R/C Airplane Pull-Pull Geometry Program Documentation

January 2, 2016

© McQuinn Management Systems 2010

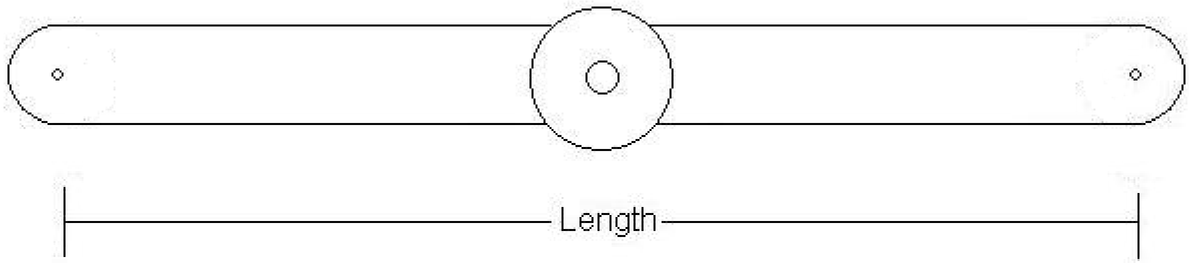
Overview

This documentation is for the Windows Computer Program for Radio-Controlled Airplane Pull-Pull rudder cable control geometry. The program is designed to calculate and diagnose problems associated with the pull-pull geometry of the RC plane. Typically the RC airplane rudder is controlled from one or more servos, an optional tiller bar, two cables attached to a control horn on the rudder of the airplane. The servos drive either directly or through the tiller arm a Servo Arm to which the cables are attached in the middle of the fuselage. The control wires exit through the sides of the fuselage and connect to the rudder horn. The rudder horn is typically either a threaded rod with fittings or a phenolic or carbon fiber (strong plate) attached to the rudder.

The goal of the pull-pull system is firstly to achieve the desired “throw” of the rudder and also to make sure the cables do not get tighter as the servo is moved throughout the full range of motion. There are four key dimensions that affect the ability of the system to deliver the correct throw without getting any tighter:

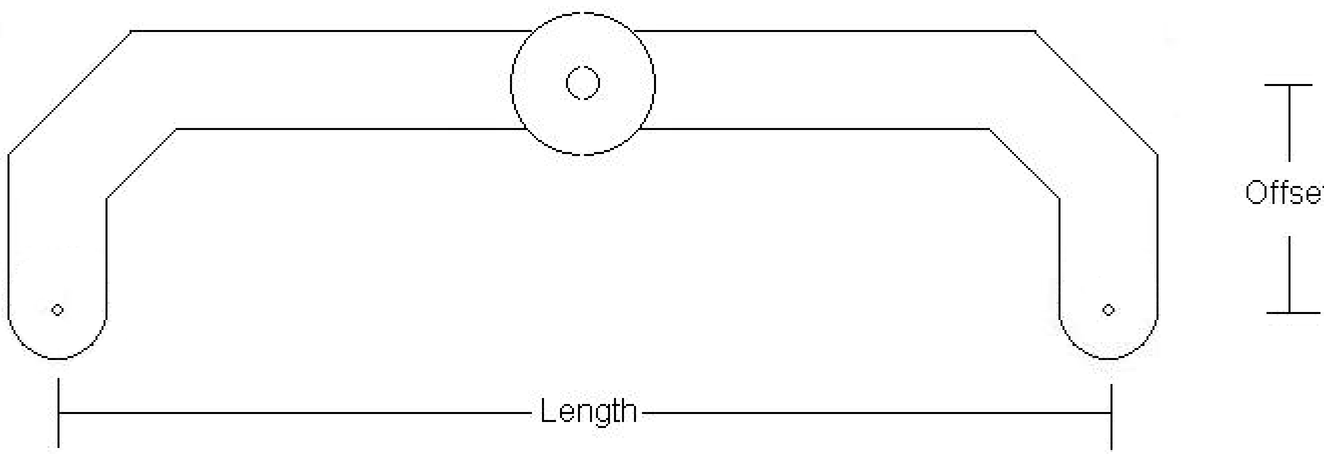
1) Servo Arm Length – the distance between the holes used on the servo to attach the cables. Typically this is about 4 inches on a 100 cc R/C plane (35% Scale)
2) Servo Arm “Offset” (if any) – the distance of the holes on the arm behind the point of rotation. On a straight arm, this is zero, but some arms have as much as one inch of “Offset” designed into them
3) Rudder Horn Length – the distance between the attachment points on the rudder horn. Usually also about 4 or 5 inches on a 100 cc airplane.
4) Rudder horn “Offset” – the distance behind the hinge line where the cables are attached to the rudder horn. If the holes line up exactly with the rudder hinge line, then there is no offset. Usually the offset (if any) is behind the rudder hinge line. This is expressed as a positive number. If the offset is ahead of the rudder hinge line then it is a negative number.

Servo Arm - Straight

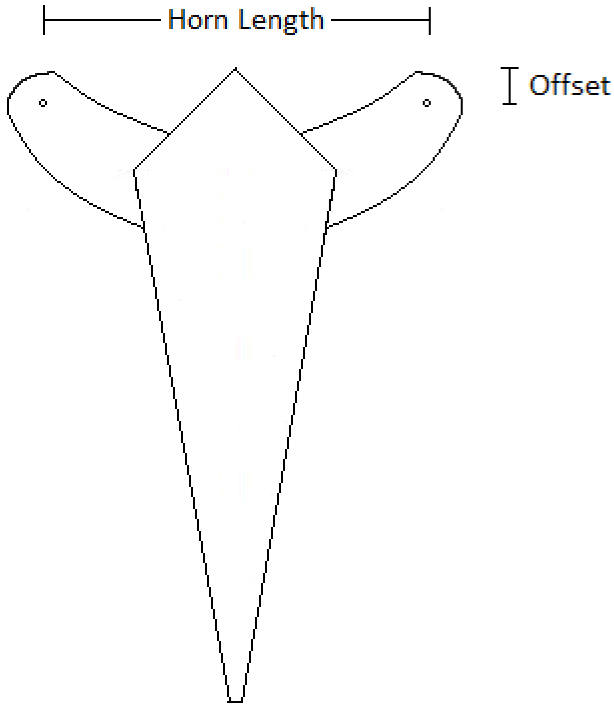


No Offset

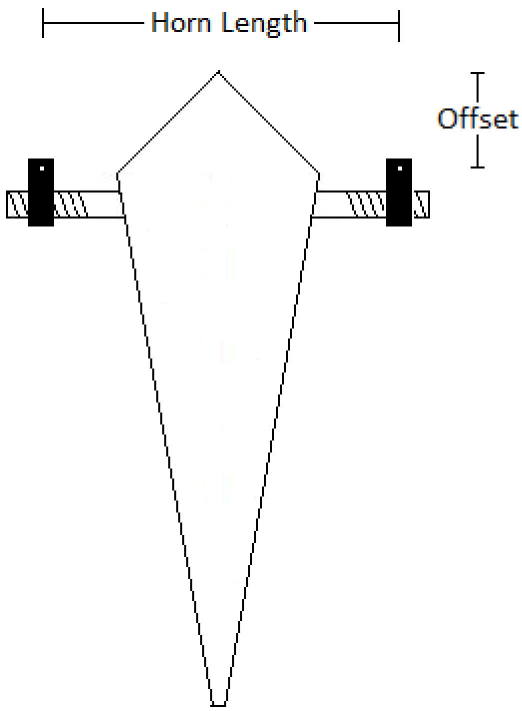
Offset Servo Arm



Rudder With Phenolic Horn



Rudder With Bolt for Horn



Getting the "Throw" correct

If your RC plane is designed for extreme 3d flying, you typically want at least 45 degrees of travel. You want to achieve this mechanically (with the pull-pull setup) as much as possible. You only want to use the programming features of your transmitter and/or servo programmer to do fine tweaking to the system. You always want your servos moving to the maximum you can get out of them – at least 45 degrees each way. Set your ATV (Futaba - Adjustable Travel Volume) or EPA (JR - End Point Adjust) to at least 100%. I use 125% as a good starting point. Do NOT be tempted to use less than 100% of the servo travel to achieve a smaller rudder throw. If you are flying precision style aerobatics (e.g. IMAC) you often only want 20 or 30 degrees of throw. Again, use the pull-pull geometry to accomplish this. If you want both high rates (for 3D) and low rates, set up the pull-pull system for 3d and then use low rates programmed into the transmitter to accomplish the lower rates.

The simple solution: for 3d rates the simplest system is to make the length of the servo arm and the length of the rudder horn exactly the same. (E.g. 4 inches). Also make the offset of the servo arm and the rudder horn exactly the same (or both zero). Use straight-through lines (not crossed). Then you have a perfect parallelogram system. If the servo moves 45 degrees, then the rudder will also move 45 degrees. There will be no tightening or loosening of the control wires at all. If you like this setup, then there is no need for the software associated with this documentation. Just set it up and go fly.

However, if you want less than (or more than) the servo deflection then you must employ a differential between the servo arm length and the rudder horn length:

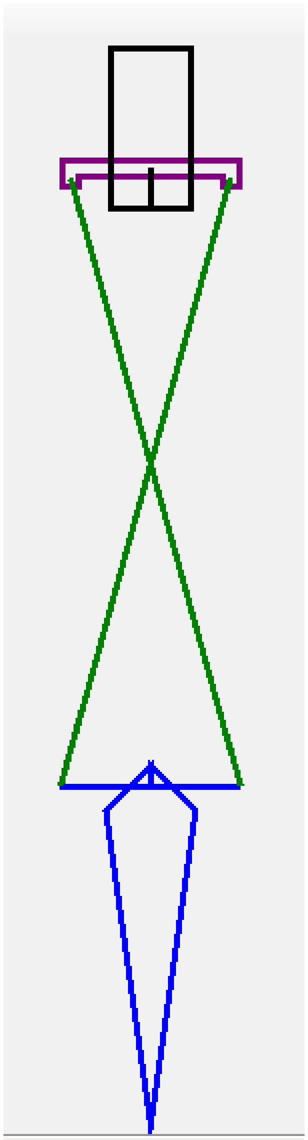
To get more throw on the rudder: Make the servo arm longer and/or the rudder horn shorter.

To get less throw on the rudder: Make the servo arm shorter than the rudder horn.

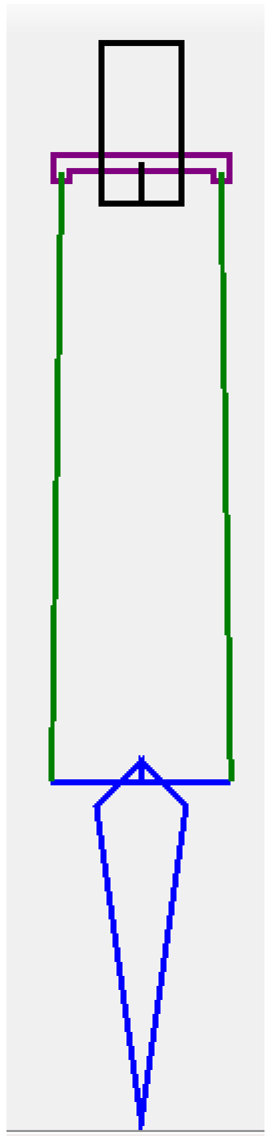
Often, you don't have complete control of the rudder horn. For some airplanes the rudder horn is an 8-32 (or 4 mm) threaded rod or bolt through the rudder about an inch behind the leading edge (hinge line) of the rudder. On the ends of the threaded rod, there are attachment fittings that extend forward but they often still fall short of the hinge line. This is called "Rudder Horn Offset" and can make it difficult to get the system perfectly set up.

Crossed or NOT Crossed

The cables between the servo and the rudder can go straight through parallel to each other or they can be crossed. There is nothing wrong with either system, although the parallel system is the only way to achieve a truly perfect (non-tightening and non-loosening) system. With a crossed system there will always be a point in the travel where the lines get slightly tighter or looser. The computer program "RC Pull-Pull Geometry" can minimize this slop.



Crossed



NOT Crossed

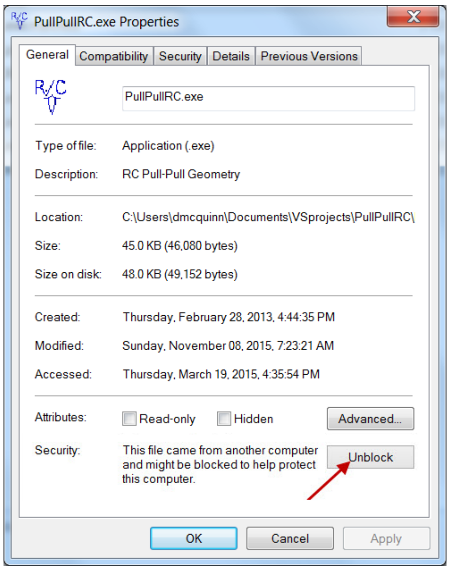
With the crossed system, when the servo rotates clockwise, the rudder is pulled right (right yaw).

With the parallel system, when the servo rotates clockwise, the rudder is pulled left (left yaw).

With parallel system, the lines exit the fuselage further to the rear. The crossed system will cause the lines to exit the fuselage further up toward the servo.

Installing the “RC Pull-Pull Geometry” Software

The program can be copied to any folder on your computer (including the desktop) where you can launch programs and save files. If you get a windows message “Windows has blocked access to this file”, then you need to right-click the zip file (and/or the EXE file), properties, and click the “UNBLOCK” button.



Supported Configurations

The program runs on Windows XP, Windows Vista, and Windows 7, 8 and 10. It runs on both 32 bit and 64 bit version of these operating systems. It takes very little memory or hard drive space. The program requires the .Net Framework (version 4) to be installed on your machine. Most computers purchased since 2009 will likely already have this component installed. If not, you can install it for free from here: MicrosoftDotNet

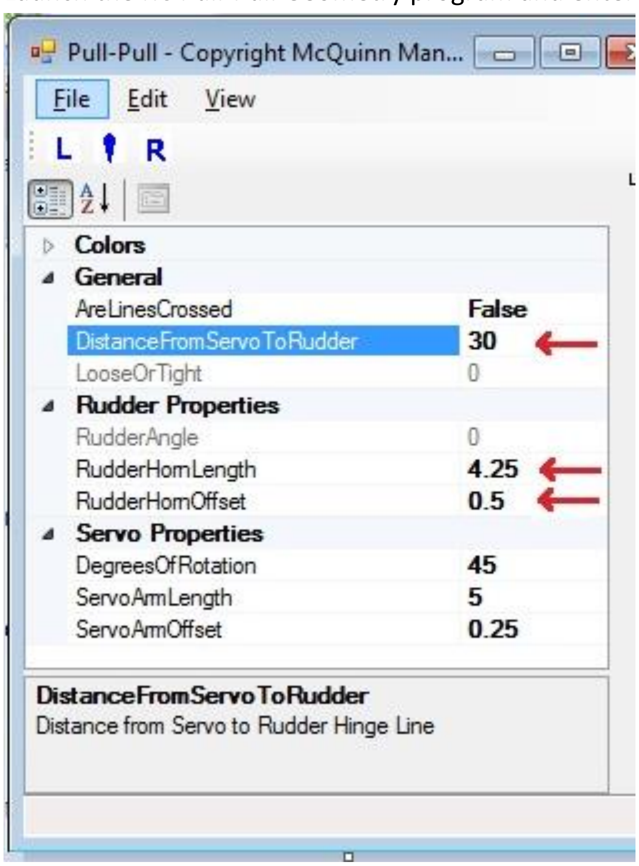
Technical Support

Contact the author via email: dmcquinn69@gmail.com or on www.FlyingGiants.com (dmcquinn)

Running the program

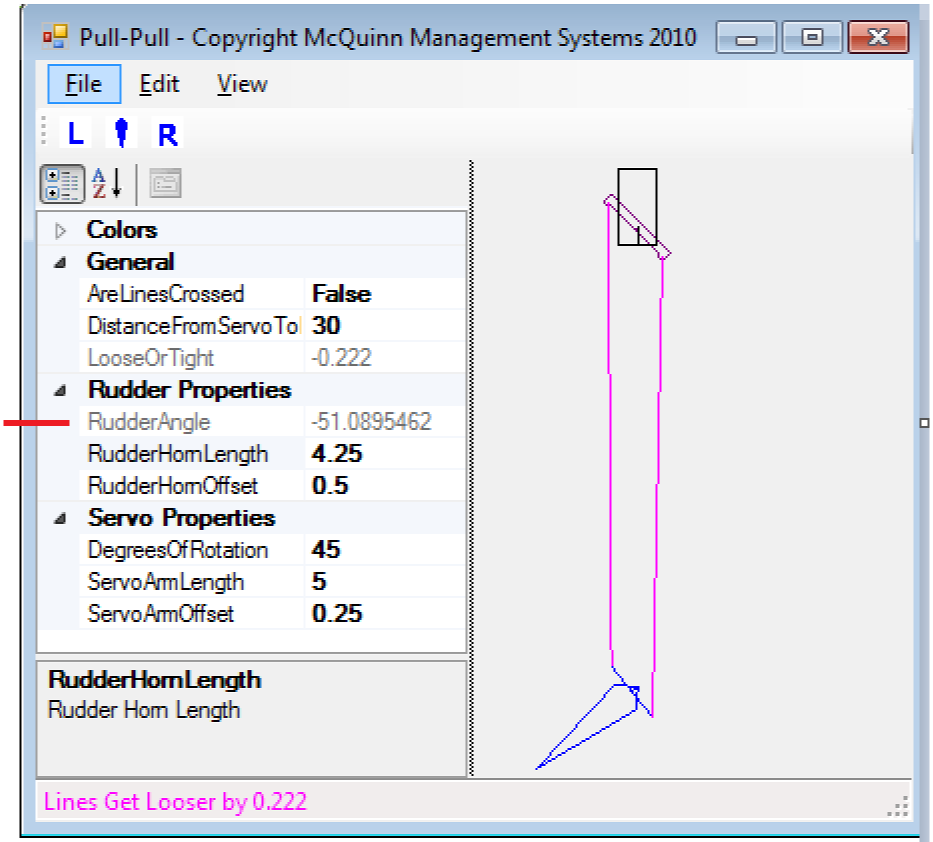
Case 1: You want to design a new pull-pull system for a large aerobatic airplane. You want 60 degrees of rudder throw each way. You have servos capable of travelling 50 degrees each way when your transmitter is set to 125% travel. So you know that you need a servo arm slightly longer than the rudder horn.

1) Measure the length of the rudder horn. If it is already installed on the rudder, you can measure it by looking from above. Or fabricate a "U"-shaped piece of cardboard that you can fit under the rudder to mark the width of the horn. Also measure the Offset – the distance behind the hinge line where the cables attach. Let's say these two measurements come out as follows: Rudder Horn: 4.25 inches Offset 0.5 inches. Take every measurement to one sixteenth inch precision. Or if you'd rather measure in millimeters, do that. The program will run in either Imperial (Inches) or Metric (millimeters). Four inches is about 100 millimeters, so sometimes it is easier (even for Americans) to use millimeters. All dimensions to the program are entered in decimal, so 4 ¼ inches is entered as "4.25". With millimeters, there is no need for a decimal point as measuring to the nearest millmeter is fine.
2) Measure the approximate distance between the rudder hinge line and the rudder servo. An approximate measurement can be made here. Usually on an 80 -100 inch fuselage, this dimension should be in the range of 30 – 60 inches (700 – 1400 mm). For this example let's use 30 inches
3) Launch the RC Pull-Pull Geometry program and enter these three numbers as follows:



4) Now click the “L” button and see how much throw you will get with this setup. I get 51 degrees with the data I am using, so we are not quite done – we wanted to get 60 degrees:

Here is the Rudder Deflection

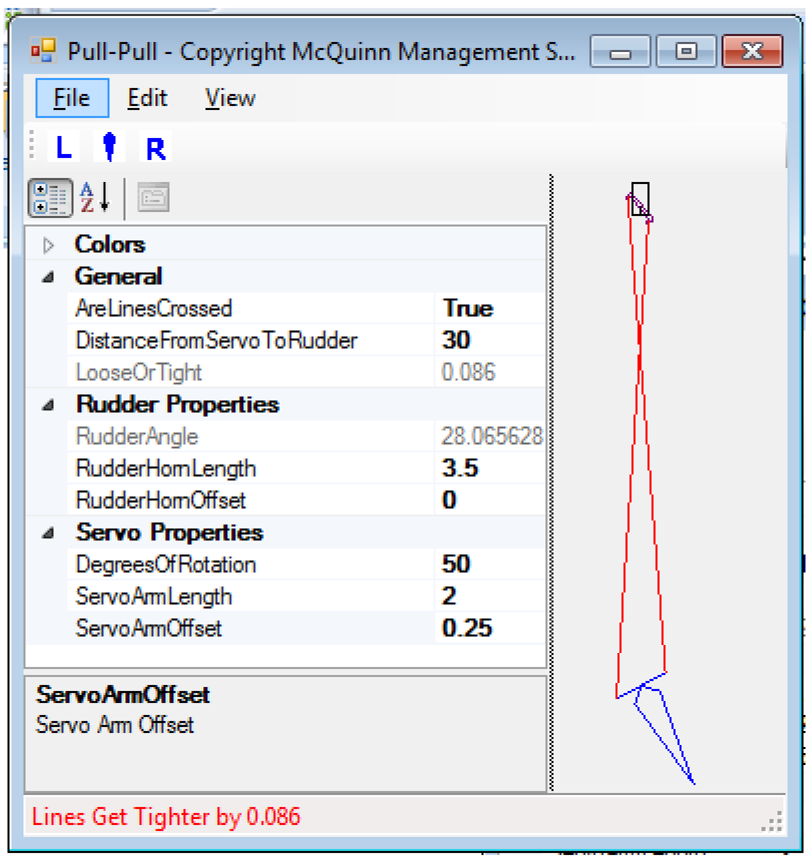


5) Now try different numbers in the property grid until you get the desired result. This is basically a trial and error approach until you get the desired results. Each time you change some number in the program, click the “L” button to see the result. The bottom line shows if the lines will get loose or tight. You do not want them to get tight any more than maybe 1/16 inch (this is shown in decimal inches so nothing tighter than 0.05). If the lines get looser, this is OK. But you want to minimize this. To continue the example:
In the field “Degree of Rotation” under the Servo Properties, change the “45” to “50”. This assumes we have servos capable of rotating 50 degree each way. Click the “L” button. I get almost 57 degrees of travel on the rudder. But the lines are going slack by more than a quarter inch. So change the offset on the servo arm from .25 to .5. This is better and you can stop here. Another alternative is to reduce the offset on the rudder horn if this is an option. For example, you can buy longer fittings for the threaded rod.

Case 2: In this scenario, you want to set up the rudder for precision flying (25 degrees throw) and this time we will use a crossed cable configuration. Change the “AreLinesCrossed” from “False” to “True”. Use the following as input parameters:

Distance from servo to Rudder:	30 inches
Rudder Horn Length:	3.5
Rudder Horn Offset	0
Servo Arm Length	2.0
Servo Arm Offset:	0.25

You should see something like this:



Note that the desired rudder movement is close (28 degrees), but more importantly, with this geometry, the lines will get tighter by .086 inches (over 1/16 inch). You should change something (typically the servo offset is the easiest to change) until the lines do not get tight.

Table of Fractions to Decimals

Fractions	Decimal
1/16	0.063
1/8	0.125
3/16	0.188
1/4	0.250
5/16	0.313
3/8	0.375
7/16	0.438
1/2	0.500
9/16	0.563
5/8	0.625
11/16	0.688
3/4	0.750
13/16	0.813
7/8	0.875
15/16	0.938