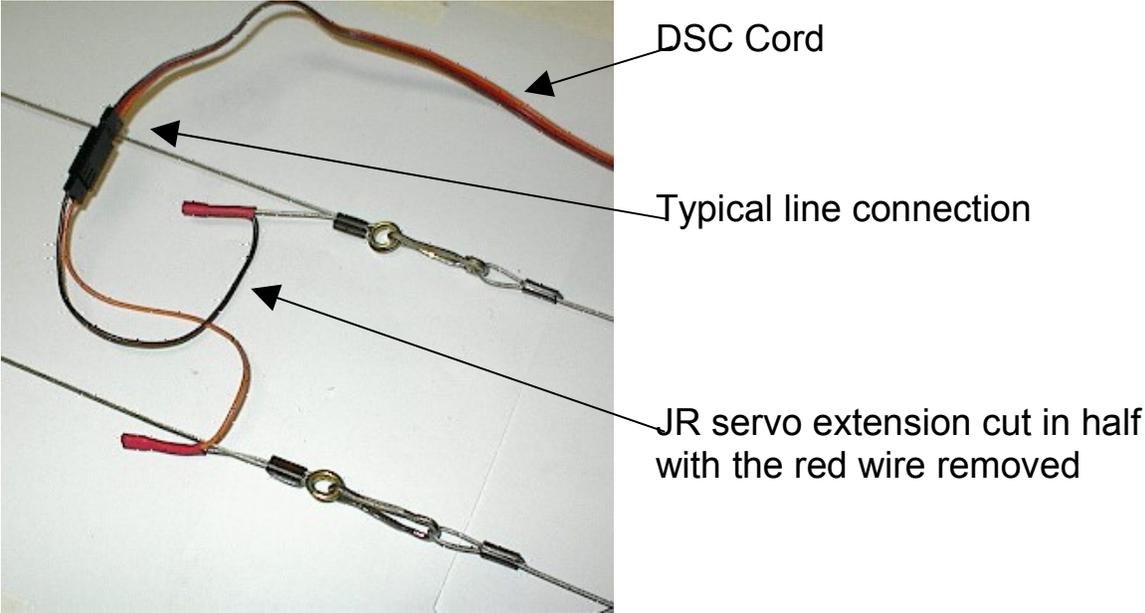


Photograph 5.3 - This is what the handle end looks like, shown here is the back side of the transmitter, DSC cord, flying lines with wire connector & handle



Inspect the wire underneath this cover to make sure the wires don't short out. This can happen as the cord gets twisted during daily use. If the wires short out here the system will be inoperable.

Photograph 5.4 - Close-up of DSC cord plugged into transmitter directly into deluxe switch harness.



Photograph 5.5

How to easily attach the transmitter to your Belt while you fly

The JR radio was designed to be held with two hands and fly a model via radio control. But we want the transmitter to hang off of our belt for CL use. Shown below are two methods that we use.

Metal Clip that attaches to belt:

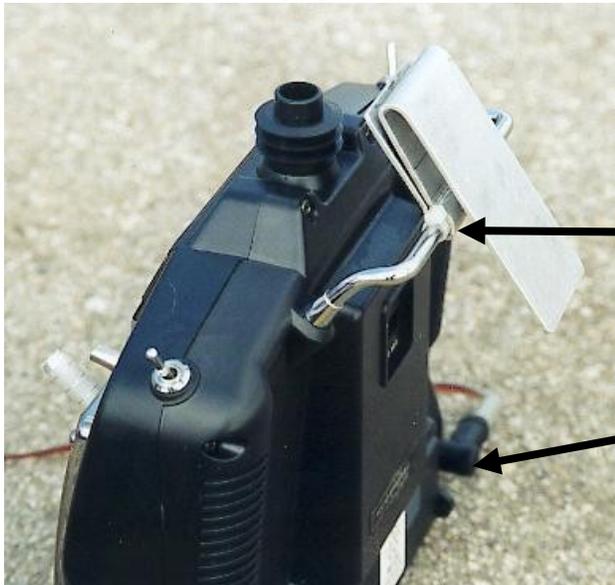


Photograph 5.6 - Grant Hiestand's and Fred Cronenwett's solution for hanging the transmitter. Simple device was made from two key clips, pop rivets and aluminum. The metal bar on the transmitter clips on as shown.



Photograph 5.7

Clip permanently attached to transmitter:



Photograph 5.8

Steve Davis fabricated this nice metal clip from a piece of aluminum. Notice he has put a zip tie on both sides of the clip to keep it from sliding back and forth. This metal clip simply slips over your belt.

Steve also uses this 90-degree adapter for the DSC cord. He found this adapter at Radio Shack.

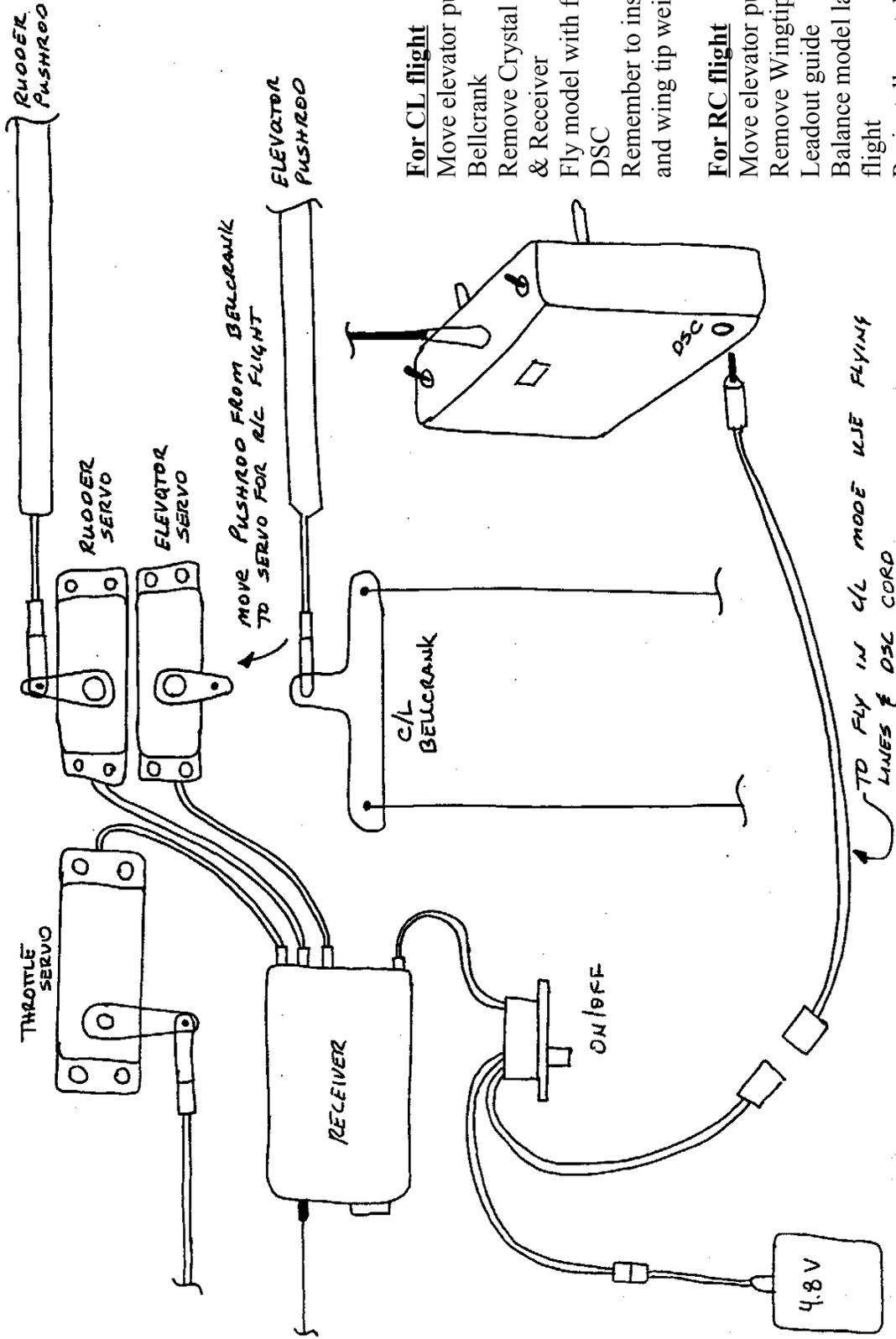
Protect the transmitter from damage

One of the best things I ever got for my equipment was a transmitter case. These small little metal suitcases protect the transmitter from damage during transport and also keep them clean. This case has kept my JR radios clean and damage free for many years now. This particular case holds both my JR radios. You can also get a case that will hold just one transmitter.



Photograph 5.9

Figure 5.1 - The Radio Control / Control Line Model Airplane using DSC



For CL flight

- Move elevator pushrod to Bellcrank
- Remove Crystal from Transmitter & Receiver
- Fly model with flying lines & DSC
- Remember to install line guide and wing tip weight

For RC flight

- Move elevator pushrod to Servo
- Remove Wingtip weight & Leadout guide
- Balance model laterally for RC flight
- Re-install crystals in receiver & Transmitter

Figure 5.2 - Overall DSC setup

Remove crystal from Transmitter & receiver
 Remove Antenna from Transmitter
 Cut servo extension in half for connectors attached to flying lines, red wire is not used

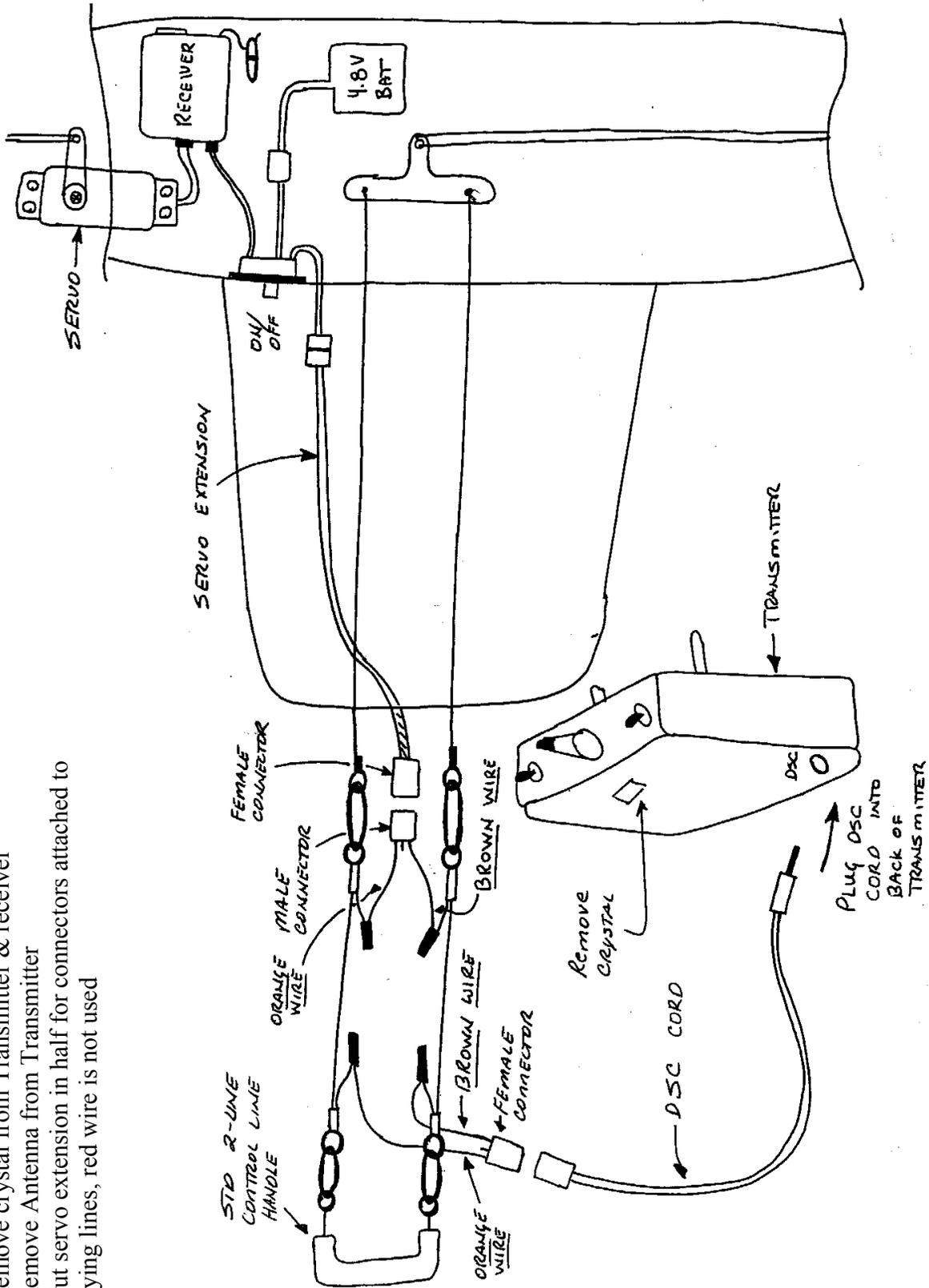
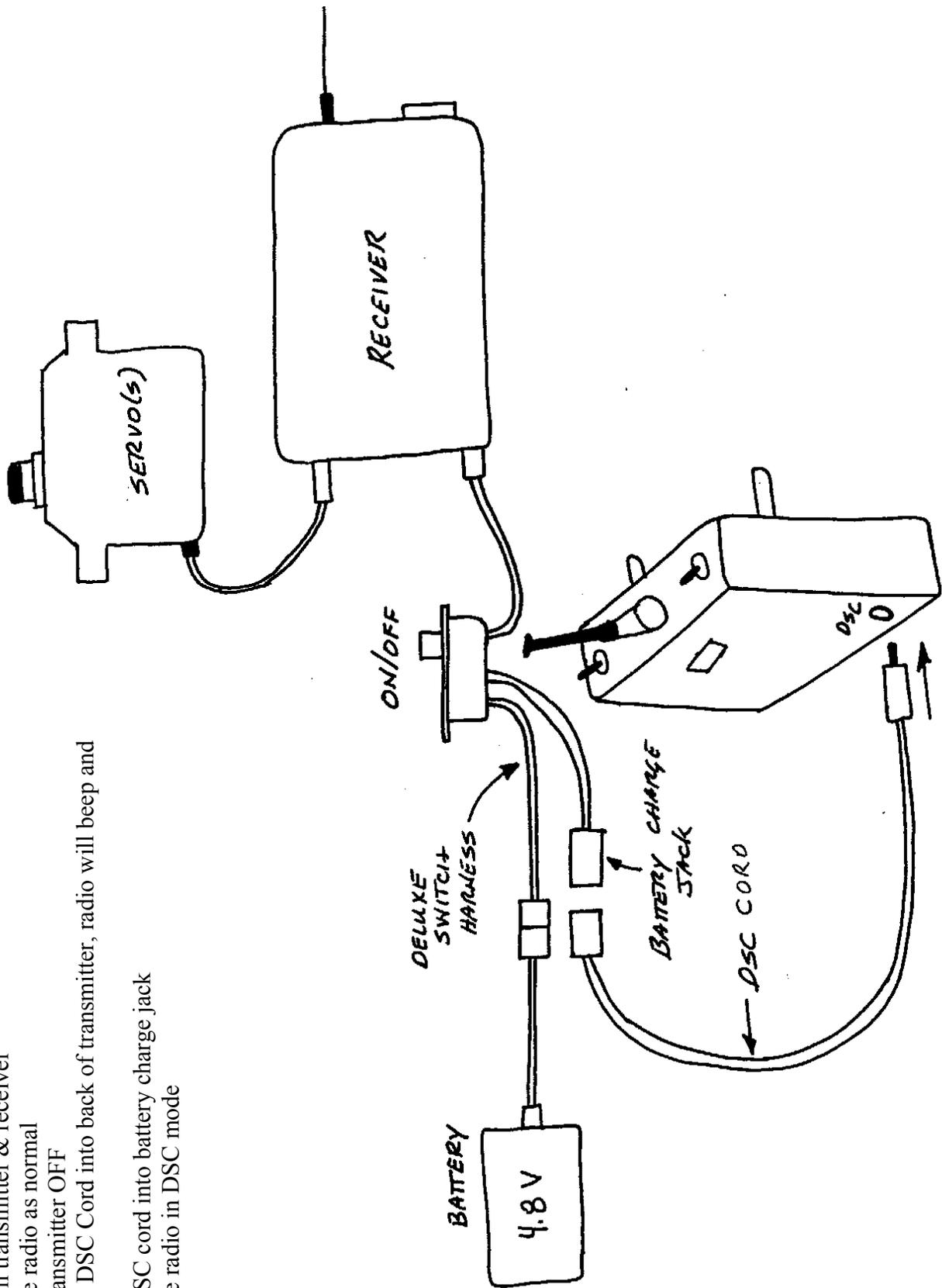


Figure 5.3 - DSC setup for the pilot in the pit area

- Assemble system per JR instructions
- Turn On transmitter & receiver
- Operate radio as normal
- Turn transmitter OFF
- Plug in DSC Cord into back of transmitter, radio will beep and turn on
- Plug DSC cord into battery charge jack
- Operate radio in DSC mode



The CL/RC model airplane using “DSC”



Photograph 5.10 - Author's Sig Seniorita: Flaps, Throttle, Rudder and Elevator Model has been flown as a CL and RC model with the same JR radio and receiver



Photograph 5.11 -Typical JR computer radio with DSC. Toggles on top left and right are great for retractable landing gear, bomb drop. Left stick is used for throttle control. The right stick, which is normally used for elevator on RC models, can be used for flaps if the spring is removed. At the time of printing the XP652 was available.

- Notes -

Chapter 6 – The Bill Young Handle

Before we get going here, let's give credit to the person who created this new CL handle. Bill Young from Arizona has been making sophisticated electronic devices for RC, CL and FF models for many years now. He is an avid electric powered modeler. He makes and sells a CL handle that combines the advantages of electronics and the typical CL stunt handle for a winning combination.

Bill has taken the required hardware and electronics and put them into a small and lightweight CL handle that has 5 channels with a comfortable spring loaded trigger for the throttle control. The toggles, trigger and other switches have been placed on the handle so that they are within easy reach for the thumb and index finger. This handle was designed to combine the transmitter and handle into one package, at the same time reducing the size and overall weight.

This Control Line handle takes a five-channel system and puts it into a handle that resembles the older 3-line handle that everyone is familiar with. It combines the precise neutral elevator adjustment capability, comfortable grip and trigger for throttle control. A toggle is located on the side for a function like flaps or retracts.

This handle has been available for several years now and has been sold worldwide. It went through extensive development testing with numerous CL pilots flying everything from carrier and electric powered models to CL scale models. The throttle control was smooth and responsive. We were able to taxi, fly steady speeds and land under power without any problems. The toggle on the left side of the handle operated the flaps. All you have to do is lift your thumb upward and the toggle is right there. This movement was very natural and does not force you to move your hand in an unnatural way affecting the smoothness of the flight. The trigger throttle control is spring loaded so if you release it during flight it acts as a deadman switch. On our electric powered models the speed control is set to be "off" at this neutral setting. The spring tension is light and easy to hold in one position.

For glow engine operation the handle has a nice feature that allows the pilot to preset the throttle to any given point for starting. This is especially useful when the pilot starts his own engine and helper holds and releases the model. There is a small throttle set button just forward of the dip switches on the top of the handle. The pilot turns on the system, pulls the trigger back to half throttle and while holding the trigger in this position, pushes the set button. When the pilot releases the trigger the throttle setting will remain at half power until the pilot returns and resets the system. Now the pilot can walk back to the airplane and start the engine at half power. After starting the engine the pilot can either push the set button again, or pull trigger past half power to regain control.

This new handle is a very easy transition from the existing 3-line handle since the trigger is in the same location. The 2nd channel (toggle on the side) can be used to drop the hook, flaps or line slider on a carrier model. The added bonus is the neutral adjustment for the elevator that is not possible with the older 3-line handle. In 1999 the .36 profile carrier event dropped the requirement to have 3 lines, thus allowing a system like this to be used. Class I and II already allow 2 line systems to be used. While the lines are thicker due to the nylon coating the number of lines drops from 3 to 2. Additionally the throttle control is not a function of line tension.

Bill currently sells this 5-channel handle and receiver that has proven to be popular due to the size and amount of functions. The weight of the handle makes a difference in how smoothly the aircraft is flown. Most CL scale models rarely have more than 5 channels, so this handle meets the requirements of the vast majority of the CL scale modeler. For those interested in a smaller, cheaper and even lighter version of the 5-channel unit he has completed a 3-channel unit that became available at the time of publication.

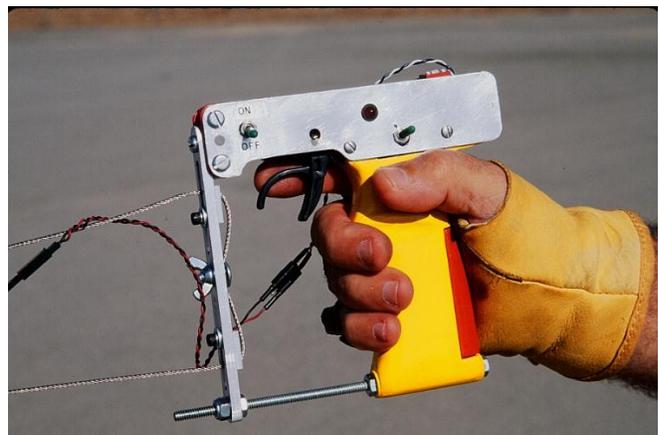
Contact Bill Young at the following address if you are interested in a handle of your very own!

Bill Young Designs **(This handle is now out of production as 2008)**
4403 E. Rustic Knolls Lane
Flagstaff, AZ 86004
(520) 522-0155

Products & Services available thru Bill Young

- 1) Fully assembled 5-channel handle & receiver
- 2) Fully assembled 3-channel handle & receiver
- 3) Buddy cord conversion for existing radios using his receiver (call for details)
- 4) Multi-channel radio conversion (see previous chapter)

Photograph 6.1 - Small and light, the Bill Young handle has neutral line adjustment, 5 channels, and comfortable trigger for the throttle. Other toggled features are placed within easy reach of the thumb and other fingers. An airplane can be flown with one hand. This is one of the early production handles that was tested.



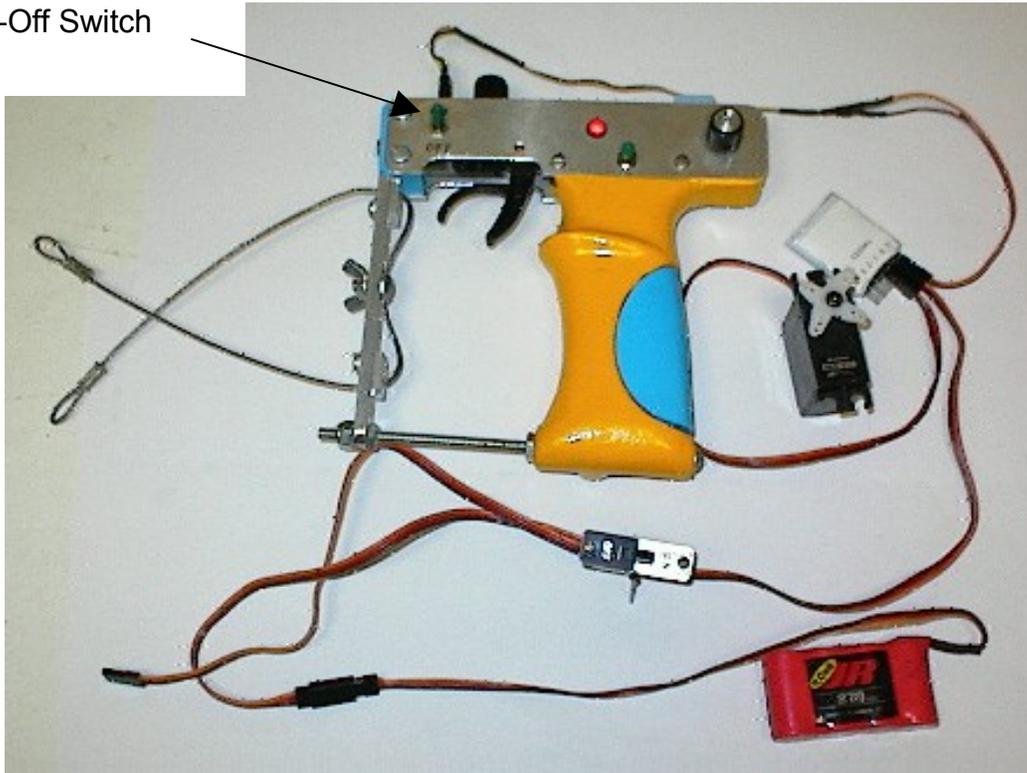
Photograph 6.2 - Author's scratch built 41" span Hawker Sea Fury built for Profile Carrier was just one of the models used to test the Bill Young handle when it first became available.

Flight pack was temporary mounted to the side of the fuselage just in front of the wing.

This model was powered with an OS-35FP and normally was flown with the Single Channel servo driver. Model weighed in at 3 lbs.

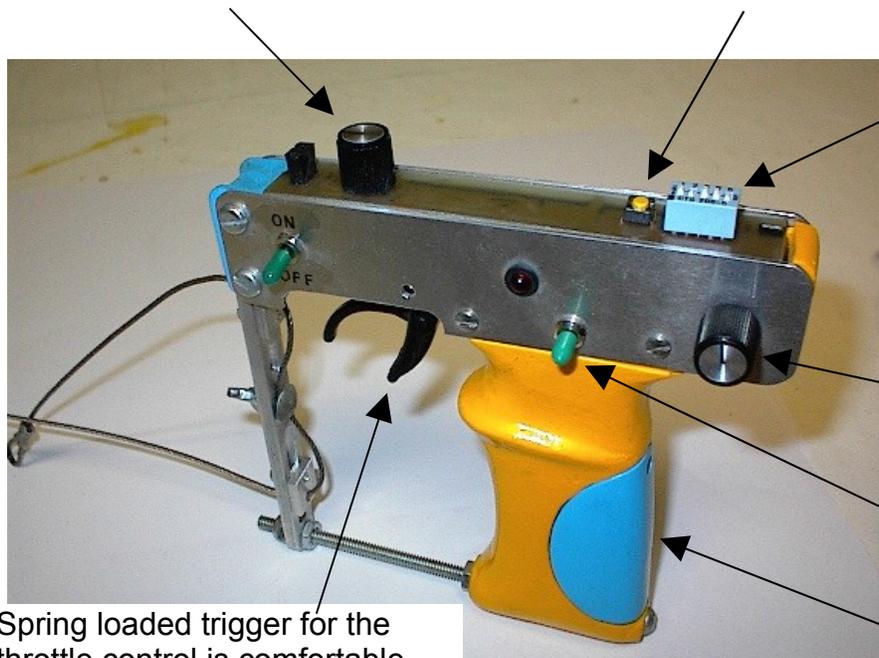
Photograph 6.3 - Typical Bill Young handle set-up

On-Off Switch



Use this dial to adjust the idle speed of the motor, trigger defaults to idle position

Push this button to hold throttle setting at any desired throttle setting to start the motor



Dip switches to control servo reversing and other custom features that Bill has programmed into the handle.

This dial is one of the channels

This toggle controls two channels

9-Volt battery is located here

Spring loaded trigger for the throttle control is comfortable and effortless

Photograph 6.4

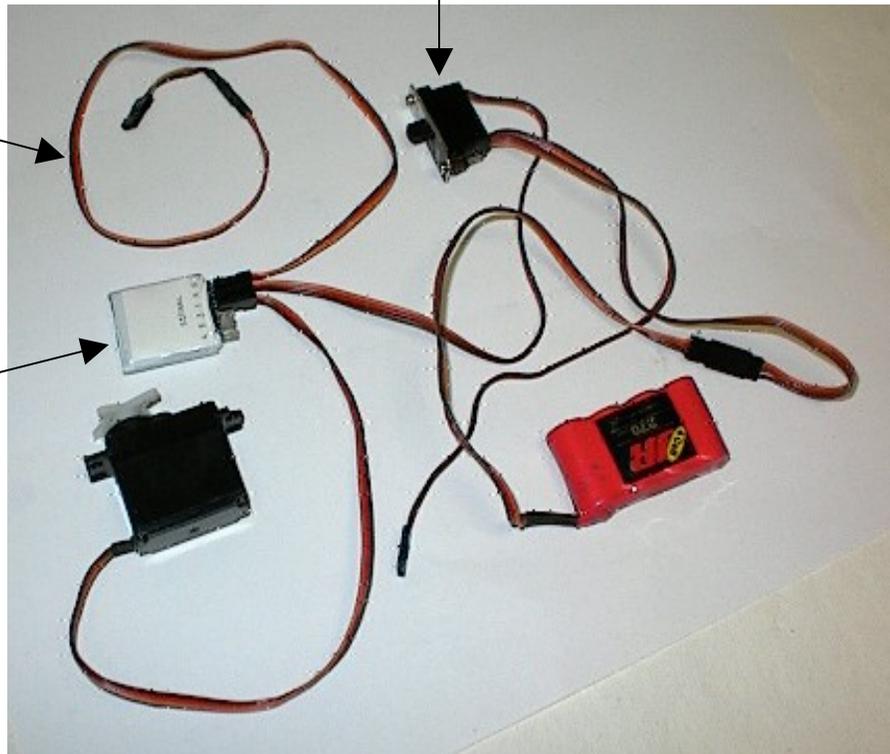
Bill Young Flight Pack

Bill Young provides the handle and receiver. You will also need to purchase a switch harness, 4.8 volt receiver battery and servos. JR equipment is shown here but other manufacturer's units will also work.

On – Off Switch, JR switch shown here with stock JR receiver battery

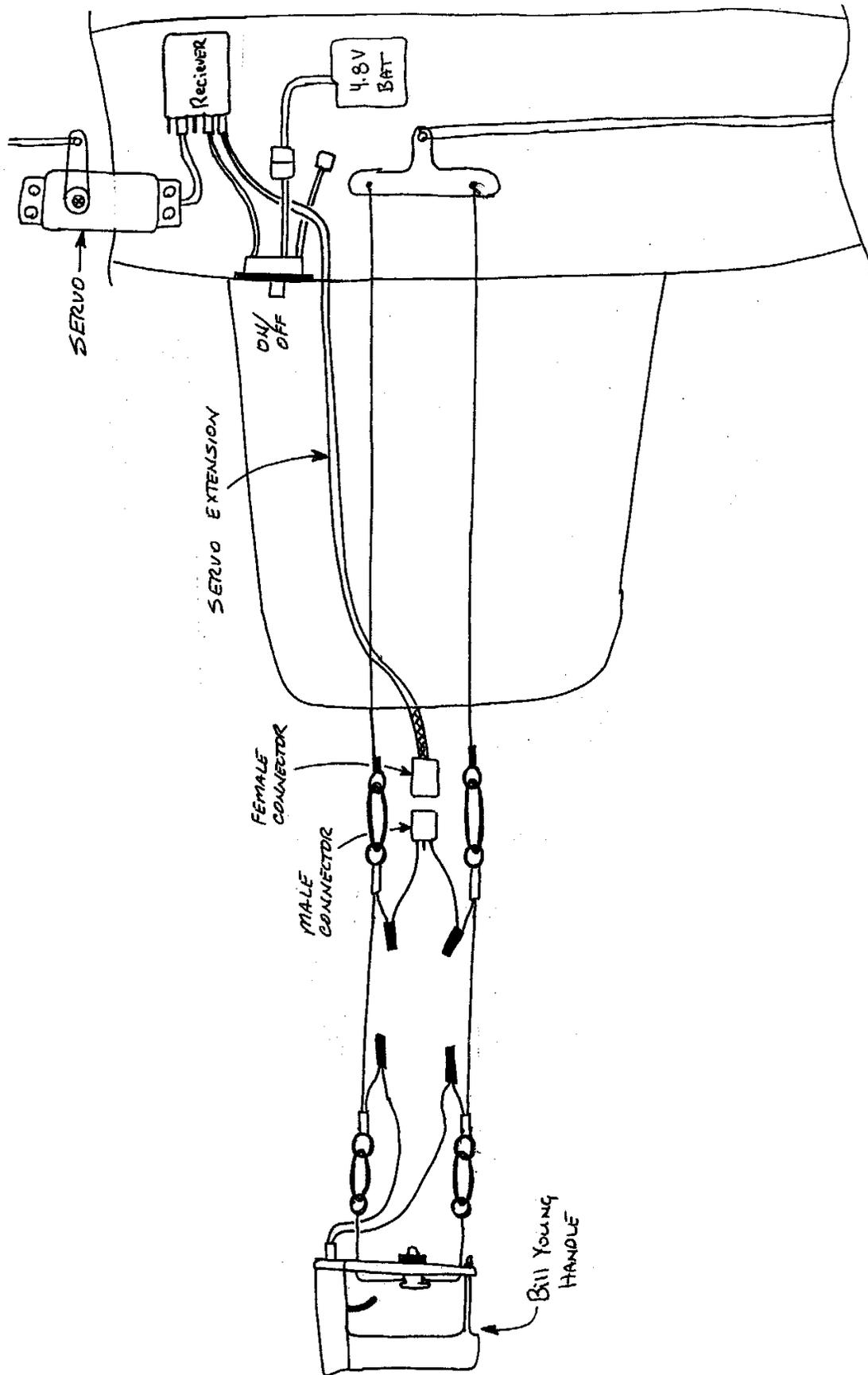
Electronic input wire, this would be located at the wing tip or side of fuselage

Receiver



Photograph 6.5

Figure 6.1 - Overall Bill Young Handle Configuration



- Notes -

Chapter 7 - A Look at Electric Power for Control Line Models

Written by Grant Hiestand

With its clean installation, virtually vibration-free performance and rock solid reliability, electric power offers some attractive advantages to the control line flyer. Nearly ten years have passed since I flew my first electric powered control line model and during that time, I have built a dozen successful planes, ranging from a modified Sig Wonder to the Sig 1/3 scale Spacewalker. For me it has represented my greatest years of growth as a modeler.

Electric power has matured as well. In the last ten years a large amount of products have been released aimed at the growing market of electric powered model airplanes. Look through the model magazines and there are numerous ads for motors, chargers, ARFs, kits and park fliers. Great advancements have been made in speed controls, motors and batteries.

While there is no practical way of encompassing the entire spectrum of electric flight in one chapter, I will walk you through a builder's project. You'll follow along as I modify a Bruce Tharpe Engineering Venture 60 kit to electric power. The principles used in this project can be applied to many other types of models from sport to scale. This will give you a starting point to further explore the ever-fascinating world of electric flight.

So what's possible with electrics?

Take a look through a magazine like Sailplane and Electric Modeler. Electrics are being flown in every size and shape from sport models to full house scale jobs. Many fine scale subjects, like Keith Shaw's Bearcat (complete with retracts) attest to the fact that not all-electric planes are gliders. They're even showing up at the Scale Masters and the Nationals, competing side by side with glow powered craft.

On the control line front, Charlie Bauer has been campaigning a profile scale B-29 as well as a Piper Super Cub in FAI competition. Electric power has also been used in CL stunt and speed models. Fred Cronenwett is building an electric powered Miles Sparrowhawk. Fred started this challenging project because of the many problems associated with running an inverted glow motor in a tightly cowled space. Not only will electric power solve the size, cooling and muffler issues, but also as a bonus, he can swing a scale diameter prop in the scale direction (clockwise). In addition, Fred, Lynn Boss and myself have electric powered floatplanes that we have been flying for several years off a float pond in Roseburg, Oregon (see plate #17 in the Photo Gallery). Not only do we have to take off from the water, but also we only have half a lap to do it in!

Be disciplined

Electric power is like a discipline. In order to fly well, an electric model needs to have the right combination of motor, gearbox, battery and airframe. If you stay within the parameters, you'll have a successful model. Many times I've noticed that our perception of what is the 'right sized model' for motor 'X' needs to be reconsidered when it comes to electrics. As a group, control line fliers tend to fly smaller planes with rather large engines because they do, after all, have to have enough power to pull the plane in addition to the lines. The line drag can be considerable especially when you're using plastic coated lines for electronic controls. So over the years, we have become accustomed to using a .40 engine on one size plane and a .25 on another because it's comfortable and we can.

Electric powered planes, however, seem to be a contradiction. They tend to have seemingly small motors attached to large airframes with generous wing areas. For example, if I put my 40-powered Venture 60 next to a .40-powered stunt model the difference is dramatic. The Venture is nearly 50% larger!

Like gas powered models, electric motors have a size of model they perform well on. A 40-electric motor on a .40 sized stunt ship would be a disaster. Because our 'fuel tank' is heavier, we need a bigger wing to get the wing loading into a manageable range. For the most part, the Astroflight motors I've used seem to be every bit as powerful as their glow powered counterparts. By that I mean the 40 seems to be the equivalent of a gas .40, and so on. However, it's not a total crossover. Gearboxes allow the motor to swing large diameter high pitch props making the geared 40 act more like a glow .60. It's this flexibility that allows the seemingly smaller motor to do miraculous things. Let's look at the numbers.

What kind of performance can you expect?

In my experience, general sport and scale competition flight is well within the capabilities of electrics. Smooth takeoffs, touch and goes, and just plain old flying fun will keep you busy for a while. You can push the envelope, depending on the plane, to include formation flying; speed, stunt, multi-engine models, camera carrying and even float flying if you're so inclined. None of my planes are able to stunt, but then they are purposely designed for smooth, stable flight. There are some individuals, such as Tony Naccarato, who have been experimenting with stunt and I had the pleasure of seeing him fly the model airplane some years back. His plane could fly for about 2 ½ minutes and was capable of figure eight's, inverted flight, overhead eights, wingovers, loops, etc.

Flight duration is closely tied with wing loading and power allocation. Planes with less than a 20-oz wing loading can easily stay aloft for six minutes or more providing you fly level and at a conservative cruise rate. We coaxed Fred Cronenwett's Piper Cub into a 15-minute flight on a calm day with judicious control of the throttle. As the wing loading or power usage increases, flight time decreases. Here's a look at some of my planes and their flight performance:

<u>Plane</u>	<u>Wing Loading</u>	<u>Duration</u>
Venture 60	17.10 oz/sqft	8-10 min
Venture 60 on floats	23.2 oz/sqft	5-7 min
G&P Sales Grumman Albatross	29.75 oz/sqft	5 min
Great Planes Piper Cub (ARF)	18.6 oz/sqft	8-10 min
Great Planes Piper Cub on floats	26.45 oz/sqft	5 min
Sureflight Cessna 182 floatplane	15.48 oz/sqft	7 min
Boeing 314	17.55 oz/sqft	5 min
Spacewalker (1/3 scale)	21.76 oz/sqft	5 ½ min
Sig Kadet Senior	15.51 oz/sqft	12 min

As you can see, the longer flight times belong to the Venture 60 and the Sig Kadet Senior. Both use the Astroflight geared 40 and are fairly close in wing area. As we approach the 30-oz/sqft range, flight times decrease and these planes really start to become sluggish in the air. Notice that the Boeing 314 has a low wing loading but short flight time. Direct drive, high amperage motors were used at nearly full throttle to fly this plane and flight time suffered because of it. The Spacewalker flight times are conservative based on the fact that I taxied part of the time on the ground as one of my competition options. In addition, I usually land with some reserve power to taxi back to the pits.

What do you need to get started?

I'm assuming you have no electric power experience or equipment, so at first this list might seem fairly large. In a nutshell, here are the components you will need to build this project:

- Venture 60 kit (I used the optional wheel pants set)
- 3" or larger bellcrank (Brodak, Sig and others sell many designs)
- Astroflight geared 40, sport version (standard gearbox)
- Master Airscrew Electric 13-8 prop
- 18 cell battery pack, 2000 mah or greater (I recommend "matched" SR packs, two rows of nine cells, staggered spacing).
- Astroflight 204 speed control
- JR 642, 644 or higher radio along with the DSC cord and deluxe switch harness, or Bill Young's handle
- Battery charger (I recommend Astroflight 110D or similar)
- Handle
- Flying lines: 60lb test, nylon coated (see chapter 2 for line construction)

There are a lot of different ways you could go on the motor and charger. I recommend using the Astroflight brushed motor over brushless unless you have someone who can give you some good advice on what to get. I use SR packs and have flown for eight years with some, close to ten years with others. These packs and a good charger will keep you flying for a long time. Please, please, don't short change yourself by trying to save a few dollars on cheap equipment. As Keith Shaw, a well known electric flier says, "**Buy cheap, buy twice**". As far as chargers go, I advise going with one that will charge at least 18 or 21 cells at once. You then have the option of charging multiple packs at the same time or one big pack. I'll explain more about chargers later.

A Venture Adventure: The Venture 60

Of all the airplanes in my collection, the two Ventures in my fleet are my favorite sport models (see photograph 7.1). The design combines strength with lightness, good looks and great flight performance. According to the spec sheet, the .60 glow powered version weighs 7 ¼ lbs. My Venture comes in exactly 6 ½ lbs...ready to fly! Building this electric conversion will not only give you a great flying model but will also give you the experience needed to tackle more complex subjects later on.

The Venture 60 Kit

The kit consists of precut lite ply fuselage sides and doublers, lite ply ribs, machine cut wing ribs, tail parts, canopy and an aluminum pre-bent landing gear. A parts bag includes the necessary blind nuts, clevises and so on. A nice set of stick-on decals is included as well. The first one was constructed to match Bruce Tharpe's prototype with transparent orange covering and the second was kit-bashed to resemble a Macchi MC-72 Schneider Cup racer.

Converting the Venture 60 to electric power

1. Fuselage

The fuselage is a straightforward slab sided design with slots cut out at key points and ribs with tabs that slide into them. The whole thing is self-aligning and builds rather quickly. To save weight, I decided to use the lite ply sides and doublers as patterns to cut duplicate parts out of 1/8th inch contest balsa. You can use this trick on any kit or plan built airplane. Often times you will be able to match or even come in under the specified finished weight. You'll need to find some 48" long stock for the sides; the doublers can be made from a 36" piece. The bottom fuse pieces are substituted in the same manner.

Lay down your 48" long piece of balsa and put the lite ply fuselage side on top. Push several modeling pins through both pieces around the perimeter to keep things from shifting around. Now cut around the lite ply pattern. You should be able to cut right to the edge for a perfectly shaped part. Cut the notches for the ribs while everything is still held down. Do the same for the other fuse side, the doublers and bottom pieces.

Once you have the pieces cut out, you can assemble the fuselage according to plan. Go ahead and use the ply formers, firewall and landing gear mounting block. The plywood plate that acts as a floor for the fuel tank will become your battery shelf. It can be glued in or made removable, depending on how you want to remove the battery for charging.

On the stock Venture I wanted to maintain a seamless look so the battery plate was glued in. That means that I have to take the wing off every time I want to change out the flight pack. To get the 18 cell into the fuselage, you have to turn the bellcrank to one side. A little fussy, but it works and it does give a clean look to the finished plane. I put a small removable hatch on the bottom of the fuse to facilitate changing of the receiver battery and speed control if necessary (see photograph 7.4, 7.5 & 7.6).

On the Macchi I wanted easy access to the flight pack because removing the wing also involved removing the floats. Just aft of the firewall I made a removable hatch 6 ¼" long which I carved from a balsa block (see photograph 7.7 & 7.8). You'll have to make a small plywood sub-rib to support the curved balsa turtle deck. A small 1/8" dowel was installed in the front and a Bob Violett hatch set was installed in the rear portion.

The battery plate sits on two ¾" balsa triangle stock rails, one on each side of the fuselage. In the space underneath the plate there is room for the receiver, receiver battery and speed control. You can see by the photograph 7.9 that the on/off switch is mounted to the plate and there is plenty of room for the flight pack. A 1" hole makes the battery plate easy to remove, as well as provides an opening to attach the speed control wires to the motor.

Once you have installed the battery plate to your liking the rest of the fuselage is a piece of cake. To provide a strong support base for the bellcrank mount, two 1/8" plywood plates 2 ½" x 3" are centered 4 ¼" back from the leading edge of the wing. Mine were cut to fit between the upper and lower sections of the doubler (see photograph 7.4). A Sig 3" bellcrank is mounted on a hardwood rail that spans the width of the fuselage. I used a carbon fiber arrowshaft for the pushrod.

- **Tail Feathers**

The horizontal stab and elevator are built according to plan. Use the spruce spar that spans the width of the stab. The fin and rubber likewise are stock. On the stock Venture, I added some circular cutouts to the tail feathers. These ended up being mostly decorative, as the weight savings was fairly small.

On the Macchi I left the fuselage and tail feathers solid (no cutouts aft of the wing) then fiberglassed the whole affair. The weight penalty was 37 ounces. This included not only fiberglassing, but also the floats and their struts. This turned out to be a wise decision, as the plane tends to take a beating flying off water. To compensate for the extra weight and to get off the pond faster, the Macchi has an Astroflight superbox installed and an 18-10 prop. Although not as nimble as the stock Venture, this plane still flies well and makes a good floatplane conversion.

- **The wing**

The wing was built per plan except in the case of the wing spars. The spruce spars were replaced with the same sized balsa stock. The results were noticeable weight savings. The rib where the leadout guide is located was doubled up with a balsa subrib to act as a mounting plate for the leadout guide. The leadout wires are 1" apart and are centered 4 ½" back from the leading edge. I chose to convert the ailerons to flaps. I installed the aileron servo per plan and coupled both aileron horns together with a section of 2-56 wire. The servo pushrod connects to a clevis trapped between the two control horns.

- **Mounting the motor**

The newer Astroflight motors have a hexagonal gearbox with tapped mounting holes. If you choose to use the motor as a direct drive there are also tapped holes in the case. The firewall is in front of the motor instead of the typical behind the motor as with most glow engines (see photo 7.3). This mounting technique allows for effective motor cooling since electric motors can get quite hot and you want to provide adequate cooling just as you would for a glow engine. Most of my planes have a large hole or several holes in the motor mount itself (or cowl), so that air can enter the cowl and exit through the fuselage.

- **Wiring**

Figure 7.1 shows the typical layout of all my electrics. When you hook up the system, the motor battery or flight pack connects to the battery side of the speed control. This is usually labeled on the speed control to avoid mistakes. The motor side of the speed control connects to the motor. Whenever I set up a system, I put an Astroflight zero-loss connector on the motor side, and a Sermos connector on the battery side. That way it's impossible to wire things up backwards. The speed control input lead goes into the throttle channel on your receiver. Install the electronic controls as you would normally (see DSC, Bill Young or multi-channel electronics chapters) for the input wire, on/off switch and other connections.

- **Radio**

I use the JR 642 radio with DSC controls for the stock Venture 60 and the Bill Young handle for the Macchi MC-72. Both systems work well. I chose the DSC radio for the stock Venture 60 with flaps because of the end point adjustment feature. The Macchi is flown with the Bill Young handle for simplicity. See the Chapters on DSC, Multi-channel or the Bill Young handle for electronic controls that can be used for proportional throttle control for electric powered models. One important note, the Single channel system does not work with the modern speed controls. The speed controls are designed to find the signal from a radio control receiver and automatically set the idle point. If your speed control has a manual adjustable neutral and gain, then single channel will work but if your speed controls are newer they won't have this feature and will not work with single channel. Astroflight used to make speed controls with adjustable neutral and gains, but this dates back quite a few years. Bottom line, you will have to use either a DSC, Multi-channel or the Bill Young handle when flying electric powered models with proportional throttle control.

- **Finish**

The stock Venture was finished like Bruce's prototype with transparent orange Monokote. I also put the optional wheel pants on and polished the aluminum gear to a mirror finish. The Macchi was painted with Nelson Aircraft's water base paint. A clear coat, also from Nelson, was applied and buffed out to a high gloss.

- **Testing the System**

You will notice on figure 7.1 that there isn't a separate switch for the motor and receiver. That's because we take advantage of the loss of signal circuit built into virtually every speed control to act as our on/off switch. As long as you aren't sending a signal into the receiver, the motor will not come on. That means, however, that you must be careful when you get ready to activate the system. If using DSC electronic controls also remove the crystal from the receiver to make sure you don't pick up any radio signal from your nearby radio control flying field.

Some speed controls, like the Astroflight 204, have a circuit built in that read the position of the throttle stick when the system is turned on. If the throttle is set to full and you activate the system, the speed control won't come on until the throttle stick is returned to the 'off' setting. Most of my older speed controls don't have this feature so I play it safe by checking the stick position **before** I plug the DSC cord into the transmitter. If you are testing the system for the first time, I recommend that you test it with the propeller removed. You won't hurt anything by doing this and it will provide an additional safety margin in case anything does happen. So with the system hooked up on your test stand perform the following steps:

1. Verify that the throttle stick is in the **Idle** position.
2. Turn the plane and system **on**.
3. Plug the DSC chord into airborne unit on model airplane.
4. Plug the DSC cord into the back of the transmitter.
5. Advance the throttle. The motor should operate through all speed ranges.

Note: We had a case where the speed control wouldn't operate because the throttle setting was set to something other than -100% to +100% on the JR radio. You can set the endpoints of the servos to most anything, but not the throttle when using a speed control. Check the numbers in the setup window if you are in doubt or are having trouble.

- **Battery Placement**

Balance on an electric model is achieved by moving the battery fore and aft. When you build the electric powered model allow for the battery to be located further aft or forward at any time. This allows you to make adjustments in the field, thus moving the center of gravity. Mine flies just fine with the leading edge of the battery pack 5" from the front of the fuselage. Secure a small amount of Velcro to the battery plate and a matching piece on the battery itself. This will keep the pack from shifting in flight and also allows for easy removal. Because of the pack's length, there is only about an inch of clearance before it hits the bellcrank.

- **Batteries, Charging and Flying**

As I mentioned at the beginning of the chapter, the subject of electric flight is vast, therefore I will only be able to give you an overview of how I go about battery charging and maintenance. There are several books available such as Entering Electrics by Harry Higley that give an in depth coverage on this and other aspects of electric flight.

For quite a few years now I've been flying with SR Batteries packs and they have always performed flawlessly, both in sport and competition flying. They feature matched cells and are guaranteed never to form a memory. Cells that are matched have been tested by a computer in order to determine their charge/discharge cycles. Flight packs made from matched cells will act similarly in their charge and discharge times. From my perspective, this provides a bit more reliability than building a pack from random cells out of a box at a hobby shop. SR will also build a pack in any configuration you require. The cost of a pack from SR is a bit more than you'd pay to make a pack yourself, but a lot of testing goes into making a matched pack and I'm willing to pay a little more to get the best for my aircraft. I have built my own packs and it's been hit and miss. Sometimes a cell will go bad in the larger packs and I'll have to tear it apart and replace it. I've had better luck with the seven cell packs than I have with larger ones. Still, if you want a specially shaped pack or just want to roll your own, it's a skill that will serve you well in the years to come. Remember that quote "**buy cheap, buy twice**"!

As far as chargers are concerned, you'll definitely want peak detection and if possible AC/DC operation. Peak detection allows the charger to automatically terminate the charging process when the pack is full. Packs that have been overcharged can be permanently damaged and their life span shortened. Look for a charger that has the capacity to grow with you. If you want to charge two 18 cell packs at once, it's nice to have a 36 cell capacity charger. You'll also need to trickle charge the pack occasionally as well. Having a charger that can plug into the wall will save you the expense of buying a separate power supply. When I get to the field I have two trickle charged packs and can fly as soon as I have the model airplane assembled. After the second flight I charge both packs together in series, usually at 4.8 amps for about 25 minutes. The negative lead from the first pack is plugged into the positive lead of the second pack leaving you with a spare positive and negative lead that you can now hook up to your charger. That is why I use Sermos connectors. A string of packs can be charged together and is limited only by the capacity of your charger. My SR charger can charge up to 36 cells at once. Charging this many cells at a time requires a fair amount of amperage. Although the maximum charge rate may read 5 amps on the charger's dial, there is always some loss in the system. The actual current draw from the charger on a 36-cell pack is probably closer to 25 amps. If you were to hook everything up and simply start charging, your car battery would drain in short order. Instead, you should charge packs of this size with the car engine running so that the alternator can supply power to the battery while the charger does its job. This will also assure you that your car will start at the end of the day.

Slow charging after a day of flying will allow the cells to return to a leveled state. Ideally, your battery charger should be able to slow charge whatever flight packs you intend to use the next day. I love the fact that I can slow charge both my 18 cell packs at the same time. I charge my packs for about 16 hours at 1/10th their rated capacity the night before I plan to fly. 1500 mah packs get a .15 amp charge rate, 2000 mah packs get a .2 amp rate and so on.

- ***Flying***

By now you will have tested the system thoroughly and are awaiting your first electric powered flight! One of the side benefits to using electronic controls and electric power in combination is that you can takeoff solo. With the transmitter in the center of the circle, but no DSC cord in it as yet, I turn on the plane. With no signal from the transmitter, it sits and awaits my command. At the center of the circle I verify the control stick is at the OFF position, plug in the DSC cord and start the motor. From this point on, I can fly out the charge on the battery or land in the middle of the flight to make an adjustment on the handle. Or I can shut the motor off up high and glide for a bit, then restart just before the wheels touch and climb back up again. Whatever you decide to do, have fun with it! After all, that's what this hobby is all about!



Photograph 7.1 - Grant Hiestand's Venture 60 electric powered airplanes, the stock Venture 60 is on the left, the highly modified version was kit bashed to look like a Macchi MC-72 Schniieder cup Air Racer. Both models are powered with an Astroflight 40 electric motor and use electronic controls.



Photograph 7.2 - This is how Grant installed the Astroflight Geared 40 in the stock Venture 60.

Several things are important here:

- 1) Provide enough cooling, the motor gets hot if run fast for extended period of time
- 2) Electric runs vibration free so you don't need as much re-enforcement as you would normally if you had the normal glow engine installed
- 3) Remember to balance the propeller
- 4) Use the tapped holes in the gear box to mount the motor to a plywood mount has shown (behind spinner)

Photograph 7.3- Grant Hiestand's Venture 60 soars overhead. This model is flown with DSC electronic controls for flaps and throttle control. Powered with an Astroflight geared 40 (standard gearbox), 13-8 Master Airscrew electric propeller this model flies great. Just the right combination of weight, power, size and wing area



Photograph 7.4 - This what the interior looks like of the stock Venture 60. The section above the wing is used for the bellcrank, electronic input lead and battery is installed in this area.

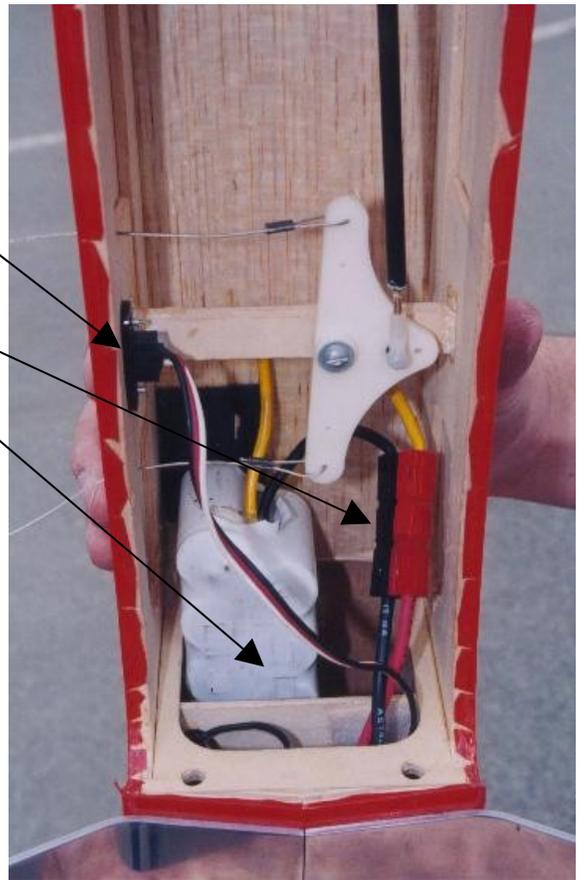
Electronic input lead to Bill Young receiver

Sermos connector from 18 cell flight battery to Speed control

Main flight battery is installed thru here

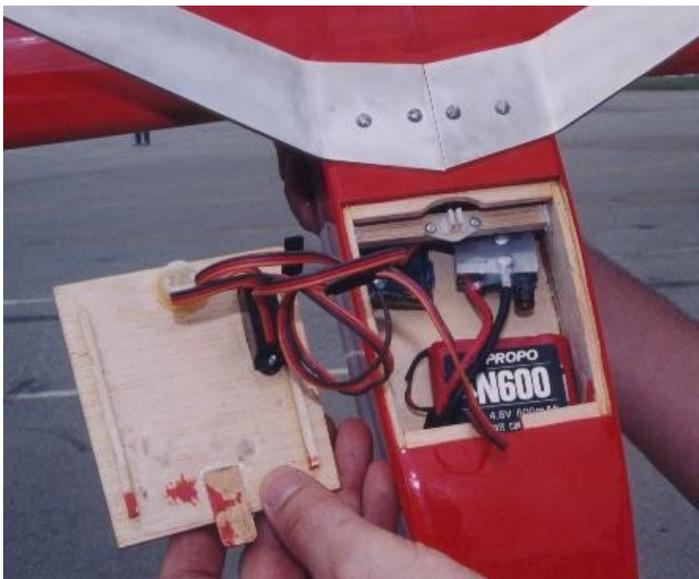
Notice how clean and new this model looks? At the time this photograph was taken this model was at least 4 years old and a veteran of many flights. Electric powered CL models avoid the fuel soaking that glow powered versions are exposed to.

Grant chose to put all of the electronics behind and below the motor as shown. The hatch with the push button release reveals the typical DSC electronic controls with a receiver, battery, speed control and ON-OFF switch. The wing has a flap servo that must be connected when the airplane is assembled

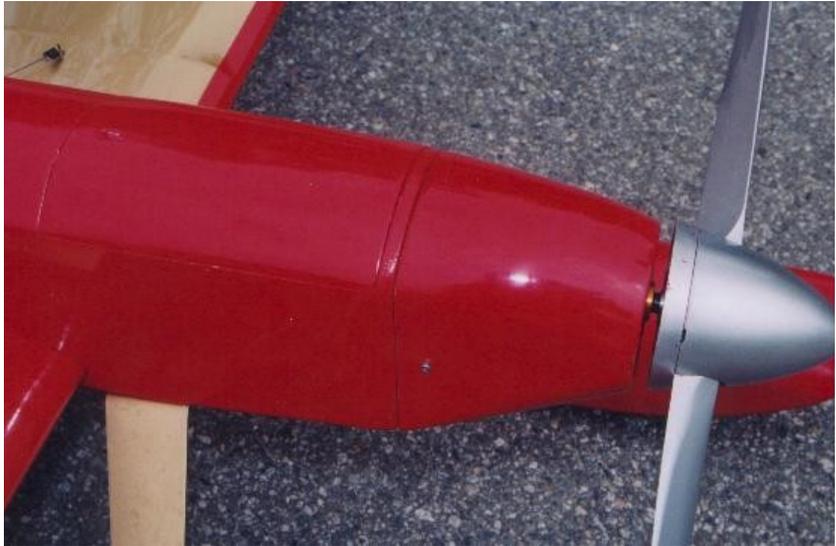


Photograph 7.5

Photograph 7.6 below



Photograph 7.7 - Grant took an alternative approach to installing the electronics and battery in the Macchi MC-72. One thing to remember with electric powered models is that you must remove and install the main battery pack before and after each flight. Time spent in the shop to make this easier at the field will be worth the time.



Photograph 7.8 - Grant shows how the top loading hatch is removed. The battery can be removed and replaced easily within minutes. Notice the ON-OFF switch is also located in there.

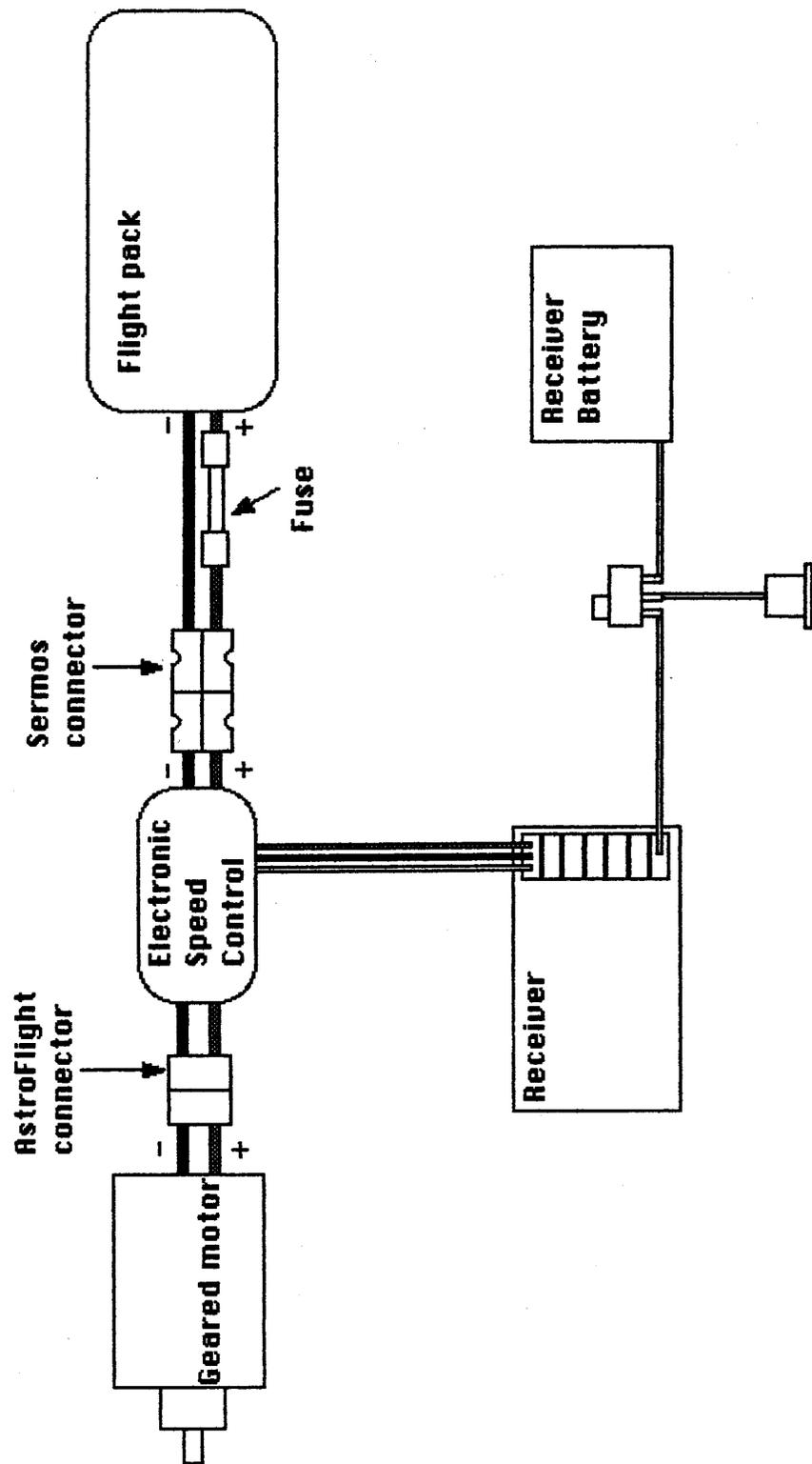


This is a SR battery pack (18 cells) that is held in place with Velcro. Move the battery to correct any CG problems. Unless you absolutely have to, do not add any nose or tail weight on an electric powered model to correct the CG location, move the battery as needed.

Photograph 7.9 - Now Grant has lifted up the plate that the battery was sitting on. There you can see the battery, Bill Young receiver, speed control and the other wires required for the electronics



Figure 7.1 – Electric Power



Chapter 8 - Trouble Shooting

I won't tell you that all of these wires, batteries and switches are perfect and won't break. I have flown many models with electronics and we have run across some problems on occasion. Wires will fray and short out, break and batteries will go dead. You will need one tool that will become part of your flight box - the electronic multimeter. Below is a table of typical problems, what needs to be checked and how to fix it.

Remember that servos can and will go bad. I have replaced 4 servos now due to wear and tear. One servo had the main pot go bad and did not return the same position from setting to setting. Also the Servo driver main throttle stick will go bad under heavy use. I have worn out two of these servo drivers to date. In almost every case the problems have been due to pilot's error or wear and tear.

<u>Problem</u>	<u>Items to check</u>
Servos don't move when Transmitter is plugged into connector at handle	Are the lines plugged in at the plane Lines are not assembled properly - check pin to pin Ohmage for each line to verify circuit is complete Plug Transmitter or Servo Driver directly to plane, bypassing the lines - If this fixes the problem look at the lines more carefully Look at all exposed solder joints and connections – look for loose or broken wire connections Check voltage of all batteries Are the lines shorted to each other? Is the plane turned on? DSC cord slightly unplugged from transmitter DSC cord is bad and shorting out
Servos don't move when transmitter is plugged into connector at the plane	Look at all exposed solder joints and connections – look for loose or broken wire connections Check voltage of all batteries
Electronics jitter and Shut down receiver	Verify ground and signal ground wire are not shorted out some where between the Servo Driver / Transmitter and plane Check battery voltage at Transmitter / Servo Driver and Receiver (Low battery voltage)

- Notes -

Chapter 9 - Operation at the Flying Site

Normal Sport Flying:

The electronics require a different set of rules for operation on the flying field as compared to the 3-line system. Before you leave the house, verify that you have the servo driver or transmitter and all of the correct hardware required to operate the system. Also verify that nothing was left ON overnight. Battery voltage may be checked with the use of a multimeter. This simple tool is very important when using electronic controls.

We generally run the engine(s) before the lines are rolled out with the servo driver or transmitter right next to the model. After the engine(s) checks out, the lines are rolled out and operation of the lines are verified. Turn the airplane on, plug in the line, and the servo driver or transmitter at the handle and verify that the electronics work down the lines. For actual flying, the servo driver can be left at the handle or directly plugged into the model to start the engine. Once the engine(s) has been started, the servo driver or transmitter is plugged into the lines at the handle end. To verify that the system is working, I usually start the engine(s) at 1/3 throttle and reduce the RPM's to an idle before takeoff. If the engine(s) does not reduce to an idle on my command then I know something is wrong.

Contest Flying:

Since time is important during CL Scale competition I generally keep the servo driver or transmitter plugged in at the handle while the engine(s) is being started. With the help of an assistant walk the airplane and the handle out to the circle and turn the airplane and the servo driver or transmitter ON. Adjust the throttle stick on the servo driver for approximately 1/3 to 1/2 throttle. When you get to the model, verify that the throttle is at the setting you expect to see. If the carburetor is still closed or fully open something is wrong. Then signal the judges and start your engine(s), walk to the handle and clip the servo driver to your belt, and reduce the engine RPM to an idle. PRACTICE, PRACTICE, PRACTICE is required for a smooth contest performance.

Safety First:

If you fly Control Line models with throttle control for any time you will eventually ground loop a model. This has happened to me multiple times for various reasons. Remember that electronics are not based upon line tension, so you always have control of the throttle. If the plane ground loops and turns in towards you need to shut down the engine as quickly as possible.



Photograph 9.1 - Ken Long's Cardboard Scratch Built Junkers JU-87 Stuka Flaps, Throttle & Bomb Drop: Multi-Channel Electronic Controls

Set at the flying field – Typical day



Photograph 9.2 - Test run motor with handle, transmitter or servo plugged directly into the airplane. The lines have not been rolled out yet. Steve has brakes on this model. For additional safety you should have a friend hold the model while you start and adjust the needle valve.



You can start the motor with the handle at the plane, or at the center of the circle. I tend to leave the transmitter with the handle.

Set the throttle to 1/3 to half power, turn on the Transmitter, walk back to the plane and turn on the airborne unit.

Verify that all connectors are plugged in. This is a common mistake.

Start the motor, walk back to the handle and throttle back to an idle.

Author shown here with the DSC transmitter clipped to the belt. The left operates up to 6 channels while the airplane is flown with the right hand.

Photograph 9.3 - The standard DSC cord is shown here, which is just the right length. If too long you can trip over the cord while you fly, or if the cord is too short, it can unplug when you extend your arm all the way out.

Chapter 10 - Installation Ideas for Profile Scale

When building your next Profile Scale model, if you decide to install Single Channel electronics you have to make some decisions before completing the model. The electronics package for the model includes wires, on-off switch, servo(s), battery, connectors and other hardware. Do not bury the servo so you can't get to it again without chopping into the model. I have been required to replace several servos on some of my Profile Scale models.

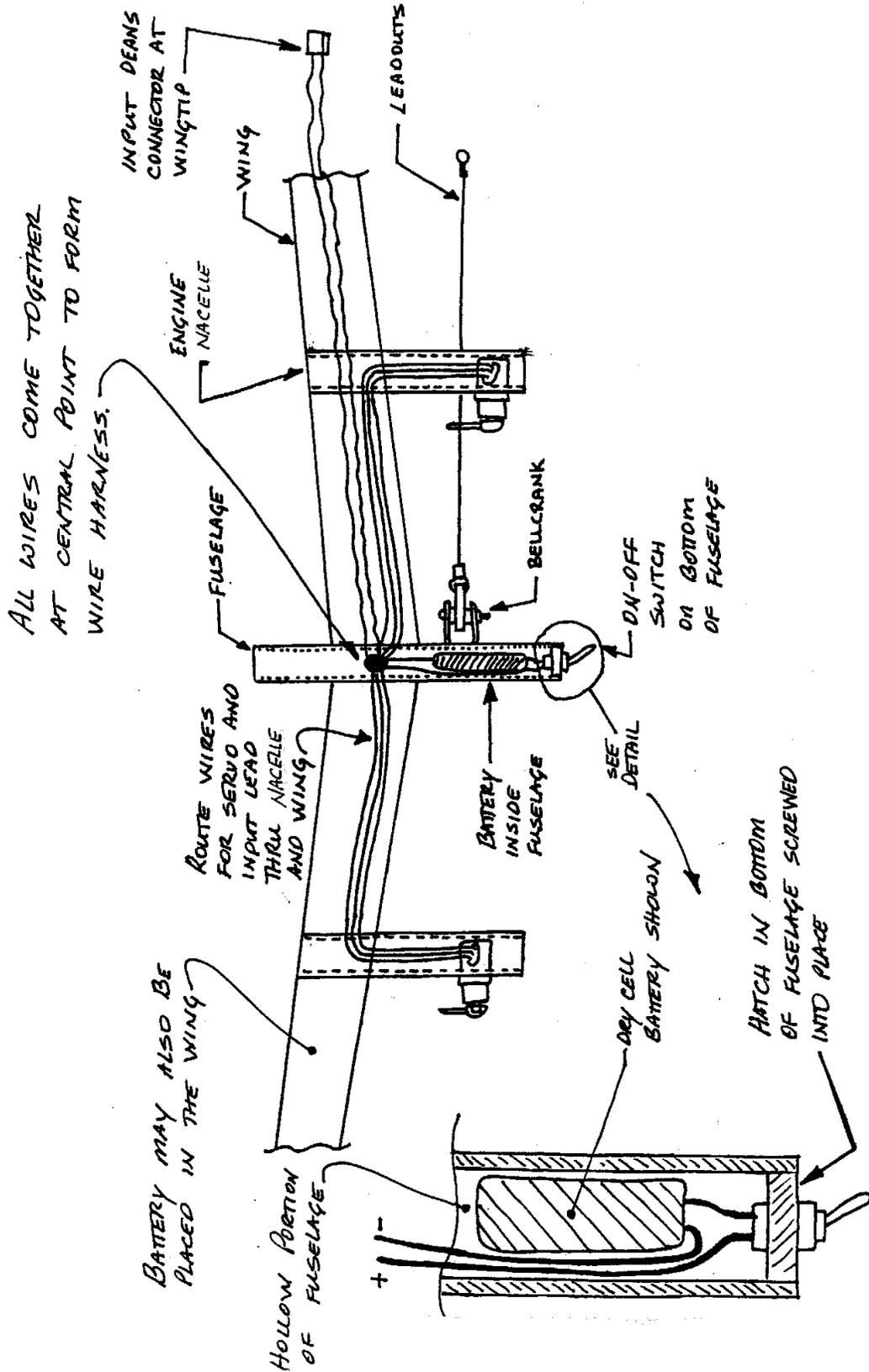
Figure 10.1 shows one way to install the servos and battery into a profile scale model. Note the wires are routed through the built up profile fuselage and nacelles. The only thing that should be exposed is the top portion of the micro servo and a portion of the on-off switch. On my A-20G Havoc I have a hatch similar to the one shown on figure 10.1 that lets me replace the batteries and service the on-off switch.

Remember in Scale Competition you are not penalized for exposed mufflers or other items such as connectors or switches. However, you can hide a large majority of the electronic equipment to present a cleaner package.



Photograph 10.1 - Author's scratch built 41" span Profile Scale Grumman F7F-3N Tigercat with OS-15FP's for power. Single channel electronic controls buried in wing, nacelle, and fuselage. Notice electronic hookup connector and leadout guide at wingtip. On-Off switch can be see directly below the Z65 on the fuselage. This model weighs 3 lbs and has a foam wing.

Figure 10.1 - Profile Scale Installation figure page



Section 2

Model Selection and Flight Testing

- Notes -

Chapter 11 - The C/L Scale Model From an RC Kit

I know what you're thinking, the words "Radio Control" have come into the picture. But if it weren't for Radio Control models we wouldn't have the large array of hinges, motors, and other hardware we use everyday on our CL models. But why stop with the hardware and motors? Very few kits, if any, are advertised as a Control Line scale model. The Sig Fazer kit is advertised as an RC model but we all know it can be easily converted over to CL Stunt.

While control line speed, combat, racing and precision aerobatic models are specially designed for CL. There are a large array of RC kits available that can be converted over to CL if you want to fly for fun, Scale or Carrier. The RC scale model kit has many parts that will be used for the conversion over to CL. The builder needs to add a line guide, wing tip weight and a bellcrank and the result is a model that can be flown for fun or scale. Don't limit your imagination; consider all types of kits, even large scale models with fiberglass fuselages. Remember that Sport scale rules allow for a 20 lbs (max weight) and 1.25 maximum cubic inches of engine.

One of the largest CL scale models being flown today is Grant Hiestand's 1/3 scale Spacewalker built from the Sig kit. With a wingspan of 103" the plane is powered by an Astro Flight 90-g geared electric motor. Keep one thing in mind when you build this large, transportation to and from the flying field can be a problem. I built and flew the 1/4 scale Morrissey Bravo (another Sig kit) and this plane was BIG. The Saito 91 four stroke easily fit inside the cowl and the fuselage was 6 feet long. This plane could be only transported in an 8 foot long trailer. Based on our experience, the best-sized model to fly in CL scale has a wingspan from 60" to 80" and is powered with a .60 to .90 sized engine.

Once you decide on what plane you want to build, get your documentation and accumulate all of the required hardware. Open up the kit and follow the instructions in the kit as if you going to build for RC with the following exceptions: let's start with the tail and take a good look at the stabilizer. The incidence on the stabilizer must be set at zero degrees to the fuselage centerline (see chapter 13). We learned this the hard way when one of our club members built a Grumman Wildcat with the scale positive incidence built into the stabilizer. This model would not trim out properly regardless of where we put the CG. Once the stabilizer was set at zero degrees the model flew great and all of its prior nasty habits disappeared. So look at the plans and build that stabilizer at zero degrees!

Second, the rudder -- you don't need it to keep your line tension, and you just may as well set it at the neutral position and forget it. In fact I flew a scratch built model with an OS-60FP for power without a rudder and it flew great. If you want, you can make the rudder adjustable on the ground with a simple clevis and pushrod. This is as far as you should go, keep it simple. Remember to lock the tail wheel so the plane will roll in a straight line or slightly to the left. The larger models will drag the tailwheel without problems. You can also hook up a servo to your tailwheel so you can make fine adjustments in the tailwheel position for a better taxi. You can also move the tailwheel during ground operations to simulate the left to right turning pattern used on some full size aircraft due to visibility problems. Some models may require more precise adjustment of the tail wheel due to the size or configuration. The Piper Cub is one of the models that need to have the tailwheel carefully adjusted to maintain the proper taxi.

Installation of the bellcrank is next and can be located in the fuselage or wing, your choice. Use your experience with your CL models to help you position it. In general, we have had good luck putting a 3" or longer bellcrank with the center bolt 1" behind the CG. Typically the CG is located at 25% of the wing chord. The CG should be between the front leadout and the center bolt. Be sure you install an adjustable leadout guide. This will be very useful in reducing the amount of line tension on the larger models. Start with 2 or 3 degrees of line rake and reduce the line rake as you test fly the model. Hang the model from the leadouts and be sure nose is slightly lower than the tail.

There have been some excellent articles on the physics of how a CL model flies and the importance of the location of the leadouts. The location of the bellcrank is really not that important; it is the location of the leadouts that is critical. On larger CL scale models having an adjustable line guide is mandatory, mostly for the sake of the pilot's arm! The larger models weighing 10 lbs or more can have large amounts of line tension. The adjustable line guide will allow you to move the line guide forward, reducing the line tension as you do so. At some point you will find a perfect location for the line guide that results in a sufficient amount of line tension without pulling your arm out of your shoulder.

When it comes to ailerons, make them separate to make the plane look scale, and make them "FIXED, BUT ADJUSTABLE". This means that you attach the control horn with a pushrod and clevis and make adjustments on the ground. On Grant's Spacewalker, the ailerons were VERY effective and were not really required to maintain line tension. Flaps are a wonderful addition to a scale model. These will allow you to land much slower and earn one more scale option in the scale flight pattern. This option is hard to screw up. If this is your first sport scale model consider a plane that will have flaps and throttle. This combination gives you six options with a single engine plane using the Sport scale rules. Remember to add the wing tip weight to the starboard wing.

Grant Hiestand has been experimenting with a GYRO that was intended for radio control. He hooked up the gyro to the ailerons and found that when a gust of wind banked the wings the gyro moved the ailerons to level out the wings. This is not required on most models, but if you are having trouble maintaining level wings due to wind perhaps this might be the solution.

Lastly, the throttle is installed per the RC instructions since we will be using the electronics. I like using a micro servo with a Du-Bro flexible pushrod. Put a non-adjustable clevis at the servo and an adjustable clevis at the engine. Once you get the electronics hooked up, make minor adjustments with the adjustable clevis at the engine to get a reliable idle.

Converting the large array of RC kits over for CL scale or fun flying opens up a whole new world. The RC market has many kits and other accessories that really lift the CL scale model of today into the 21st century. Remember, the only difference between an RC model and a CL model is that we fly in a circle and control the stabilizer with a bellcrank. Good luck and look twice at the RC equipment at the hobby shop next time you go shopping.

For additional photographs and 3-views call Bob's Aircraft Documentation
The group NASA supports all forms of Scale modeling including free flight, Control Line and Radio Control scale models, *Be sure to get a copy of the Scale resource guide from NASA*

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Visit the web site for details on how to join



Photograph 11.1

Front: Sig Kadet Senior by Grant Hiestand
Highly modified to look like a De Havilland Beaver

Rear: Author's Hanger Nine Piper Cub with
Great Planes 60 sized floats

Both models powered by an Astro Geared 40
electric motor and DSC electronic controls



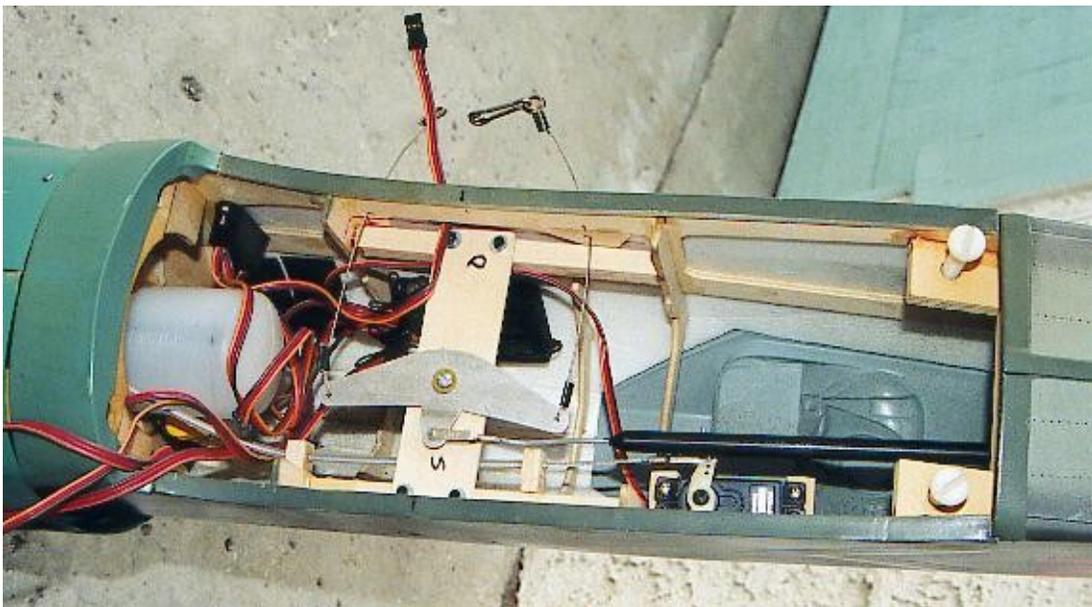
Photograph 11.2 - Lynn Boss's F4U corsair built from the Royal Corsair SR kit that was intended and labeled as a Radio Control Kit. This model spans 63" and is powered with an OS-90 four stroke. This particular model uses a 3-line bellcrank for throttle control and features bomb drop with down elevator.

RC to CL kit conversion



Photograph 11.3 - Author's FW-190 from the Great Planes Almost Ready to Fly kit. This kit is no longer available. This model features flaps, bomb drop, throttle and retractable landing gear. Notice that the ailerons intended for radio control were used as flaps. This photo was taken when the model was being tested with an electric motor before the bomb drop unit and a .46 sized glow engine were installed.

Photograph 11.4 - This is what the interior of the model looks like, a mixture of CL and RC. Notice the metal bellcrank is not a problem.



Chapter 12 - Picking Models for CL Scale

Some people ask what they should build for CL scale and the answer is very broad. We all know personal tastes and opinions will vary but there are some basic themes that generally apply to all CL scale models.

Control Scale Kits

Have you noticed the total lack of CL scale kits on the market today? Back in the 1950's there were a lot of kits on the market advertised as a CL scale kit, such as the older Top Flite kits like this Mustang kit. But these models are small, maybe powered with a .35 sized motor or smaller. Be careful of the older kits for several reasons. These kits tend to build up heavy, are small and some of the outlines on these kits are not accurate enough for Sport Scale competition today.



Photograph 12.1

Brodak Manufacturing sells a large array of Control Line kits including some CL stunt models that are semi-scale. These kits are perfect for CL fun scale, but the outlines are not accurate enough for Profile scale competition. What we are looking for, is a kit, profile or full bodied with accurate outlines that can withstand the scrutiny of the scale judges when comparing your model against a 3-view of the full size version.

It is a very common practice today to take a Radio Control Scale kit and convert it to Control Line (see previous chapter). If you look at the RC scale kits with the idea that they can be converted, then there are lots of CL scale kits out there. If it has wings and weighs less than 20 lbs, we can fly it in CL scale. The size of the model, such as wingspan is not as important as the weight of the model and engine you pick.

Size of the model

The size of the model is important to determine early. It will determine the motor you will use, and how many options you can install like retracts flaps and others. For those of you who follow the RC scale arena, the trend is obvious towards Giant scale. Bigger flies better, this has been proven many times in RC scale.

My first CL scale model was powered with an OS-25FP and had a span of 36" and weighed a little under 3 lbs. The model was so small I had no room to install anything but a throttle servo and the motor. I consider this size of model to be to smallest CL scale model I would build for competition.

The .049-sized models are really too small and rarely have throttle controls except for the newer motors. These models are small, easily affected by the wind, fly on short lines and have nothing more than throttle.

Photograph 12.2 - P-47 model built by Steve Davis. This model is quite small, has single channel electronic controls, OS-10FP for power and spans 27". This was built from an old CL kit from Top Flite.



Once you break into the .40 sized model with a wingspan of 50" or more then you get a model with a sufficient amount of wing area to carry some options. Notice the bottom line, wing area. If you look at the electronics, flaps, retracts, bomb drop and the other options we like to install in our models, they are heavy. A 2-ounce servo in a 2-LB model represents 6% of the total model weight. That same 2-ounce servo in a larger model, let's say that weighs 12 lbs represents 1% of the model weight.

Some models don't have much wing area no matter how big you build it. Let's consider the following models: Piper Cub, Lockheed F-104 Starfighter, and the P-51 Mustang. Each of these are radically different from the other in many ways.

The Piper cub is easy to build and fly but does not offer many competition options to pick from. The plane has lots of wing area and simple landing gear, but installing the bellcrank can be a problem, due to the location of the wing and cockpit. This model could be built in almost any size with great results, from .049 sized up to 1/4 scale.

The full size Starfighter has a wing the size of your dining table, which will translate into a model with a wing that is really small. Models with small wings or high wing loading must fly fast and in CL scale flying fast is not that desirable. This model would be a challenge to work properly for CL scale purposes.

The P-51 is a nice compromise, a generous wing with lots of options to install. You could have the following options: retracts, open-close air scoop, throttle, flaps, open-close canopy, tank and bomb drop. Now let's consider this P-51 in three different sizes: 36", 55" and 75" span. The first thing I calculate is the wing area for each size. Consult a book on your subject aircraft to get enough information about the airplane such as wing span and wing area.

Full size data for the P-51 Mustang

Wing Span = 37 feet, 0 inches

Wing Area = 233 square feet

Fuselage length = 32 feet, 3 inches

Scale factor = full size wing span / model wing span (be sure to use the same units, inches)

Model wing area = full size square feet / scale factor squared

Conversion factors

1 square foot = 144 square inches

1 foot = 12 inches

Convert full size numbers to inches

Wing span: $37 \times 12 = 444$ inches

Wing area: $233 \times 144 = 33,552$ square inches

Fuselage Length: $(32 \times 12) + 3 = 387$ inches

Wing Area sample calculation for 55" span model:

Step #1: figure out scale factor
 $444 / 55 = 8.073$ scale factor

Step #2: square the scale factor
 $8.073 \times 8.073 = 65.169$

Step #3: Determine wing area
 $33,552 / 65.169 = 515$ square inches

P-51 Mustang wing areas:

36" 220 square inches

55" 515 square inches

75" 957 square inches

Have you noticed that the 75" model has 435% more wing area for only being twice as big? Every time you double the size of the plane the wing area goes up by a factor of 4. Why this fascination with wing area? Because the next thing we need to calculate is the wing loading of our new projected model.

Wing loading makes or breaks a good flying model. Here is a chart that shows the wing loading I like to maintain with my models depending upon the size of the model. Remember how bigger flies better? Notice how the smaller models can not tolerate the heavier wing loading that the larger model can.

General guidelines for wing loading:

200-400 square inches 10 –16 ounces per square foot

400-800 square inches 16 – 25 ounces per square foot

800-1200 square inches 22 – 32 ounces per square foot

Based upon our numbers from above, the model P-51 would have to weigh:

36" span model	220 sq. inches	21 ounces or 1.3 lbs	14 ounces per square foot
55" span model	515 sq. inches	79 ounces or 4.9 lbs	22 ounces per square foot
75" span model	957 sq. inches	172 ounces or 10.7 lbs	26 ounces per square foot

That 36" span model is tempting but look at the target weight of the model, 21 ounces! This model might fly ok at two lbs but that is pushing it. I flew a 48" span P-51 for a few years and that model first took to the air at 4 lbs. Then I added some detail like flaps, still had fixed gear and weighed 5 lbs. At 5 lbs it flew like a rock, no spunk and it was slow. Then I went through the plane and got it back down to 4 ¼ lbs and what a difference. I could do warbird takeoffs and it was fun to fly again.

One of my current models is a sport model with 1,200 square inches, spans 80" and is powered with a OS-90 four stroke. It weighs in at 12 lbs and is designed to carry a 35mm camera in flight. Adding additional items to that model like extra servos and other hardware doesn't affect the flight performance because of the large wing area, yet adding two extra servos can make a smaller model's performance unacceptable.

What if you don't know the full size wing area?

Some projects have very little information; you might be lucky to find one 3-view on your subject aircraft and a few photographs. The method above assumed we knew the wing span, length and wing areas and calculated the numbers mathematically. In the case where we don't know any of these numbers we have to take a different approach.

What we need to do is to take our 3-view and enlarge it until it is the size we desire in our finished model. One method is to measure the wing span and length of the aircraft directly from the 3-view itself using an accurate scale. The larger the drawing the more accurate our results will be.

For example let's say we have a 1/72 scale drawing of the P-51 Mustang:

Wing span = 6.17 inches

Length = 5.375 inches

Root chord = 1.42 inches

Tip chord = .71 inches

Average chord = $(1.42 + .71) / 2 = 1.065$

Now we need to convert these numbers to a model that we are going to build. When we had the area of the full size P-51 we simply scaled the numbers down. In this case we need to scale the numbers up. For example let's pick the 55" span model.

Scale factor = $55 / 6.17 = 8.914$ (we are enlarging the 3-view 8.91 times, or 891%)

Average wing chord = $8.914 \times 1.065 = 9.49$

Area of wing = $9.49 \times 55 = 522$ square inches

Notice how the full size numbers came up with 515 square inches and by measuring the 3-view I came up with 522 square inches. The error is due to the measurement of the relative small size of the 3-view.

Other methods for enlarging 3-views:

- 1) **Overhead projector.** Make a copy of your 3-view on a clear sheet and project it onto a wall. Be sure the overhead projector lens is perpendicular to the wall and not pointed to the side or upwards because this will distort the image. Tape banner paper (typically at most office supply stores) to the wall and using a pencil trace the image. Do not move the projector until you are done!
- 2) **Enlarge the 3-view with a copier.** Outfits that copy large drawings (such as Kinkos) have copy machines that can enlarge drawings 400%, but the final piece of paper can be no wider than 36". Enlarge your 3-view until it is $\frac{1}{4}$ of the final size of your model and then run that thru the copier at 400% enlargement. The image that is enlarged can be no wider than 9".
- 3) **Scanning the 3-view** into the computer than drawing on a CAD program. This requires a computer, scanner and experience with the computer programs.



Photograph 12.3 - Typical overhead projector available at an office supplies store. This is an economical way to create drawings for your scratch built model airplane.

Level of Competition

Now you have to decide how detailed you want the plane to be. Is the model intended for fun, sport, precision or FAI competition? The level of competition will determine size, amount of detail and number of options.

Let's look at that P-51 again. If being built for FAI competition, you have to have retracts, but in sport scale you could get away with fixed gear. Flaps are easy to do and should be added to the sport scale model. Ultimately you have to decide how many options you want to add to the model. Remember, as you add more items that move, your odds of having problems on contest day will increase.

Build the model so you can overhaul the plane a year from now and replace every servo, battery, wheel, strut and piece of hardware possible. In some cases it is not possible to do that, but from experience we know that servos go bad, tanks leak, pushrods break, tires wear out and the unexpected will go wrong and some part will need to be replaced or fixed. Serviceability at home and at the field are very important.

Options

Map out the options you want to perform at the contest before you start building. Let's take that P-51 and consider Sport, Precision and FAI competition. One important factor is the difference between the options in all three categories. Retractable gear is expected in FAI while in Precision scale it is desirable, but not mandatory. In Sport scale retractable gear is overkill and not required. Also remember that in Sport scale, taxi, touch & go and retracts count as two options, but not in Precision scale. We need to find 6 options for Sport and Precision scale and five for FAI. Remember throttle control is considered an option. Here are the options I would recommend for the P-51 model for each level of competition:

	<u>Sport Scale</u>	<u>Precision Scale</u>	<u>FAI</u> :
Option #1	Throttle control	Throttle control	Throttle control
Option #2	Flaps	Flaps	Flaps
Option #3	Touch*	Retractable gear	Retractable gear
Option #4	Go*	Touch & Go	Bomb Drop
Option #5	Taxi*	Bomb drop	Open Canopy
Option #6	Taxi*	Taxi	(only need 5 in FAI)

Also, one thing to consider is the realism effect in CL scale. The full size P-51 Mustang was capable of doing limited aerobatics, but was not known to do 3 outside loops. The point is that if you show up at a scale contest with an Extra 300 and put down inverted flight and outside loops as options, the judges won't flinch. However with the P-51, the judges will probably downgrade your realism score, or in extreme cases not allow that option to be used. Remember this is a Scale contest, not Precision aerobatics. Pick options that the subject aircraft was capable of doing.

* touch & go, taxi and retractable gear in sport & profile scale count as two options each, see the AMA rule book for details on this

Chapter 13 - CL Scale Model – Stabilizer & Wing Incidence

At some point you will want to build a one of a kind model that does not exist in plan or kit form and you will have to scratch build the plane yourself. This has been one of the most enjoyable things that I have done. Over the years I have built and designed my own models from my own plans. Some of the models are sport models like my camera plane and others are scale models scaled up from 3-views. Regardless of what you decide to scratch build, you are embarking on new territory that can have pitfalls. Be ready to redesign if needed if your first prototype does not fly well. But there are some known items that can be taken care of before we build our first prototype.

Rudder offset – Many people think that a Control Line model must have rudder offset to fly correctly. At least for CL scale this is not the case. I have built and flown two models that did not even have a rudder and they flew just fine. Line tension was never a problem with these models, the latest being my 80” span camera plane. The rudder just gets in the way of the camera lens image. Some smaller models may require rudder offset, but the larger models can have the rudder set to neutral or not exist at all and still fly correctly. If in doubt make the rudder fixed, but adjustable so that you can change the offset at the field.

Stabilizer incidence – This is the relative angle of attack of the horizontal stabilizer to the fuselage centerline. Many RC kits and full size aircraft have positive incidence in the stabilizer that can prove to be detrimental to a CL scale model. The Short Sunderland and Grumman Wildcat both have a positive angle of attack built into the stabilizer.

Several years ago we were test flying a .35 powered Profile scale Grumman Wildcat. We moved the center of gravity several times and in every case the model just did not fly correctly. The model was built to match the 3-view including the incidence in the horizontal stabilizer. The model was then modified by removing the positive incidence in the horizontal stabilizer. Once the positive incidence of the stabilizer was removed plane flew great.

One of my more successful models has been my 41” span Hawker Sea Fury that I built for Profile Carrier. This model was scratch built by taking a 3-view and drawing up the plans for a 41” span version. I followed the 3-view faithfully except for two items. First, I set the horizontal stabilizer incidence to zero degrees. Second, I put the wing angle to attack to 3 degrees. The result was a great flying, stable model.

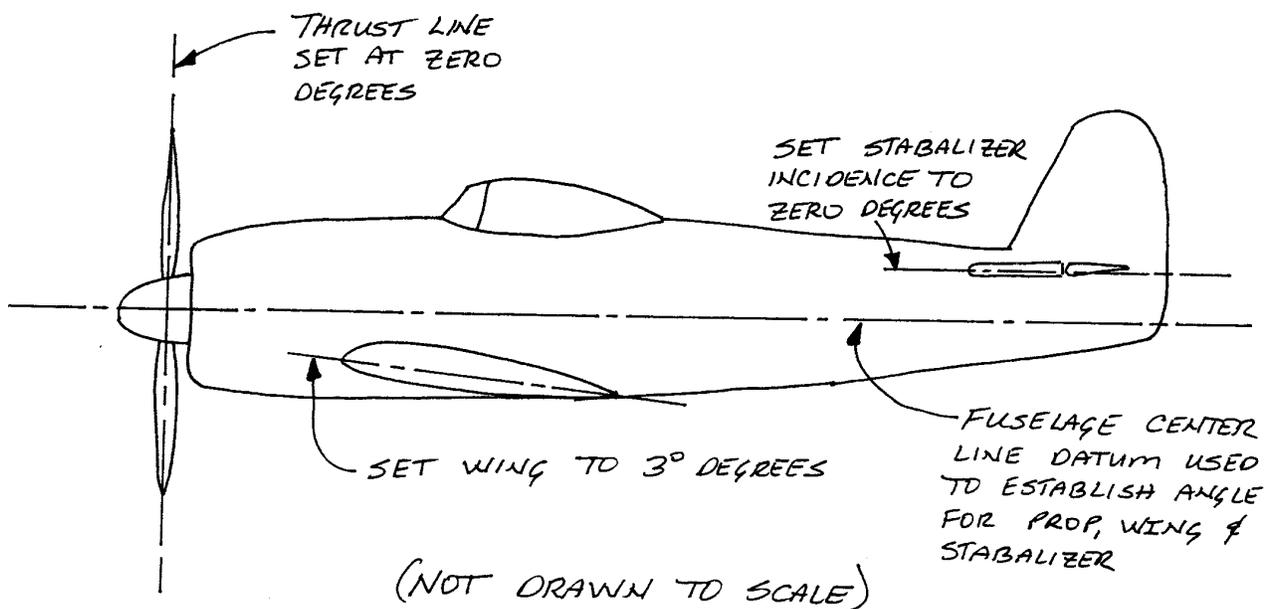
Propeller thrust line & offset – Aircraft such as the Grumman Bearcat have down thrust built into the full size aircraft. Some CL models are built with outboard offset to provide additional line tension, that has traditionally been done on precision aerobatic models. All of my CL scale models have the motor thrust line set straight ahead, so no outboard offset is required for CL scale models. Additionally, the offset will look odd when the scale judges look at your model during static judging. One reason why we don’t need outboard offset is that the CL scale model does not perform (typically) the aerobatic maneuvers that prompted the offset in the motor.

Wing angle of attack – When I set up the Hawker Sea Fury I located the wing at the correct location, but put a 3-degree angle of attack relative to the fuselage centerline. The resulting model flew just like I wanted it to. Because of the angle of attack, the wing produces lift while the fuselage is horizontal. If the wing is set to a zero degree angle of attack, the entire model would have to be 3 degrees to obtain the lift required, resulting in an odd configuration in flight.

Special or unique aircraft configurations – Aircraft such as Merle Mohring's XB-35 flying wing (see gallery section) required additional experimentation. Originally he had installed 4 engines, only to find out he had more power than he needed. After a few test flights he removed two engines and made the two outboard props just dummy props that spin with the wind. Had he built another of these models, he would have installed smaller engines. More than once we have built a foam prototype to determine CG location, how well a model will fly, test electric motor selection and other features. So if you have a really unique project that has a lot of unknowns consider building a very simple version from foam or other materials to duplicate the size and configuration of the finished model. This test aircraft is not detailed, in some cases not even painted. You will make drastic changes to this test prototype to make it fly correctly. After 10 or 20 flights the model will be flying correctly, allowing you to build the good version with all of the required improvements.

Additional comments – Be prepared to make changes after the first test flight. I built my Grumman Tigercat with all of the proper angles and engine thrust line with the horizontal stabilizer at zero degrees. But when it came time to test fly the model I found out that I needed a slight amount of down elevator to fly level. Some models may require no up or down to fly level, some may require a slight amount of up. After the first test flight adjust the neutral adjustment at the handle to obtain level flight with your hand in the relaxed neutral position.

Figure 13.1



Chapter 14 - Trimming the CL Scale Model

The CL scale model is a different beast compared to a precision aerobatics model. The purpose of CL scale is to make a miniature duplicate of one particular plane. The relative flying speed of the model, how well it flies and how it is flown makes a difference in your flight score. One would expect the Piper Cub to be slow and docile, while the P-51 to fly faster. This where trimming the model for CL scale is important.

When I test fly a new CL scale model my goal is to determine what needs to be changed to make it fly correctly. We are not interested in sharp corners during maneuvers but a stable model that can takeoff easily and land correctly. The CG location and leadout guide are the first two things that will be adjusted after the maiden flight.

After the maiden flight the CG is normally adjusted to account for landing gear or other features. The model should be able to fly level and if the elevator position is changed, it should not result in a 5-foot radius turn into a wing over. By Precision aerobatic standards, my CL scale models are slugs and can barely complete a lazy wing over. The reason for this is that the CG has been pushed forward resulting in a stable, docile model airplane. On my Piper Cub I had to push the CG forward to make the landings smoother due to the location of the landing gear even through the level flight was acceptable.

The leadout guide position is critical only in that it affects the line tension. We typically do not fly CL scale models with aerobatic options so keeping line tension at the top of the circle and during overhead options is not as important. You want to maintain line tension during level flight and for perhaps a mild wing over. On the larger models the adjustable guide is critical to keep the line tension to practical levels.

Takeoff

Seems simple enough, but on every competition flight you are judged on how well you takeoff and land. Here are some techniques we use. Trim your model accordingly and you will gain valuable flight points.

For the P-51, I would start the takeoff run with the engine at idle, put the elevator to neutral and slowly increase the throttle to full power. The tail should rise on its own and then run along the ground on the main wheels until you reach a good flight speed so you do not stall the model. If the model is trimmed right it should lift off by itself, or maybe with a small amount of up elevator applied. If you need to apply a lot of up elevator to get airborne the plane is too nose heavy.

Models with tricycle landing gear require a different procedure. Apply full down elevator, slowly advance the throttle until full power is attained. Relax the full down elevator once you reach takeoff speed and, if trimmed correctly, the model should lift on its own. If you need to apply lots of up elevator to takeoff and it results in snapping motion off the ground then there are problems. The wing should have some angle of attack relative to the ground. Sometimes the nose wheel is too short and the wing is level or has negative incidence relative to the ground. The increasing ground speed forces the model to the ground, but if the wing has positive incidence relative to the ground the wing will want to lift off by itself with a sufficient amount of airspeed.

Landing

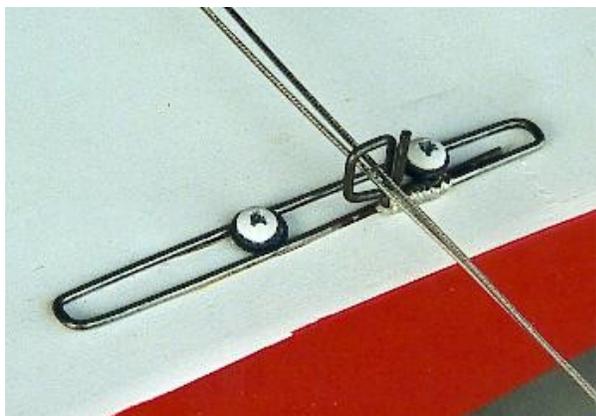
Once you have established a level cruise speed with the flaps down, lock your hand and do not move the elevator. That's right, we are going to land the model without moving the elevator. Throttle back slowly, lower the landing gear and continue to throttle back. At some point you will find a throttle setting that results in a gentle sink rate. If you throttle back too much it will fall out of the sky, and if you throttle up, you would maintain level flight. So let's find that magical sink rate by adjusting the throttle and let the model settle in on the main wheels. Once the main wheels touch and are rolling, throttle back to idle and let the tail wheel settle. In some cases you may want to apply full up elevator to ensure the tail stays down. The tail should drop and the tailwheel will start to roll.

Landing a model with a nose wheel requires a different setup. My A-20G Havoc has a pair of OS-20FP's and takes three laps to land properly. First, after finding a cruise level I start to throttle back and apply more and more up elevator. I set up the model to fly nose high slightly above stall speed with the nose pointed upwards about 5 degrees. After the nose high attitude is setup, the throttle is pulled back some more until a sink rate is found for landing. During this last portion, the elevator position is not changed. This will result in the main wheels hitting first and then allow, the model to rotate to the nose gear. Once the mains are rolling on the ground, apply full down elevator to keep the nose wheel from bouncing and throttle back to idle. Some models with nose wheels like my A-20 Havoc can not land 3-point, otherwise they bounce over and over and never settle down, sometimes known as porpoising.

Flying Lines and Handles

Every plane is slightly different and every one of my models has it's own handle and lines. Each set of lines is rarely used on another model. The reason is that you establish a line length and handle adjustment that works with that model. I also never remove the handle from the lines so that the handle neutral adjustment is never affected.

I leave one line connector on the airplane, and the other line connector stays with the set of flying lines. That way when you connect the lines to the plane the next weekend you don't have to guess which lines goes where. You can also color code your connectors if that works better for you.



Photograph 14.1 - Adjustable line guide



Photograph 14.2 - Notice location of the bellcrank and landing gear location.

Chapter 15 - The Control Line ARF

- How to experiment with new ideas quickly -

There are many opinions on the affect that ARF's (Almost Ready to Fly) have had on the model airplane industry. Some say the creativity of building your own model has been stripped away while others like the fact that they can have something flyable in less than 3 days worth of work. All of the ARF's on the market are intended for Radio Control, however, I have converted several over for CL use with great success.

The first one I flew was the EZ Zero with an OS-50 for power. It featured retracts, throttle and flaps. I had a great time with the plane and learned a lot. Recently I have been flying the Hanger Nine Piper Cub with an 81" span. This plane is an ARF, but looks much better than most ARF's that are on the market. The plane can be used for many purposes, but I put it together for two reasons - for fun scale ROW Floatplane and a platform for video taping CL models from the cockpit.

The Hanger Nine Cub Model is large enough to carry a full size 8mm Canon video camera inside the fuselage where the pilot would sit. The model is powered with an Astro Flight Geared 40 electric motor (Super box with 3.4:1 ratio) and uses DSC electronics to operate the throttle. Since the speed control required for electric power is an electronic device no 3-line mechanical system can be used on this plane. The Super gearbox is capable of turning an 18" propeller, however I choose to fly with a 16-8 propeller. The larger geared propellers have more thrust, fly slower and look great!

These models can also be a great way to learn about scale. You might be the best builder, detailer and painter, but how should the model be configured? These models allow you to experiment with ideas, smoke systems, throttle, flaps and other features without spending valuable time building a dedicated scale model. If you have never flown a model with throttle, flaps and retracts this is best way to go for your first model. This will allow you to go through the motions of setting up and flying a scale model without the building time. Then, when you do make mistakes with the ARF, it is no big deal.

Instead of putting wear and tear on your detailed scale model, the ARF will serve as your practice plane that you fly on a regular basis. The availability of ARF's changes quickly, for example the Great Planes FW-190 ARF that I currently use as my practice plane is now out of production. But look for a model that allows you to install retracts or other features that you want to experiment with. Strip ailerons can be converted into flaps.

Next time you are inspired to fly something different, consider an ARF and drop in electronics, Throttle control and retracts. You might find that it is a fresh change of pace from your typical Control Line model.

- Notes -

Chapter 16 - Throttle Control and Test Flying

While most Control Line models have a fixed venturi with a needle valve, which means the engine runs at a set RPM until the model runs out of gas, scale CL models have throttle control. I fly models that have a carburetor so that I can adjust the RPM of the engine during flight. Throttle control on a scale model is expected if you are going to be competitive in competition. While it is possible to enter a scale contest with a model that does not have throttle control your odds of placing well is not good.

Throttle is mainly used on scale, carrier and sport models. If you fly combat, speed, racing or stunt you have probably never really thought about it at all. The next time you have a whim to build a different kind of model consider putting in throttle control for a change of pace. You will find that it opens up a whole new range of challenges and fun.

Normal operation

Throttle control changes how you fly and what you can do with the model. Instead of starting the engine and hanging on with the engine at full bore we can reduce the RPM to an idle before takeoff. I normally warm up the engine in the pit area checking for proper operation at full throttle and at idle. Once I get into the circle I set the throttle at 1/3 to 1/2 power and start the engine. When I am ready to takeoff I will reduce the RPM to an idle and then start my takeoff roll.

I never fly at full throttle with my larger models, because the line tension and speed would not be safe or practical. Grant Hiestand and I have flown very large CL scale models in excess of 17 lbs. After flying one of these monsters you are very glad you had throttle control. The line tension is a function of how fast you fly. I normally fly at 1/2 power that results in a nice cruise speed with the engine humming along at a modest RPM.

Now that we have throttle control, this means that we can land with the engine running instead of landing dead stick. Every model will land differently. My A-20 Havoc which I fly in Profile Scale competition, has a pair of OS-20FP's for power with single channel electronics controlling the throttle. This model has tricycle landing gear and must land nose high or it will bounce. The two main wheels must land first with the nose wheel touching the ground after the mains have touched. In fact, the landings with this model are planned 3 laps in advance. The throttle is reduced slowly, as the speed reduces, up elevator is cranked in raising the nose. As I slow down even further, even more up elevator is applied, resulting in a slow flying model with the nose pointed up (approx. 5 degrees) even though the model is descending. Once the nose is high enough and the descent rate is correct I let the model settle in on the mains. Obtaining the combination of nose high, speed and decent rate is tricky and takes practice. Once the mains touch, the throttle is pulled back to full idle and full down elevator is applied. The full down elevator keeps the nose from bouncing too much. During takeoff with this model I apply full down elevator until I have enough flying speed at which point I apply up elevator and climb out. The full down elevator during the start of the takeoff run keeps the nose wheel from bouncing.

Models with tail wheels will land differently and it is hard to generalize this type of model, but the Sea Fury that I fly in .36 Profile Carrier is very easy to land. All I have to do is reduce the throttle until the sink rate of the model is ideal. If you simply go from 1/2 power to full idle when you are 20 feet above the hard deck the results will not be good. Reduce the power slowly until the model begins to sink at a rate that is safe and realistic. Let the mains touch and then reduce the power to idle and let the tail wheel settle. Finally, taxi up to a position close to your parking spot on the circle and shut down the engine.

Test Flying

Since we have control of the engine at all times we can land and shut down the engine at any time. This is especially helpful when test flying new models. If you want to test fly a new scale model you just don't cram the power to full and apply full up elevator. How will the model react? Will it be overpowered? Is the CG in the right spot?

One of the first things I do when I fly a model for the first time is a taxi test, at a low power setting. During these two laps I figure out if the model is going to turn in on me when I apply more power to take off. Some models have required me to step back several steps to keep line tension on takeoff. Since the vast majority of the engines we use turn the propeller counter-clockwise, the torque wants to make the nose of the model turn to the left. This is why pilots of full size Corsairs, Mustangs and Bearcats apply large amounts of right rudder on takeoff roll. Also see if you need to apply some wheel brakes to perform the taxi option. You should be able to come to a complete stop with your engines idling to perform the taxi option properly. I had to put a small piece of fuel tubing between the wheel hub and wheel collar under compression to get this model to stop with the engines at idle, because the model basically had permanent brakes.

After the taxi test, apply more power, let say about 1/3 throttle. The point here is to get the tail off the ground (assuming you are flying a tail dragger) and roll on the mains without taking off. This part will give you some idea how effective the elevator will be and how the model will react. If everything is going good by now, then apply just enough power to fly 2 or 3 feet above the ground. If the model is stable you will be able to tell at this point. If there is a problem your prized model will only be a couple feet above the hard deck. Land right away and evaluate how the model flew with that amount of line rake and CG location. Ask yourself, was there enough line tension? Is the elevator too sensitive?

I was test flying a friend's Bearcat (Brodak kit) powered with an OS-26 four Stroke engine several years ago. Steve had spent weeks building this model and it could all be over if the test flight did not go well. After getting this model 2 or 3 feet off the ground it became very apparent that the CG was too far back. This model was almost unstable and dangerous to fly. Very small movements of the elevator resulted in drastic up and down movements of the model. The model finally settled down and I barely got it back on the ground safely. In fact, I broke off one of the gear doors during the hard landing. After adding some noseweight the model trimmed out very nicely. After making the required changes now is the time to really have some fun. Nine times out of ten, I make very few changes at this point.

Formation Flying

Now this is a real challenge - how close do you get? Since the people I fly with all have throttle control, we normally fly in the circle together. But instead of just passing we use our throttle control to fly in formation. We have flown models within 2 feet of each other at 40 mph, but to do this we need models that are equally matched in size and speed. The line length does not have to be the same, but radically different line lengths can be problem. The cruise speed of the models should be very close to each other. In other words flying a 90 mph carrier model in formation with a Piper cub that only flies at 50 mph is not practical. The throttle control systems must be precise enough so that small changes can be made to the throttle setting during the flight.

Once you have selected two models that are equally matched in flying speed one pilot should decide to fly lead. The lead model will be placed 1/8 to 1/4 lap ahead of the chase model and both model engines should be started. Once both engines are idling, the models are released at the same time and the lead model sets the pace for the takeoff roll. The chase model must know where the lead model is so he or she does not overtake the lead model during takeoff. The pilots must communicate during the flight with information for the other pilot such as; "I'm taking off now", "slowing down", and "fly faster".

Once the models are at cruising speed the lead model should set the throttle and not change it. This will allow the chase model to carefully adjust its throttle setting to form up on the lead model's tail. The chase model pilot will be making constant changes to the throttle setting to stay on the tail of the lead model. If you need pass, the chase model should climb and then fly over the lead model with the lines going over the head of the lead pilot.

Stacked formations of 4 or 5 models are possible, but this requires practice and matched models. We did this once and I can't wait to try it again. But this requires the 3rd model to fly formation behind the 2nd model and so on. Basically each person is really flying formation with the model ahead of them and should not really care where the other models are located. If everyone who is flying in the circle follows these rules, it works very well.

Formation flying is one of those adventures in life that is unique. Every flight is a challenge because of wind, or the general flying conditions. What you can't see in this picture is that Grant's Venture 60 while approaching the lead model (with a camera attached) was caught in the turbulence coming off of the Seniorita. His model rolled to the left as the model approached and then dropped away below the Seniorita. The Venture 60 survived the flight without any problems.

Notice how the line lengths of the two models are identical in this setup. Since then we have started to make the lines for the chase model 1 or 2 feet shorter than the lead aircraft. By moving the chase model inboard slightly, you get out of the turbulence zone created by the lead model.



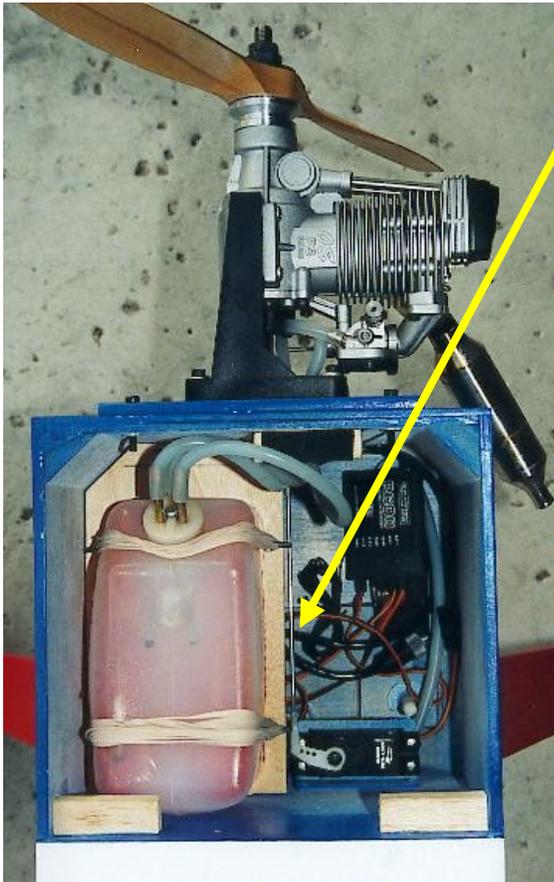
Photograph 16. 1

Grant Hiestand flying his Venture 60 directly behind the Authors Sig Kadet Seniorita

The Venture 60 is about **5 feet** behind the tail of the Seniorita

The Seniorita was flying with a Canon 35mm camera and tripped with a servo
Author's Piper Cub can be seen on the ground parked on the edge of the flying circle

Throttle control Setup photographs

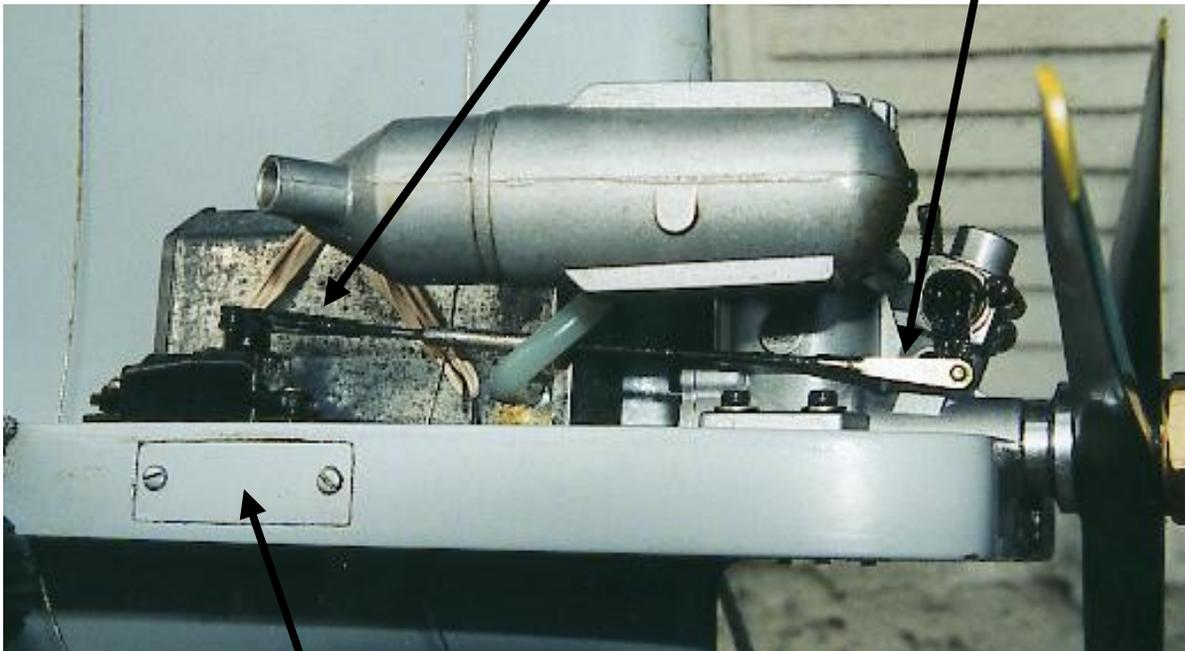


Photograph 16.2 - This is the setup for my camera plane. Notice the stiff metal pushrod from servo that goes to the motor.

If you use a flexible pushrod, support the plastic tube that the pushrod slides thru at both ends and enough points in between.

Photograph 16.3 - This is the setup on my 53" span scratch built A-20G Havoc for Profile Scale. Notice the soldered clevis located at the engine and the adjustable clevis at the servo. The adjustable clevis could be removed from the servo and turned to speed up or slow down this engine as needed (see chapter 17).

Non-Adjustable soldered clevis



Hatch used to gain access to servo connector inside profile nacelle

- Notes -

Chapter 17 - Multi-Engine CL Models

How to set up and fly multi-engine CL Scale models

Eventually, most scale modelers want to fly a twin or perhaps a bomber with more than one engine. Trying to keep 2 or more engines going at once sounds complex, but properly done it is quite easy and rewarding. The sound of a twin or four engine bomber is unique. The following contains some pointers on how to set and fly a scale model with throttle control and two or more engines.

First and foremost select two engines that are matched; therefore the same manufacturer, type and size. If you were buying new engines, buy them at the same time. Before you build the model you must decide what kind of control system you will be using to adjust the throttle. This chapter will show how to set up a model with electronics. Some of the principles being discussed here can be applied to a model with a 3-line system.

Let's use the B-17 as an example for this discussion. Each nacelle will have its own fuel tank, servo, engine and fuel tubing. Since each nacelle has its own fuel tank, the #1 engine is not dependent upon the #2 engine or anything else to work properly. Set up each nacelle just like you would if you were setting up a single engine model. You just have to repeat this step three more times for the B-17. Putting a servo in each nacelle eliminates any problems with bellcranks, pushrods, torque tubes or other mechanical devices. While it is possible to have one servo drive the four carburetors, we have found through countless models that a servo for each engine simplifies the multi-engine model. All four servos on this B-17 will receive the same signal, power and ground, and will respond in the same manner. If you are using multi-channel electronics, the output from the receiver will be transmitted to the four identical servos. You will have to make your own 4 servo Y-harness, but most radio manufacturers make a 2 servo Y-harness.

After you have installed a servo in each nacelle, turn on the electronics so that all four throttle servos will be the idle position. Like the engines make sure the servos are matched, so that there are no differences that will cause other problems with engine synchronization. Also make sure the servo arms are identical and turn in the same direction on all four servos so that the engines respond properly. Mount the servo arm so that the full throw of the throttle stick won't buckle the throttle pushrod. Install the throttle pushrod in each nacelle, a non-adjustable solder clevis at the servo, and a threaded adjustable clevis at the engine. When the servo is in the idle position make the length of the pushrod correct so that the carburetor is fully closed. Adjust the length of each pushrod until the gap between the rotating barrel of the carburetor and the carburetor body are the same for all four engines. This step puts you one step closer to maintaining engine synchronization. Each nacelle will have a servo, requiring a straight pushrod between the carburetor and the servo arm. You can use a flexible pushrod cable or a 2-56 threaded rod.

When you get to the field to fly the B-17 you will need to spend some time to get everything adjusted properly. Use the steps required to synchronize the engines on a multi-engine model. Since we installed an adjustable clevis at the carburetor we can make very small changes in the RPM (**R**evolutions **P**er **M**inute) of the engine by making small changes in the length of the pushrod. If the #3 engine is running faster than the other three, it will shut down last. If we shortened the length of the pushrod to the #3 engine, the high speed RPM will not

change and the RPM at a given throttle setting will match the other engines. Shorten the pushrod length by turning the threaded clevis (See photograph 16.3). To get the engines synchronized we need to make small changes in the length of the engine pushrods so that the engines shut down at the same time. This will require the engines to be tuned first, one at a time, adjusting the high speed needle valve to obtain peak performance. When you tune the engines for high speed also verify the engine will idle properly.

Unless you remove the engines for servicing when you fly the airplane again, you will not have to go through the same procedure every time you fly. Every time I fly with one of my twins I warm up the engines before I fly and make sure the engines idle properly and shut down at the same time. During scale contests you are given only so much time to get all of your engines running. While it may be possible to flip start all four engines on the B-17, I recommend the use of an electric starter. You will save yourself a lot of problems if you warm up the engines on your multi-engine before your official flights at a contest.

As with any glow engine, there are problems that will come up and engines will quit in the middle of the flight. Both the port and starboard engine on my .15 powered Grumman F7F-3N Tigercat have quit (one at a time, not at the same time) in flight without any major problems. If you fly in the counter-clockwise direction the starboard engine quitting is no problem, but when the port engine quits things can get interesting. When this happens on my Tigercat I can not make fast changes in the throttle setting or the nose of the airplane will turn in towards me. When this happens, slowly reduce the throttle and land soon as possible. When the port or starboard engine quits on a twin, taxiing can be quite difficult. Despite these minor problems twins, Tri-motors and 4 engine bombers can be a lot of fun. Consider a twin for your first multi-engine project. Good luck and keep your wings level.



Photograph 17.1 - Author's 53" Span Scratch built Douglas A-20G Havoc
Twin OS-20FP and Single Channel electronics
Note main wheels touch first and then rotate to nose gear

Section 3

Control Line Scale Competition

- Notes -

Chapter 18 - CL Scale Competition

You can compete in several levels of CL Scale competition at the local level or even the international level. There are six classes: Fun, Team, Profile, Sport, Precision and FAI. All Scale events (except Fun Scale) have the builder of the model rule. This means I cannot have someone else build the model and enter that model in a scale contest under my name. The pilot must be the person that built and detailed the model. In Scale events you are judged on how well your model duplicates the full size original in appearance (static judging) and flight characteristics. You are required to provide documentation proving outline and marking of the aircraft in question (see chapter on documentation).

Fun Scale -

This is currently being run by club rules, which was started by the Garden State Circle Burners in New Jersey. Basically this event is intended for first time pilots with no experience. The builder of the model rule is not imposed here. This means you can fly a model built and detailed by someone else. 90% of your score is based upon how well you fly the model, the remaining 10% is the static judging. The static judging has greatly reduced standards and allows for almost any model as long it looks like a scale model. Carrier and semi-scale stunt models may be entered in this event.

Team Scale -

This event was also started by the Garden State Circle Burners in New Jersey. The team consists of a builder and pilot, flying under sport scale rules. Again this is run using club rules. This event is not normally run at all contests. If sponsored at your local contest get a full set of rules before arriving at the competition.

Profile Scale -

This event works just like Sport scale however the fuselage and nacelles are very thin (1" maximum width) and it is intended to be a beginner's event. From the side, the model has the correct outline. This event is an AMA sanctioned event at the Nationals. The Garden State Circle Burners from New Jersey were responsible for getting this event on the AMA list of sanctioned events. This is a very popular event and can be found at almost any CL Scale Contest.

Sport Scale -

Models in this event are static judged at a distance of 15 feet. This event is a great challenge and requires the model to maintain all outlines including the fuselage cross sectional shape. Although static judging can get very demanding, the cockpit interior is not judged in this event. The flight portion has 4 mandatory maneuvers and 6 options chosen by the pilot. The 4 mandatory are takeoff, landing, 10 level laps and realism. The remaining six options can include taxi, touch & go, throttle control, multi-engine, retracts, flaps, wing over, loop, bomb drop and other mechanical options that are typical for the aircraft being presented. In sport scale, taxi, touch & go and retracts each count as two options. Static and Flight points share equal weight so you must do well in both to win.

Precision Scale -

Models in this category are judged up close! Everything gets judged including the cockpit. Modelers should strive for perfection when attempting this event. While it may seem daunting at first, methodical, careful building will result in a model you will be proud of. The flight portion again has 4 mandatory maneuvers and 6 options. The four mandatory flight tasks are takeoff, 10 level laps, landing and glide slope (realism in sport scale). In this category, taxi, touch & go and retracts only count as one option each. It can be difficult to fill out the entire option list with certain types of aircraft. A model such as a Piper Cub with just throttle control will have a hard time filling out all six options. A warbird with lots of mechanical options will have no problem filling out the options sheet with throttle control, retracts, flaps, multi-engine, touch & go and taxi. Be prepared to document everything and have everything perfect. The direction of wood grain on the instrument panel can even be questioned and points deducted if it is not going in the right direction!

FAI Scale -

This is international level of scale that is flown in Europe, United States and other foreign nations. Every two years a team from the United States is sent to the World Championships. The team is selected the year before during the Team Trials. The next team trials will be held in 2001 and 2003 and so on. This event is most demanding and is similar to Precision scale. Models built from fiberglass kits and normal kits are not encouraged. This event has the same basic flight program as Precision scale. You still have to do five options so your choice of model and options are very important. FAI competition is only offered at the AMA Nationals every year and at the team trials every other year. FAI can be sponsored by smaller regional contests, however this is rare. If you are serious about this category I would suggest doing additional research before building a model for the Team Trials.



Photograph 18.1 - Author's 1/4 scale Bravo flown in Sport Scale from the Sig kit. Powered with a Saito .91 four stroke, featured flaps and throttle using a converted Airtronics radio in as described in the Multi-channel chapter. This model weighed 17 lbs and spanned 87"

Chapter 19 - Flaps & Retractable Landing Gear

The ultimate option

The bottom line in Scale competition is OPTIONS. Two of the more impressive options for a CL scale model are retractable gear and flaps. Imagine a P-51 Mustang with the gear locked down through the entire flight and landing with the flaps in the up position - realism points will suffer, especially in Precision scale. Now take the same model, add electronic controls, flaps and retractable gear.

The model is built with these options in mind. Before you start closing up the fuselage and wing sections, you have to decide what features will move and how to hook them up. Flaps are the easiest and a blast to fly with. Landing speeds are reduced to a crawl and really add to the realism points.

When picking how you are going to activate the flaps during flight you have to make some important decisions. If you use a toggle switch the flaps will drop quickly, sometimes too quickly. When you lower the flaps on your model you will have to apply some elevator trim to maintain level flight. The nose will pitch up as the flaps are lowered. Additional down elevator trim must be applied to keep the nose pointed in the same direction. The reverse is also true, as flaps are pulled up the nose will drop and additional up elevator must be applied. If you can find an electronic device that can slow down the servo, use it. But the easiest solution is to activate the flaps by using the control stick instead of a toggle switch. Remove the spring from the backside of the elevator stick from the transmitter and you are on your way. You may have to install a metal piece to hold the stick in any one position. This will allow you to lower the flaps slowly; allowing you to feed in down elevator trim while the flap is lowered.

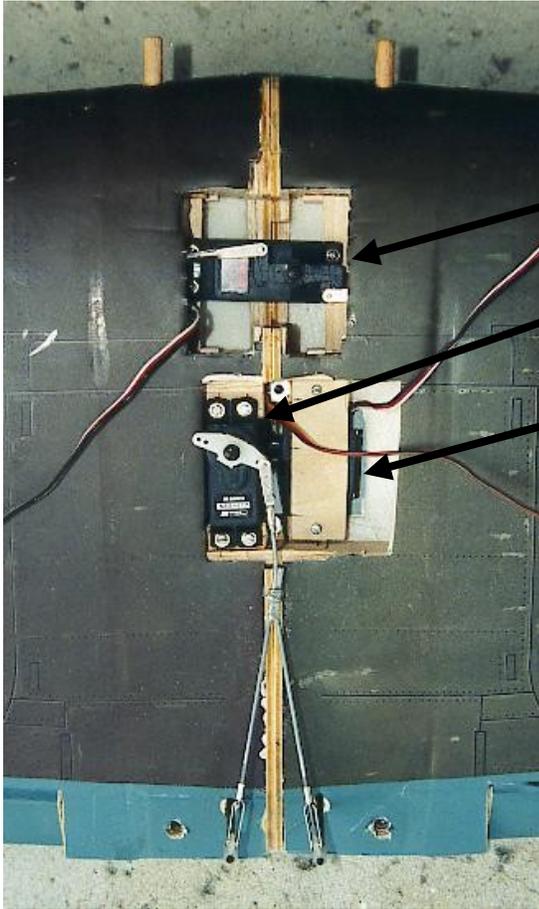
Retractable gear is one the hardest options to pull off, yet one of the most impressive. The majority of the retract systems are air powered. The smaller units can be operated with a retract servo, but sometimes the size and weight of the landing gear overwhelms the retract servo. What ever system you use, Spring Air, Rhom Air, Robart or some other brand always test the valve and the entire system before installing it into the model. Warbirds such as the P-51 tend to have long struts with large, heavy wheels.

You must choose a retractable gear unit that can handle the weight strut and wheel that goes with your model. Robert has a large selection of specialized retractable gear units designed for certain kits. Contact Robart for a complete list. The air cylinder or retract servo that retracts the wheel must be able to overcome all of the loads during flight and be able pick up the weight of the strut and wheel. The port landing gear on a P-51 will retract more easily than the starboard landing gear due to the centrifugal force during of control line flight.

After you get the landing gear to retract you are not done. Now you must get the landing gear doors to work with the retractable landing gear. In some cases the landing gear doors can be the hardest option to figure out. Take for instance the P-51 Mustang. If we walk up to a full size P-51 that has been sitting for several hours you will notice the flaps are down and the inner gear doors are open. When the pilot fires up the engine the flaps come up and the inner gear doors close. This is because the inner gear doors and flaps are operated with hydraulic pressure that only keeps these doors closed and flaps up while the engine is being operated.

When the pilot retracts the landing gear on the full size P-51 the inner landing gear opens, the main gear retracts and the inner gear door closes. To duplicate this will require some type of mechanical or electronic sequencer. So when installing retractable landing gear research your subject aircraft so that your model can best duplicate the operation and configuration of the full size aircraft.

How to setup mechanical retractable landing gear



Photograph 19.1 - Overall view of wing setup with retracts, flap and bomb drop servo.

Retract Servo

Flap Servo

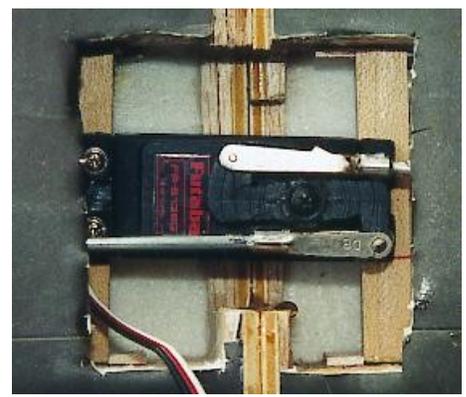
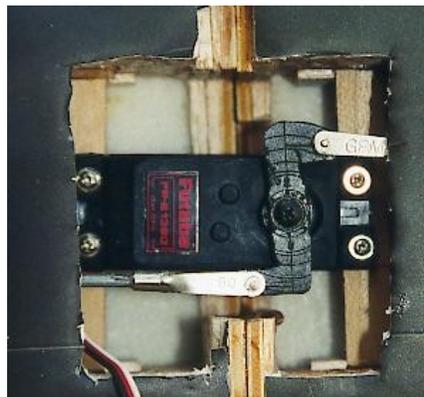
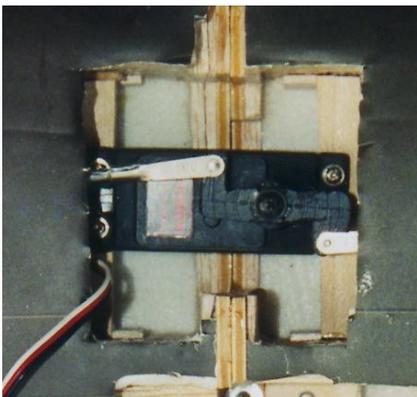
Bomb drop servo underneath plywood

Left to right shows the servo in several positions: 1) Gear extended 2) Gear half retracted 3) Gear retracted. Notice how a dog-leg in the servo arm is required when the retract servo rotates 180 degrees

Photograph 19.2
Position #1 - extended

Photograph 19.3
Position #2

Photograph 19.4
Position #3 - retracted



- Notes -

Chapter 20 - CL Scale Documentation

A great Scale model starts with great documentation. In fact some pilots won't even consider building a scale model airplane until they have the entire documentation package assembled. This normally includes a 3-view, proof of color and markings and other supporting data. The documentation folder you give the judges can make or break you during the static judging. Except for Fun Scale, 50% of your total score is the static points. In Precision Scale you are also judged on the quality of your documentation presentation. All of your static points are derived from your documentation folder as the judges determine how faithfully you reproduced a miniature version of the full size aircraft being presented.

The entire purpose behind scale is to build an exact duplicate of one particular airplane that looks and flies like the original. Once you have chosen what kind of airplane you want to model, your next job is to locate enough documentation on one particular airplane that strikes your fancy. The ideal documentation package will include color photographs, 3-view and color chips, however color chips are not always possible. Some projects such as original WW-I fighters will only have black and white photographs available. To really do well, especially in Precision and FAI scale competition it is critical that you can look at and touch your subject aircraft.

For the purpose of this discussion let's say we have selected the Hawker Sea Fury single seat fighter. Our first stop will be our local hobby shop that specializes in 1/72 scale plastic models. I am not interested in the plastic models and the large number of books and magazines about full size aircraft. Consider building a plastic model of your subject aircraft. It is a wonderful 3-dimensional version that will help you interpret the 3-views, plans and drawings as you build your larger flying version. Also look for bookstores or mail order outfits that specialize in aviation books such as Zenith, or Squadron. If you are building a sport scale model you may only need to pick up one or two books on your subject aircraft. Now we need to choose a paint scheme to copy. One way is to locate a restored Hawker Sea Fury and duplicate that paint scheme down to the last detail. Remember you can not change any number or marking that is on the full size aircraft. Do not change the N-number on the full size aircraft to your AMA number on your model. Believe it or not this is a common mistake!

You could visit every airshow in the United States until you find the best looking Sea Fury but this is asking a bit much. Did you realize that there are between 15 and 20 flyable Sea Fury's on the national register? There are also about the same number in museums spread around the country that have been restored for static display only. Any of these examples would be a good candidate for your scale model. While at the Oshkosh EAA Fly-in I found three Sea Fury's on display just begging to be photographed. One of them belonged to Ellsworth Getchell who is very active on the airshow circuit. When you find your subject aircraft, grab 2 rolls off film (36 exposure each) and start shooting. Start with an 8 point walk around which will include the left and right side of the aircraft and shoot the details (see photograph 20.1 thru 20.14). Be sure to take a photograph of the landing gear, propeller blades, small markings, elevator and any other small details on the airplane you can spot. When shooting the landing gear be sure to use the flash so that the details can be seen clearly. Take lots of pictures, you may only use 12 pictures in your documentation folder, but you will be looking at all of the pictures while you build and detail your model. You will be referring to these photographs as you build your model so keep them handy.

The odds of finding a Sea Fury locally can be very remote, so this where Bob Banka's Aircraft Documentation can help you out. Bob has the largest collection of documentation photographs and sells prints from his original negatives. With over 8,000 photo packs he has at least 13 single seat Sea Fury's available. While a Piper Cub can be found at almost any airport, the unique and rare airplanes that we enjoy modeling are rarely in our back yard. Call Bob and order his catalog to see what he has available. His catalog also lists over 35,000 3-views that will also be required for your documentation package (relax, you only need 1 out of the 35,000 that Bob has available in your documentation folder).

Now pull out that 3-view of the Sea Fury and the photographs of Ellsworth's airplane. You will be building a duplicate of Ellsworth's airplane; that means if he modified his plane; you need to modify your model to match. Many restored WW-II fighters have been "modernized" which means there will be differences between the restored version and the wartime version. Ellsworth has removed the tail hook from his plane and faired in the bottom of the rudder. And he has also removed the support structure that is normally behind the pilot's seat. Other Sea Fury's have been modified to accept an American radial engine, the difference being that the American engine will turn a 4-blade propeller counter-clockwise, while the original British engine turns a five-blade propeller clockwise! While the 4-blade propeller is not authentic, it does not matter since we are creating a scale model of a restored aircraft. If the Sea Fury was restored for static display it would contain the authentic instruments and engine. When warbirds are restored to fly again they have to incorporate instruments and other modern features that would not have been part of the aircraft when it was originally built. These changes will have to be incorporated into your model. Fairing in the bottom of the rudder changes the outline of the model so you will have to clearly point this out to the judges. The photograph will take precedence over the 3-view in cases like this.

Be careful when deciding what photos you are going to include in the documentation package. You may pick a picture because it shows the flap detail that you faithfully duplicated on your model. But you may not realize that the picture also shows another feature that is not on your model. The scale judges will notice the flap detail, and will also notice the other feature in the photograph is not on your model. **Bottom line; only include photos that shows items and details that are on your model, otherwise the judge will notice and deduct points accordingly.**

Now let's talk about how you should present the information you have collected. You need to provide the judges information about the full size aircraft and your model airplane quickly and efficiently. You have up to eight pages to do this for Profile and Sport scale. With a Precision scale model you have up to twenty pages and you are judged on your documentation. Your documentation package will determine how you will place in the competition. Consider having other experienced scale modeler's static judge your model before you enter your first contest. They can act the role of the scale judge, take a fresh look at your model and documentation and make comments accordingly. After they judge your model talk to them and make changes to your documentation package or scale model as needed. Your scale model airplane may be perfect, but if your documentation package confuses the judges, your static score will suffer.

-

Documentation folder contents and layout

1) Information about yourself and the model airplane

- One page that has information about the model, engine size, wing span, paint, operational details such as landing gear, moving rudder pedals, etc. Mention things like was the model scratch built, or it was from a kit.
- The documentation should include your name, where you are from and AMA number
- Information about the full size aircraft. Include information such as wing span, length, maximum speed, and basic information about how it was used. The judges are not looking for in depth information here.

2) Proof of Scale – your 3-view goes here

- Typically a 3-view is used here, but you can also use photographs or a plastic model. If you choose to use a plastic model or photographs then additional research is required to see what the current AMA rules require.
- 3-views must come from a reliable source. You can draw your own 3-view, but you must have the 3-view approved before it can be used in competition. Refer to the AMA rulebook about how to accomplish this.

3) Proof of color scheme

- This can be a color painting or drawing, photographs or written documentation
- Show the 8-point walk around in this section for color scheme and markings. Include any detail photographs that prove color scheme and smaller markings
- You can also use detail photographs here for color as needed.
- Some aircraft modeled no longer exist and you may not be able to present an 8-point walk around. Present as much information as you can to prove the color scheme.

4) Degree of gloss and color chips

- This is where you document if the aircraft had a high gloss finish or a matte finish
- Paint chips available from the Federal Government are one of the standards you can use in this section to prove you have painted your model the correct color. Refer to the section on how to order color chips (see page 100)

5) Photographs of subject aircraft

- This is where the detail photographs go. Landing gear, under side of the wing, canopies and cowl detail to mention a few.
- The 8 point walk around would be located in the Proof of Color Scheme section
In some cases your subject aircraft may not exist anywhere in the world. In this case you would have to present photographs of typical subject aircraft for the details such as landing gear and the canopy. Be sure that the photos represent the correct version of the aircraft you have modeled.

Put all of the above information in a 3-ring binder and type the pages if at possible. A concise and clear presentation will go a long ways in helping you get a high static score. In precision scale the documentation folder is judged so make it clean and presentable.

Photographs 20.1 thru 20.8 Typical photo walk around

Notice how every angle and side of the aircraft is shown in the photographs

Bob's Aircraft Documentation is an excellent source for photographs like these

Propeller shape, wing dihedral, landing gear position can be determined by these photographs

Photographs provided by Bob's Aircraft Documentation



Photographs 20.9 thru 20.14
Typical detail shots

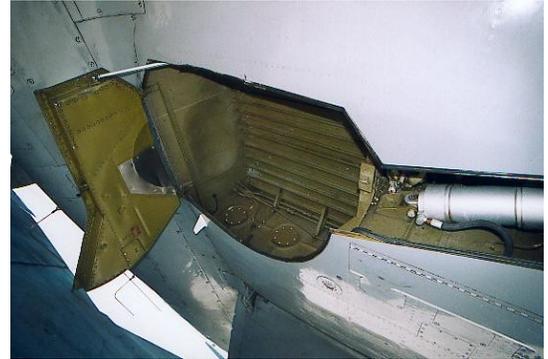
Photographs provided by Bob's Aircraft Documentation



Inboard sides of landing gear leg showing wheel, strut and door detail



Outboard side of landing gear leg shows door detail



Interior of wheel bay also should be detailed, notice gear door and hydraulic piston that closes gear door.



Underside of stabilizer, nothing there, but without this photo you would be guessing.



Underside of wing, notice stars & bars, formation lights and wingtip light. You would also need a similar photo of the port wing



Tailwheel detail, I had to crawl on the ground and use a flash to get this shot. Notice the color of the interior and scoop detail in front of tailwheel.

- Notes -

Chapter 21 - Documenting the Color of your Subject Aircraft

One of the more important sections of your documentation package is color and proof of color. Your photographs, color painting or drawing or written documentation will show the judges where the colors are located on the aircraft. But now you need to prove to them that you have chosen the correct color. This is where color chips come into the act. These are standard color chips available from the Federal Government or Frank Tiano (see list of contacts). Historical documents also list which aircraft used what colors during military service. When you go about documenting the color of your aircraft you may be presented with several options.

1) You can look at, touch and personally examine the subject aircraft you are modeling

In this case you have chosen an aircraft in a local air museum or airport. Talk with the owner of the aircraft first before touching the aircraft. *Don't ask for forgiveness later; ask for permission before you get started.* Take your Federal Standard Color Chip fan deck with you and determine the exact color that is on the plane. Basically you will place the fan deck up against the actual full size aircraft and determine what color on the fan deck best matches the color on the full size aircraft. Do this for each color on the plane.

Write down the FS numbers that best match the full size aircraft and order the 3" x 5" color chips from the address on the next page. In your documentation package tell the judges you inspected the full size aircraft and these were the colors that matched. Include the color chips in your documentation package with FS number and general information about where this color was located on the full size aircraft.

2) The aircraft no longer exists anywhere, or you don't have access to the subject aircraft

In some cases you may have ordered pictures from Bob's Aircraft Documentation, found photographs in a book, or perhaps a color drawing with a paint scheme that you like. The color drawing and photographs can vary the shade of red and other colors depending upon how they were printed. When you can't prove the color of your subject aircraft with FS color chips, you may have to use one of the color photographs or some form of written documentation.

Let's say for example we have photographs or a color drawing of a Republic P-47 Thunderbolt. The documents we have show an aircraft with olive drab top surfaces, gray bottom, black and white invasion stripes and a red band on the cowl. The color drawing is just fine to show the judges where the colors are located on the plane.

Now we need to find some historical reference that documents the olive drab, gray and other colors this P-47 was painted with. One of the more complete sources is the IPMS color cross-reference guide by David H. Klaus (Available thru Meteorprod.com). This book lists the colors by name, FS number and how it was used. Other books on your subject aircraft may also list the FS number. Put this written documentation in your package to show the judges and include the color chips. Plastic model kits also are a great source of FS numbers; the kits often list the proper FS numbers for painting the plastic model.

Conclusion:

Depending upon what you choose to model, finding the documentation may be easy or difficult. The historical information about FS numbers is well documented for military aircraft, but the civilian aircraft will be more difficult to prove. *If you have a color photograph and there is no information about FS color chip information about your aircraft you may be forced to use the color photograph as a color chip. In this case pick one photo and tell the judges to use this one particular photograph as the color chip.*

Once you get your color chips for you subject aircraft mix your paint to match the color chips. Also be sure to match the degree of gloss that best matches your subject aircraft.

How to order color chips and Fan Deck of color chips:

Write to: General Services Administration
 Federal Supply Service Bureau
 Specification Section
 470 East L'enfant Plaza S.W. Suite 8100
 Washington, D.C. 20407
 (202) 755-0325

Make checks payable to: "The General Services Administration, Attention: Specifications"
Be sure to include a cover letter with your check when you order color chips.

Personal checks over \$20 are not accepted, send a money order or use your credit card. This information about price can change quickly so please call to verify the prices and availability are correct. Also verify that the FS color chip you want is available, some of the color chip numbers listed in the IPMS color guide are not always available. The best way to do this is to have the fan deck of all the color chips that way you can verify the FS number availability and see what color you have selected.

3" x 5" color chips are \$2 each, \$2.50 foreign (tell them what FS numbers you want of course)

Fan deck of all the color chips (highly recommended) is \$35 (\$43.75 foreign)

You can order your own copy of the IPMS color cross-reference guide:

Meteor Productions, Inc
P.O. Box 3956
Merrifield, Va 22116
703-971-0500
Web Site: meteorprod.com

\$45.00 for IPMS Color Guide only, plus postage, call for details

\$58.95 with FS595 fan deck color chips, plus shipping, call for details

Call for current pricing and availability

Chapter 22 - All 3-views are Not Created Equal

How to select the correct 3-view to suit your needs

Scale modeling challenges the builder from every angle. The model must be built light and flown properly to do well in competition. In RC and CL Sport Scale, 50% of your total score is the static points that the judges award for outline, markings and color. The outline line portion alone accounts for 40% of the static score. Even though the judges may have seen the full size version in the past, they will rely on the 3-view drawing that you provide. The 3-view that you put into your documentation package is a very important decision because your static score will depend on it.

The complexity of the 3-view determines where and how you will use it. Each 3-view must have a top, side and front view, however some are more detailed than others and may add the following: fuselage cross sections, airfoil, panel lines, actual dimensions, cockpit details, marking location, and internal structure. Some even have a separate bottom and top view. Scale drawings of multi-engine aircraft will sometimes show the location of the wing root with the wing removed. Also look for 3-views that show the shape of the inboard and outboard nacelle on four engine aircraft.

Once you have decided on your scale project think about your documentation package before you start building. Once you have built and painted the model it is too late to make corrections. By now you have picked up as many 3-views as possible of the same aircraft and now its time to decide which one you are going to use in the documentation package. If you are building from a kit, now is the time to fix the outlines of the non-scale components before you start building. When your model is judged, it will match the 3-view you have included in your documentation package. If scratch building, draw your plans from this 3-view.

The complexity of the 3-view that you have chosen is also important. When building a Precision scale model the fully detailed drawing will be helpful. However, if you plan on entering the model in Sport Scale then select the simplest 3-view that is correct for that aircraft. Cockpit interior detail is not required in Sport Scale and would only confuse the judges with information that does not apply. Some drawings show only the major panel lines, some have every panel line, and the some don't have any panel lines at all. If the 3-view you present has panel lines the judges will be looking to see if you added the panel lines to the model exactly as shown on the drawing. This also applies to other smaller details, like pitot tubes and gun barrels. If you prove to the judge that your model should have gun barrels and your model does not have these details, you will lose static points. **Remember that your photo documentation will take precedence over the 3-view.**

But let's stand back and take a really good look at the 3-view you have chosen. Look at the photos of your subject airplane and determine if the 3-view shows the exact same version in the photographs. The P-47D Thunderbolt has two versions, one with a dorsal fin and one without. Be sure to look for differences such as this. The P-51D Mustang has two different canopies and the difference is very slight, but this will hurt you in outline points if your model is different from your photos and/or 3-view. Research your subject aircraft until you get a 3-view that shows the exact version you are building. If you can't find an exact match with the 3-view refer the judges to your photo documentation.

Unlike the P-51 Mustang (numerous 3-views are available for this aircraft) it is very difficult to find 3-views of some aircraft. When you do find a 3-view, you are left with the difficult decision as to whether to use the 3-view or keep looking for a 3-view that better suits your needs. If there are small variations between your subject aircraft and the 3-view, then this line drawing will probably be acceptable. In your documentation package, you will have to point out the differences between the 3-view and your photographs to the judges. Do not assume that the judge will find all of the differences, since they are working under a limited amount of time and must judge many models in one day. When the 3-view cannot be used, then you may be forced to keep looking. Accumulating the proper amount of information to build a scale model sometimes takes months or years.

Now we will throw in a modern restored warbird such as the P-51D Mustang and Hawker Sea Fury. Relatively few restored warbirds have been returned to the 1940's military configuration. A typical conversion for a P-51D Mustang is to install a passenger seat behind the pilot. The production Hawker Sea Fury was designed to use the Bristol Centaurus sleeve valve engine with a 5 blade propeller. However, due to lack of spare parts, many owners today have installed a Wright 3350 radial engine. The cowl does not change, however the clockwise rotating 5 blade propeller is replaced with a 4 blade counter clockwise rotating propeller. Additionally some of the restored Sea furies have installed longer canopies to allow a passenger seat behind the pilot. Elmer Ward's Bearcat was restored and painted up like Gulfhawk IV (bright orange) and is a very beautiful aircraft. However, Elmer installed a longer canopy and a passenger seat. Plus the headrest normally installed on the stock military aircraft was removed. You will have to identify all differences such as these between the 3-view and the subject aircraft and point them out to the static judges.

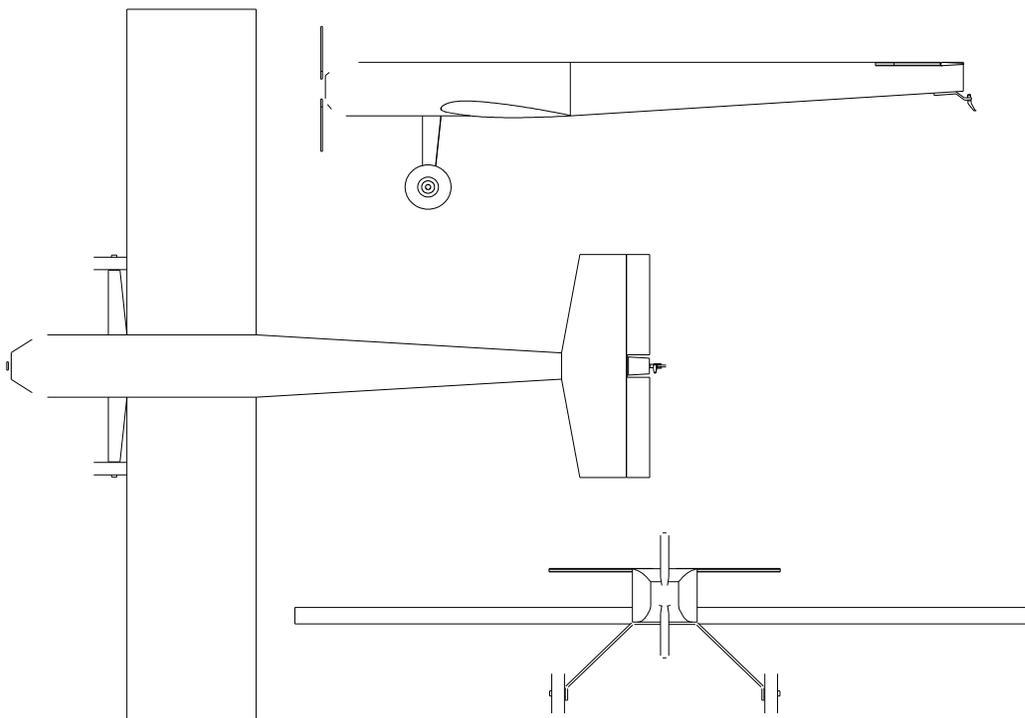
The homebuilt aircraft will have many variations since each builder will include other details that someone else did not. Hopefully the builder did not change the basic outlines of the aircraft. The 3-view of any homebuilt will probably be the basic aircraft as intended by the designer. Be extremely careful when modeling a homebuilt aircraft. For a truly accurate scale model you will have to review every aspect of the subject aircraft to locate all of the outline and detail changes.

Some 3-views are not even remotely correct and have major outline errors. Remember the vast majority of the published 3-views are line drawings that were not drawn by the original manufacturer. Don't count on the manufacturer's drawings to be accurate, because many times they are not. The information that the draftsman had in front of him/her will determine how accurate the 3-view will be. Some 3-views were drawn from photographs, while others were drawn from actual drawings from the manufacturer. And then some 3-views were drawn from actual measurements from the full size aircraft. I have at least two 3-views in my collection with major drafting errors that render them unacceptable for a documentation package. However these 3-views may have other information on them such as fuselage cross sections, airfoils or other information that is correct and useful. This 3-view should be for your eyes only, and should not be included in your documentation package.

By now you have figured out that the judges have a very difficult job in front of them. As you collect information on your subject aircraft start two different piles, one for you to look at, and one for the judges to look at. CL Sport Scale does not allow for more than 8 pages of documentation including the 3-view. Regardless of the number pages of the 3-view it only counts as one page. The other 7 pages will contain all of your color and marking information. Now you can see that the documentation package has to be tailored to the kind of event you are entering. Precision Scale level competition will require different preparation than a Sport Scale model. Again you should have already chosen your 3-view for the documentation package. If you change to a different 3-view mid-stream then you will change your static outline score. Make notes in your documentation package with the 3-view pointing out to the judges how your subject aircraft differs from the 3-view. Additionally, keep at least 3 copies of the 3-view in your documentation package, this way each judge will have a copy to work from. Good luck with your next scale project and land softly.

Typical 3-view

This is the 3-view for my camera airplane shown in the gallery section
Bob's Aircraft Documentation has many 3-views for full size aircraft available for sale



- Notes -

Contacts

Scale Documentation:

Bob Banka

3-views and photo documentation

Bob's Aircraft Documentation

3114 Yukon Ave

Costa Mesa, CA 92626

714-979-8058

Web Site: bobsaircraftdoc.com

Squadron Mail Order

Source for Aviation Books and plastic model airplanes

1115 Crowley Drive

Carrollton, Texas 75011-5010

(214) 242-8663

Web site: Squadron.com

Zenith Books

Source for Aviation Books

PO Box 1

Osceola, WI 54020-0001

1-800-826-6600

Historic Aviation

Source for Aviation Books

121 5th Avenue NW Suite 300

Web site has handy search feature

New Brighton, MN 55112

651-635-0100

Web site: historicaviation.com

Wings & Airpower Magazines

Source for magazines with lots of historical photographs

Sentry Books

Web site has listing for back issues

10718 White Oak Ave, Box 3324

Granada Hills, CA 91344

Web site: airpoweronline.com

Frank Tiano

Source for Color chips & Scale bombs, Call for details

15300 Estancia Lane

West Palm Beach, FL 33414

561-795-6600

IPMS Color Guide

Source for FS colors used on Military Aircraft of all nations

Written by: David H. Klaus

They also carry the FS595 Fan deck

Meteor Productions, Inc

P.O. Box 3956

Merrifield, Va 22116

703-971-0500

Web Site: meteorprod.com

Components for Electronic Controls:

Custom Electronics

Box 123
Higginsville, MO 64037
(888) 584-6284
(888) 584-6285 Fax

Servo Driver for single Channel Electronic control

Bill Young Designs

4403 E. Rustic Knolls Lane
Flagstaff, AZ 86004
(520) 522-0155

Bill Young handle and receivers **(Out of Production)**
Multi-Channel radio conversion

Calvin Wollitz

8996 Barco Lane
Jacksonville, FL 32222
(904) 771-0613

Multi-Channel radio conversion **(Out of Production)**

Tacklemania.com

18840 U.S. Highway 19 North
Suite 422
Clearwater, FL 33764
(727) 445-4629

Surflon insulated fishing leader for flying lines
Web site only shows what is in stock, if you can't find
what you are looking for check back later
you can only order over the web from this source

Special Interest Groups, Magazines & Clubs:

National Association of Scale Aeromodelers (NASA)

Bonnie Rediske
128 Darnley Drive
Moon Township, PA 15108
Website: Scaleaero.com/amascala.htm
Visit the web site for details on how to join
Make sure you get the **NASA Scale Resource guide** – filled with lots of resources

Model Aviation Magazine

CL scale column by Bill Boss
Published monthly by Academy of Model Aeronautics
5151 East Memorial Drive
Muncie, IN 47302
Web site: modelaircraft.org

Control Line Hardware & Kits:

Brodak Manufacturing
100 Park Ave.
Carmicheals, PA 15320
724-966-2726
Web Site: Brodak.com
Catalog available

CL kits, bellcranks, assorted CL hardware

RSM Distribution
1570 E. Edinger, Unit G
Santa Ana, CA 92705-4909
714-547-5745
Web site: rsmdistribution.com

CL kits, bellcranks, assorted CL hardware

Windy Urtnowski
93 Elliot Place
Rutherford, NJ 07070
(201) 896-8740
E-mail: windy@windyurtnowski.com
Web site: windyurtnowski.com

CL kits, bellcranks, assorted CL hardware
How to Video tapes for CL stunt

Radio Control Model Airplane Kits:

Bruce Tharpe Engineering
8622 E. Evans Creek Road
Rogue River, OR 97537
Information: 541-852-1708
Orders: 800-557-4470
Email: tharpe@cdsnet.net

Venture 60 and other model airplane kits

Electric Powered Flight Components:

SR Batteries, Inc
Box 287
Bellport, NY 11713-0287
Phone: 631-286-0079
Fax: 631-286-0901
Web Site: srbatteries.com

High Performance Nicad batteries, matched Cells

Astroflight
13311 Beach Ave.
Marina Del Ray, CA 90292
Phone: 310-821-6242
Fax: 310-822-6637
Web Site: astroflight.com

Speed controls, electric motors and chargers

- Notes -

Conclusion

What ever your experience level with Control Line I think you will find flying with throttle control and electronics a real joy. For those who still stand by their old 3-line system I have countless quotes and stories from those who use to fly with 3-line and now fly with the electronics. The vast majority of the people who fly with electronic controls never build another model with a 3-line bellcrank again. Give the system a try and let me know what you think. I am interested in your comments, questions and improvements to the information presented here.

Here are some myths that constantly come up in discussion

I am use to the 3-line handle - I can't change now

I have had many older pilots change over to the electronics after flying with 3-line for 20+ years. These pilots maintained that they did just fine with the 3-line system and then they flew one of my airplanes with electronics. Until they actually tried electronics they never really understood the system and it's advantages. The electronic model (especially with the DSC radio) is easier to set up and adjust. Once you set up a model with the DSC radio and end point adjustment you will think twice about the 3-line mechanical setup. Additionally the Bill Young handle duplicates the trigger on the older 3-line handle.

I can't fly with one hand while my left is at my belt

This has been compared to patting your head and rubbing your belly at the same time. This rumor is not true. Some pilots have the habit of flying with both hands when using the 3-line handle, one to fly the plane and the other to move the throttle trigger that sticks up above the 3-line handle. We have flown 20 lb models with one hand; you simply have to adjust the line guide to maintain a minimum line tension without breaking your arm. Some pilots may feel more comfortable with the Bill Young handle, which is very similar to the older 3-line handle.

I don't know anything about electronics

You are not soldering up circuit boards with the material presented here. If you can take wire, connectors and solder and follow a basic wiring diagram you can assemble the Single Channel system. You will need a soldering iron, multimeter and some other basic tools. The DSC radio makes it really easy because all you have to do assemble a set of lines and use off the shelf hardware to make the system work. And systems like the handle from Bill Young take off the shelf hardware and create a plug & play setup that is easy to setup and maintain.

All those batteries are just too complex

Yes this system has batteries, no getting around it. If you go with single channel you can use dry cell batteries at both ends. The DSC and converted radios normally come with a charger and if you follow the manufactures instructions, you will do just fine.

- Notes -

Photo Gallery



Plate #1 - Kieth Trostle's Precision Scale Martin Baker MB-5
Flaps, Throttle, Radiator Scoop, Rudder moves with Pedals
Nationals 2000 Precision Scale Champion, 5 flying lines
55" span, .65 glow powered



Plate #2 - Grant Hiestand's Precision Scale 1/3 Scale Spacewalker
103" span, Astro Flight 90 Geared Electric Motor, 18 lbs
1993 & 1995 Nationals Precision Scale winner
1995 NASA Flight achievement award winner

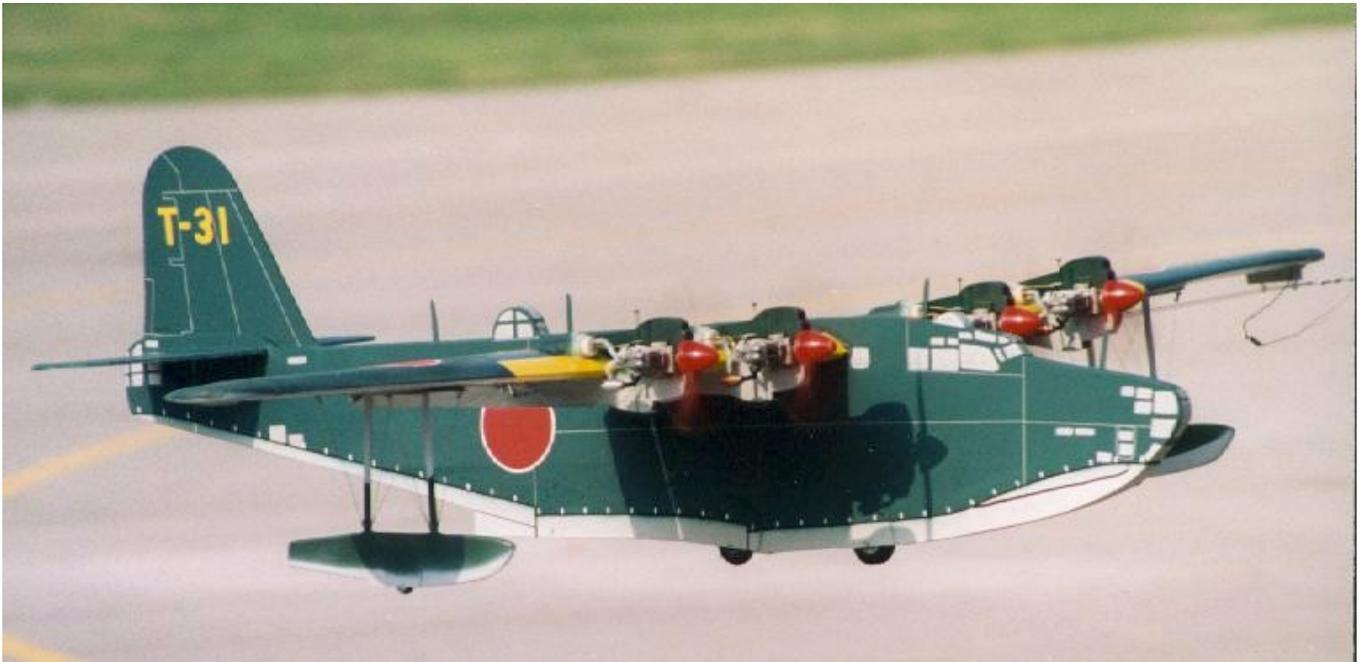


Plate #3- Merle Mohring's Scratch built Emily Flying Boat
Control Line Profile Scale, OS-26 four strokes for power, 90" wing span
Throttle & Flaps, Multi-Channel Electronic Controls



Plate #4- Fred Cronenwett's Fun Scale Hanger Nine Piper Cub
81" span, 9 lbs with Astro Geared 40 with 16-8 Propeller
Astro Flight Super Gearbox, DSC electronic Controls
This airplane can carry an 8mm video camera inside the cockpit!



Plate #5- Merle Mohring's BF-109G built from the Innovative Kit with an OS-90 four stroke for power, retracts, flaps, throttle with multi-channel controls



Plate #6- Fred Cronenwett with his scratch built Camera plane on floats. This model can be flown from water or land. 80" span, shown here with an ST-90, but has since been replaced with an OS-91 four stroke. DSC electronic controls. This is a wonderful test aircraft for motors, electronics, camera platform and other features.



Plate #7- Lynn Boss's P-47 Bubble top Thunderbolt from the Top Flite gold edition kit. This model uses DSC controls for retractable landing gear, flaps, throttle, tank & bomb drop and steerable tailwheel. This is a precision scale model that is powered with an OS-90 four stroke.



Plate #8- Merle Mohring is getting his Royal B-17F ready for flight. This model spans 77" and has four OS-26 four strokes for power. Multi-channel electronic control for throttle, retractable landing gear, rotating turrets and flaps.



Plate #9- Grant Hiestand with his scratch built Beechcraft Baron 58 from Royal plans. This model featured retractable landing gear, flaps and throttle with multi-channel electronic controls. A pair of twin Fox .40 sized glow motors was used for power. The model spans 72" and weighed 11 lbs. Grant found a Baron at the local airport, took pictures and duplicated the paint scheme on his model. This model was flown in Sport Scale.



Plate #10- Fred Cronenwett with his 36" span Sterling Corsair in 1990, Single channel controls, monokote for covering. This model was powered with an OS-25FP. This model is so small the only thing that could be installed without making the model too heavy to fly was a throttle servo. The model weighed 3 lbs and flew on 52 foot lines

Shown here with the servo driver plugged directly into the airplane



This is the full size version that is owned and operated by Planes of Fame Air Museum in Chino California.





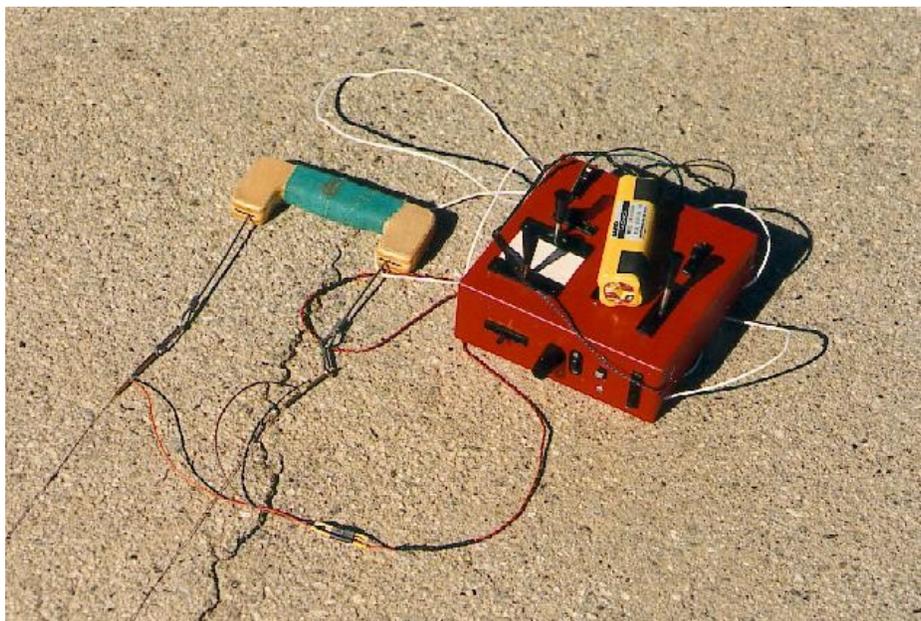
Plate #11- This is an ARF model that was used to test the Prototype single channel electronic control system by Fred Cronenwett. 63" span, Fox Eagle 60 for power and this model was a blast to fly. Grant later flew this model for several years with an Astro 40 geared electric motor. A lot of valuable lessons were learned from this model flying it on a daily basis.



Plate #12- Flown by Merle Mohring, this Mig 15 was fast and a challenge to fly. You can see here is has a prop in the nose. You can't see the tuned pipe that runs thru the fuselage.



Plate #13- This model is not shown for its good looks. This was the prototype used to test the converted ACE radio that became the Multi-Channel electronic controls. The basic system was crude at this point, but proved that it could be done. 48" span, OS-35FP for power. This model weighs 4 lbs in this configuration. The lines used on this model were normal flying lines coated with Clear dope, we later switched to the fishing leader.



Boeing 314 Clipper



Plate #14- Grant Hiestand built this 88" span Boeing 314 Clipper from white foam and covered it with Econokote and then painted it. Powered with four electric motors, this airplane used DSC electronic controls and was flown off of the Roseburg, Oregon float pond in 1999.

This model is a flying test bed for the fully detailed version. Grant was using this plane as a test bed for the electric motors, size and overall weight of the model.

Is it the real thing or a very large CL model?

The Schneider Cup Racers



Plate #15- Curtiss R3C-2 Seaplane built by Dave Shrum of Roseburg, Oregon. 3-line control for throttle control with an .60 glow engine for power



Plate #16- Supermarine S6B scratch built by Grant Hiestand. 51" span, F.A.I. 15 electric powered with DSC electronic controls. Grant carved his own plugs for the floats and fuselage to create the fiberglass fuselage and floats.



Float planes at the Roseburg, Oregon float pond.

Plate #17

Shown to the left is Grant Hiestand's scratch built 314 Clipper, Steve Davis' PBY Catalina from the Kyosho ARF kit and Fred Cronenwett's scratch built 41" Grumman Tigercat on floats.

These and other floatplane models were flown off of the float pond shown below. The pond was a 180-degree arc dug into the ground and filled with water as needed. There was a fire hydrant next to the road that was used for the water supply.

Carrier Deck

Float pond





Plate #18- Author's Hanger Nine Cub with floats flying from the Roseburg, Oregon float pond. The floats were built from Great Planes float kit (balsa).



Plate #19- Grant Hiestand's Great Planes ARF cub taking off from the Roseburg, Oregon Floatpond powered with an Astro Flight 40 with super box and onboard video camera

Plate #20- Merle Mohring's scratch built XB-35 for profile scale. This model had throttle control and was an experimental model with a flying wing. Models like these require testing with a prototype due to the unique flying properties. Merle learned a lot from this model and made several adjustments while flight testing this model to make it fly successfully as shown

Northrop XB-35 Flying Wing

By: Merle Mohring





Plate #21- Steve Davis built this RYAN STA from the Byron Originals kit. 90" span, OS-90 four stroke for power. DSC electronic controls for flaps, brakes, steerable tailwheel and throttle control.



What sets this model apart from others is the detailed cockpit, panel lines, pinking tape on the wings and rivet detail. This is a precision scale model that weighs 17 lbs and this model look great in the air.

German Mistal Experimental

Plate #22- For those who know your German WW-II aircraft here is a unique scale model. Called the "Mistal", the German Luftawaffe took a Ju-88 and Bf-109 or FW-190 fighter and bolted the two airplanes together. The idea was that the pilot sat in the fighter and flew the composite aircraft until it was time to release the Ju-88 bomber full of bombs to hit somewhere in the UK. This model shown below is my attempt to see if this could be done with model airplanes. The Red and blue model (representing the Ju-88) is what I called PT-2.5. The 1/12 scale Hurricane (Profile Scale) has an OS-25FP for power while the mother ship has an OS-60FP for power. The Hurricane represented the Bf-109 or FW-190 fighter. This is another example of test flying a weird idea before building the fully detailed version.



Hook for Banner tow

Bomb Bay doors

We never tested actually separating in flight like the full size Mistal did in WW-II over the UK. The Hurricane and the mother plane were both scratch built by Fred Cronenwett.

The red and blue model called PT-2.5 featured bomb bay, hook for banner tow and throttle control.

Yes it flew, but was not agile like most of my scale models. Both models used electronic controls (Single channel) to control throttle with one stick.



- Notes -

Glossary

3-point	Landing a model airplane with all three wheels touching the ground at the same time
3-view	Line drawing of aircraft from the top, side and front to establish configuration
adjustable leadout guide	Mechanical restraint at the wingtip to control the location of the flying lines that can easily change position by loosening a bolt or screw
aerobatics	Flight maneuvers such as loops, wingovers and inverted flight
aileron	Movable surfaces on the wing that control the roll of a aircraft along the fuselage centerline
air valve	Device to control the flow of pressurized air to retractable landing gear
AM	Amplitude Modulated Radio Control Units
AMA	Academy of Aeronautics based in Muncie, Indiana
ARF	Almost ready to Fly model airplane that is built and covered. Basic assembly is only required by the modeler
battery charger	Electrical device to recharge batteries to their peak voltage
bellcrank	Mechanical device that connects the two flying lines to the elevator pushrod to control the flight of a Control Line model
brushless	Electric motor that does not have magnetic brush in direct contact with the motor shaft
CAD program	Computer aided drafting, computer program used to create drawings
canopy	Clear greenhouse cover for the cockpit that can slide back, open upwards or to the side
carburetor	Adjustable venturi with needle valve to control the RPM of the engine from low to high speed
carrier	Model airplanes that fly and land on a simulated carrier deck with ropes to restrain the model airplane while landing
center of gravity	Location on the model airplane where the model balances when supported at that one location. The Center of gravity is usually 25% of the average wing chord.
CL	Control Line
computer radio	Radio control transmitter with programmable functions
control line scale	Control Line models that are built to duplicate a man-rated flying aircraft in configuration, color and markings
control stick	Movable stick on a transmitter or servo driver to control a servo
cruise speed	Speed of the model airplane between the landing and maximum velocity
crystal	Radio control electronic device that controls what frequency the radio controls transmits to the receiver.
dead stick	Landing the model airplane with the engine shut off
deadman switch	Spring loaded switch that allows the throttle to return to idle when the pilot no longer has control

deluxe switch harness	JR brand of switch harness with the wire bundle with 3 wires, required for DSC controls
direct servo connection	JR functionality on Radio Control units, allows radio control transmitter to link directly up with receiver without any radio signal being transmitted
documentation	Book, folder or 3-ring binder that contains historical and line drawings of one particular model airplane so that the judges can determine how well your model was reproduced.
DSC	Direct Servo Connection, used on JR radio control units
DSC cord	Wire that connects the JR radio transmitter during DSC operation to the receiver
electronic controls	Method of controlling movable features on a control line scale model airplane using servos and other devices. The electronic signal is sent down two flying lines without transmitting a frequency through the air.
electronic multimeter	device for measuring ohmage and voltage
elevator	Movable portion of the stabilizer that controls pitch of the model airplane during flight
end point adjustment	Changes location of servo arm on Computer radio control units regardless of how far the control stick is moved
FAI	Federal Aviation International, International level of model airplane competition
FF	Free Flight, models without any controls during flight, they are launched and are trimmed to fly by themselves.
fixed venturi	Constant diameter venturi with a needle valve resulting in a engine that has a fixed RPM during engine runs
flaps	Movable portions of the wing to slow down the airplane for landing
flight check	Verification that all of the functions on the model airplane are functioning correctly before taking off
flight pack	Main battery used to power the electric motor, usually consists of 7 or more nicad batteries.
floatplane	An airplane that can land and takeoff from water
flying wing	An airplane that only consists of a wing, the typical elevator, rudder and fuselage are not present
FM	Frequency modulated radio control units
formation flying	Flying two or more model airplanes together in close proximity
four stroke	A model airplane engine with valves, every other stroke of the piston ignites during operation
frequency	The amplitude of the signal transmitted from the transmitter to the receiver
FS number	The number applied to the color chip available from the federal government.
fun scale	Competition that does not have strict rules, static represents 10% of the total score.
fuselage	Main structure of the airplane that typically contains the engine, attachment for the wing, stabilizer, fin and any passengers
Garden State Circle Burners	Control Line model airplane club based in New Jersey

Giant scale	Model airplanes larger than 1/4 scale or 80" in wingspan
glow engine	Model airplane engine that runs as a two stroke with a glow plug that ignites the combustible gas in the piston on every stroke.
ground	Wire that connects the ground from one voltage source to another, or circuit
ground loop	A condition when the airplane turns to the left or right quickly on takeoff or landing
GYRO	Electronic device that automatically corrects for deviations in the flight direction or banking of the wings. Automatically moves the ailerons, rudder or elevator to compensate
handle	device the pilot holds that the flying lines attach to control the movement of the elevator
horizontal stabilizer	Fixed portion attached to the fuselage that maintains pitch during flight
kit bashed	Modifying production model airplane kits into something else the kit manufacturer had in mind
leadout guide	Mechanical restraint at the wingtip to control the location of the flying lines
line rake	The amount of angle between the flying lines and the wing. Resulting in an outward facing model to the direction of flight of the control line model airplane
line tension	The amount of pull the model airplane has during flight due to centrifugal force
loop	Aerobatic maneuver that consists of flying in a tight circle by applying full up elevator
maiden flight	The first flight of a model airplane after being built
matched cells	Nicad battery cells that discharge and charge at an equal rate
micro servo	lightweight and small servo
multi-engine	A model airplane with more than one engine
multi-channel	Electronic control systems that have 2 or more channels, typically older radio control units that are permanently converted to Control Line use by removing the RF decks that produce the radio signal.
N-number	Registration number used on full size aircraft
nacelle	structure typically used on multi-engine aircraft attached to the wings to house the engine and perhaps landing gear
neutral and gains	Manual adjustments found on older electric motor speed controls
NICAD	Sealed rechargeable battery
nose heavy	Condition where the center of gravity is at or near the leading edge of the wing
options	One of 5 or 6 maneuvers to be selected by the Control Line scale pilot during flight judging
overhaul	To repair, clean and update control and other systems on the model airplane
porpoising	Continual bouncing during landing that does not quit or subside over time
port	The left side of the fuselage or wing when looking in the forward direction

Precision scale	Control Line Scale model airplanes that are judged up close for authenticity and fidelity to the full size version
profile carrier	Carrier models with a flat fuselage less than 7/8" wide when viewed from the top
Profile scale	Scale models with a flat fuselage less than 1" wide when viewed from the top
prototype	The original of a new and untested design
radio control	Model airplanes that can fly in any direction using a radio signal (frequency) to control the throttle, ailerons, elevator, rudder and other functions
RC	Radio Control
receiver	Electronic device to receive a radio signal to control servos on Radio Control model airplanes
retractable gear	landing gear that can fold up into the wing or fuselage
retracts	slang for retractable (landing) gear
ROW	Rise off water
RPM	Revolutions per minute
rudder	The movable portion of the vertical fin to control yaw on a model airplane
rudder offset	built in offset that does not move during flight to offset any engine torque or other flight loads
scratch build	Model airplanes built from plans where the builder cuts out all of the pieces themselves
Semi-scale	Model airplanes that resemble the full size version but are not exact duplicates.
servo	Electronic device with a stepper motor to control the position of pushrod
servo driver	Electronic device to move a servo arm to any position required without any radio signal
servo extension	Wire that extends the distance from the receiver to the servo
servo reversing	Electronic device to change the direction of rotation of the servo arm
signal	Electronic pulse that controls the position of the servo arm
single channel	Electronic control system using a servo driver to control only one channel
speed control	Electronic device to proportionally control the RPM of an electric motor
sport Scale	Control Line scale competition where models are judged from a distance of 15 feet
stabilizer	Fixed portion of the stabilizer that controls pitch of the model airplane
stabilizer incidence	Angle of stabilizer relative to the fuselage datum line
starboard	The right side of the fuselage or wing when looking in the forward direction
Electric starter	12 volt powered hand held electric motor with a rubber cone to aid in the starting of model airplane engines

static judging	The act of reviewing the documentation package to see how faithfully the builder duplicated the full size aircraft. Model is judged on accuracy for markings, outline and details
strip ailerons	Full span movable controls on the trailing edge of the wing usually used on Radio Control model airplanes to control roll
switch harness	Wire harness with ON-OFF switch, battery charge jack, battery connection and receiver connection. Normally comes with radio control units
taxi	When a airplane rolls along the ground before takeoff and after landing
taxi test	During flight testing, an extended high speed taxi to determine how the model airplane is going to handle when it approaches flight speed
throttle	Proportional control of the engine RPM
throttle control	The act of changing the RPM of the engine during flight
toggle switch	Switch that is either ON or OFF
touch & go	Landing the model airplane, touching the wheels for a short time and then taking off again without coming to a stop. In some cases the tailwheel may or may not touch the ground.
transmitter	Electronic device with control sticks that transmits a radio frequency to control the model airplane
trim pot	Fine control on transmitters for servo position, used in parallel with the main control stick.
turbulence zone	Portions of the air behind the model airplane in flight that results in unstable flight
wing	The portion of the aircraft that generates lift during flight
wing angle of attack	angle of the wing airfoil to the fuselage datum line
wing area	The surface area of the wing as viewed from the top
wing dihedral	The angle of the wing as viewed from the front of the aircraft
wing loading	The amount of weight per unit area, based upon the total weight of the airplane and the total area of the wing. Typically stated as Ounces per square foot.
wingtip weight	Additional weight at the starboard wingtip to help maintain line tension during flight due to the drag of the flying lines

- Notes -

About the Author

My involvement in model airplanes started back in 1976 when a family friend, Luciano Nustrini, gave me a ride in a small plane over Florence, Italy. He also introduced me to model airplanes. At the time Luciano was flying large Free Flight models, the type that you launch straight up with the engine running. The time he spent letting me fly his model airplanes had a profound influence on me.

The next time you have the opportunity to work with a child, take them up in a small plane for a ride or fly model airplanes with them, it is worth the effort. I learned a great deal from Luciano in the short time I stayed with his family in Florence. This book is dedicated to Luciano who passed away several years ago doing what he like best, flying.

I started flying Control line in 1976 and then took a short break during high school and engineering school. After graduating from Engineering school with a Mechanical Engineering degree in 1988 I started doing what I liked best, Control Line scale. I have competed at the nationals twice now and countless other contests on the West Coast since 1988.

I have been a contest director, event director, scale judge and contestant. Working with other pilots like Grant Hiestand, Steve Davis, Ken Long, Merle Mohring and Lynn Boss I have learned a great deal from these gentlemen and many others. This book is summary of what I have learned from my own experiences and from other pilots. Hopefully this has been helpful in your efforts in Control Line scale.

Thank you,
Fred Cronenwett

