AEROBATICS CLINIC

MODEL SETUP AND TRIMMING

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1. INTRODUCTION

This document gives a brief overview of the important aspects to be considered in setting up model aircraft for precision aerobatics.

It is important that the model is well trimmed, as it will ensure that the pilot can focus on executing precision manoeuvres and not “fight” a badly trimmed model.

The trimming process is an iterative process. Once all the trimming adjustments have been made, the process must be repeated to ensure that the trimming has the desired effect.

It is important to follow the trimming sequence as shown in the Trim Chart (Chapter 10), otherwise some of the corrections will negatively influence the model characteristics you are trying to correct.

2. AIRCRAFT STATIC SETUP

First perform the following static setup before flying the model.

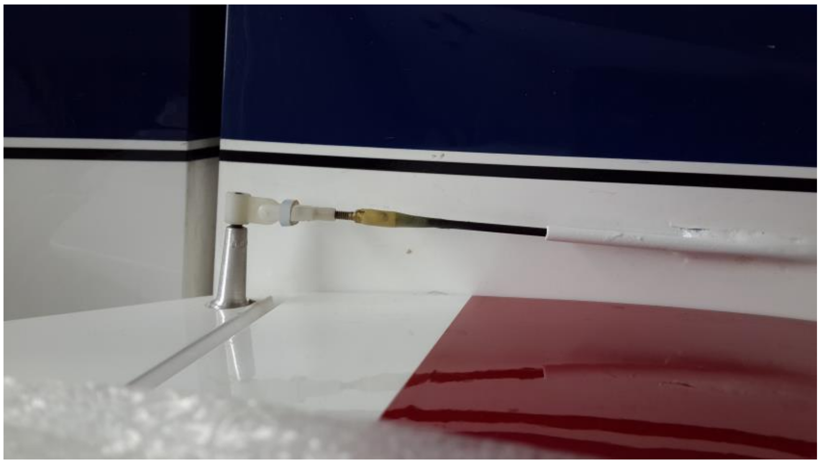
- Check that the vertical fin is perpendicular to the stab. This should be done during the construction phase.
- Check that the wing is parallel to the horizontal stabilizer. Adjust if required by inserting a shim between the wing and the wing seat or adjust the wing tube position.
- Measure the wing incidence with respect to the thrust line. It should be between +0.25 and +0.5° (leading edge higher than the trailing edge) with respect to the thrust line. The incidence of both wing panels must be exactly the same.
- Measure the horizontal stabilizer incidence with respect to the thrust line. It should be zero degrees wrt the thrust line. The incidence of both horizontal stabilizer panels must be exactly the same.
- Ensure that both elevator halves are parallel to each other in the neutral, full up and full down positions. Use 2mm carbon rods stuck to the elevators to check the throws precisely.
- The rudder must be aligned to the centre line of the fuselage.
- Engine thrust : 0 to 1,5° down thrust and 1,5 to 3° right thrust.
- Electric Contra Rotating props thrust settings : 0 to 1,5° down thrust and 0° right thrust.
- Neutralize all the control surfaces.
- Adjust the aileron throws to have the same throws up and down (no differential throw).

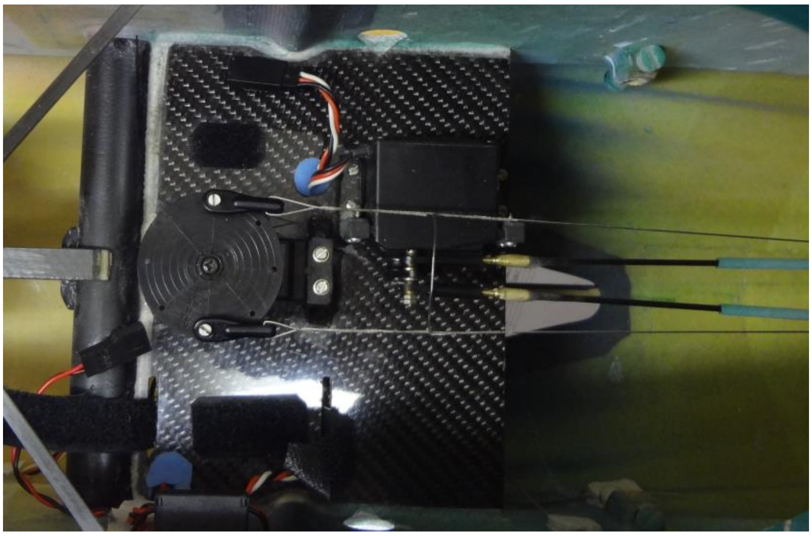
3. CONTROL HORN SETUP

To ensure best linearity between stick position and control surface movement, it is necessary to have the control horns and the pushrods perpendicular to each other. See photos below for details.
On most servo control horns, the splines inside the control horn are slightly offset with respect to each horn arm. By rotating the control horn on the servo output shaft, there should

be a position where the pushrod will be perpendicular to the servo horn.

The sub-trim on the transmitter can also be used for fine adjustments.





There are certain tradeoffs that must be made when setting up the control horns and linkages. The tradeoffs are as follows:

CHARACTERISTIC	**SERVO ARM**	**CONTROL HORN**
Fast control surface response	Maximum length	Minimum length
Maximum Torque	**Minimum length**	**Maximum length**
Best Precision / High Resolution	**Minimum length**	**Maximum length**
Least play	Maximum length	Maximum length

The bold printed setup is the best for precision aerobatics and best utilization of the resolution of the radio equipment.

Most modern radio sets offers 11bit resolution. That means 2048 discrete control steps from +140% throw to -140% throw, or from +84° to -84°. It means that the smallest control input is approximately 0.08°. Use this resolution.

Another consideration is using low latency channels on the receiver for split elevators and ailerons to minimize lag between channels. Long latency will result is rolling action during quick elevator inputs or barrel roll effect for quick aileron input.

To utilize the best accuracy and resolution of the servos, ensure that the servo arm and control horn lengths are such that the servo travel is around 100% for normal flying.

Use a switch to select a different radio setup or condition suited for snap rolls and spins.

4. TRANSMITTER SETUP

STICK TENSION

- Mode 1and 2
  In order to minimize accidental elevator input during rolls (mode 2) and when rudder corrections are made (mode 1), increase the elevator stick tension slightly.

SERVO SELECTION

- Aileron and Elevator
    - Speed : < .12sec/60°
    - Torque : > 6.5kg-cm (for 2m aerobatic models).
    - Accurate (no play on gear train and very little deadband).

- Rudder
    - Speed : < 0.12sec/60°
    - Torque : > 9.5kg-cm (for 2m aerobatic models).

EXPONENTIAL SETTINGS

- Use as little exponential as possible. Typical settings are between 10 and 20% for aileron and elevators and 30 to 50% on rudder.
- For engines use an exponential setting as shown in the Figure 1a below.
- For Electronic Speed Controllers (ESC), use an exponential setting as shown in the Figure 1b below.

DUAL RATE SWITCHES AND CONDITIONS / FLIGHT MODE SETTINGS

- Use DR/Condition switches to set up unique control surface throws for spins, snap rolls and stall turns.
- Select switch position on the transmitter that will ensure easy and quick access to the switches without having to take fingers off the sticks.
- Some transmitters also have “Logic” selectable Conditions or Flight mode, which activates a condition when the stick(s) are at specific programmed positions. This type of Condition selection is very useful for executing snaprolls.

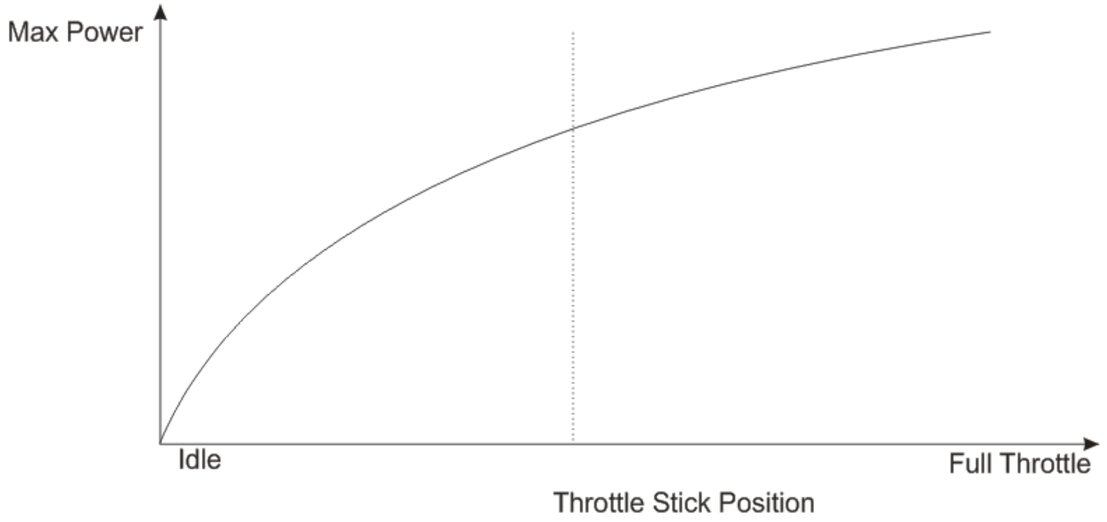


Figure 1a

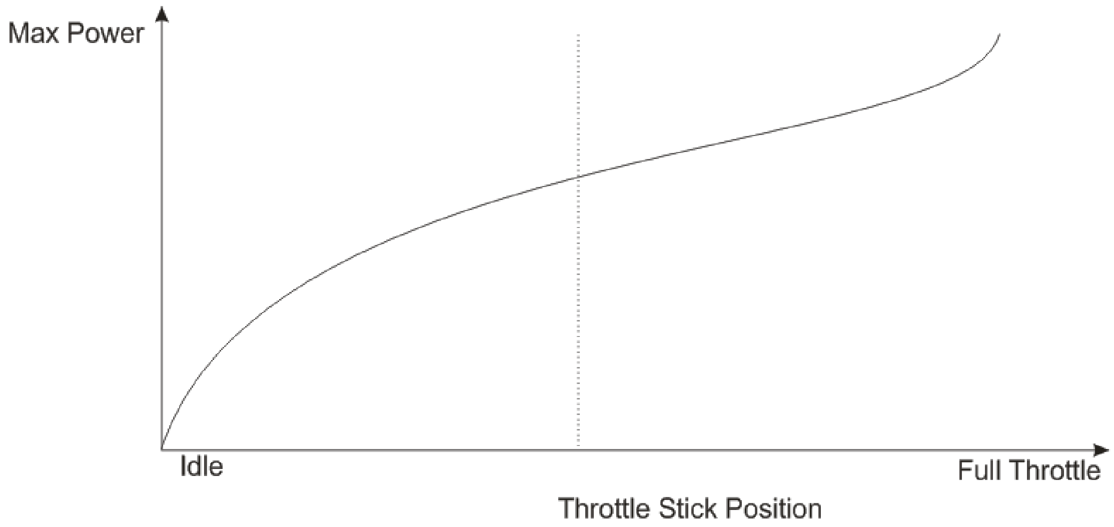


Figure 1b

Figure 1 Throttle Curves

5. ELECTRONIC SPEED CONTROLLER AND ENGINE SETUP

5a Engine Setup

The most reliable way of setting engine carburettors is described below. To perform these tests it is necessary to be able to pinch the fuel line to the carburettor while the engine is running.

CARBURETTOR SETTINGS

- Full throttle adjustment.

  Set the top end needle for maximum RPM and turn it 2 to 3 clicks richer. At full throttle, briefly pinch the fuel tubing to the carburettor or the fuel pump. If the revs drop immediately after pinching the line, the setting is to lean. Turn the needle valve out a few clicks and repeat the test until the revs pick up slightly and then drops.

- Idle needle adjustment

  After setting the top end, proceed with the idle adjustment.
  Let the engine idle for 10 to 15 seconds and then pinch the fuel tubing closed. If the engine stops immediately, the idle setting is too lean. Turn the idle mixture screw out 1/8th of a turn at a time. If the revs take 3 to 5 seconds to pick up and then stop, the idle mixture is too rich. Turn the idle mixture screw in 1/8 of a turn at a time.
  Recheck the top end setting again, as the idle screw has some effect on the top end.

5b. Electronic Speed Controller (ESC) Setup

A typical ESC setup is as follows:

- Brake setting
  - Activate the brake in order to reduce acceleration on the down lines.
  - With the model stationary on the runway, the brake is active only if the prop stops when the throttle stick is in the idle position. If it windmills, the brake is ***not*** activated and it will provide braking action during flight.
  - Set the initial brake between 18% and 28% and the end brake setting to between 40% and 50%. A hard brake is not as effective as an intermediate brake setting.
  - Delay to initial brake : 0 seconds
  - Duration from the initial to End brake setting is approximately 0.4 seconds.
  - Auto R/C : Off – set specific end points.
- Timing : As per the motor manufacturer recommendations.
- Throttle curve – Linear

Note : The settings above are applicable to a Jetti Spin 99 ESC.

6. PRINCIPLES OF AEROBATICS FLYING

- PRECISION
- LINES
- LOOPS
- HEADINGS
- CONSTANT RADII
- CONSTANT ROLL RATES
- GRACEFULNESS

7. JUDGING CRITERIA

Details of the judging criteria can be found in the FAI Sporting Code at the following address: https://www.fai.org/sites/default/files/documents/sc4_vol_f3_aerobatics_18.pdf .

8. AEROBATIC SCHEDULES

See sporting code for details on the MAASA website.

9. MAASA Website

http://www.maasa.co.za/

10. TRIM CHART

The trim chart below lists most of the characteristics that need to be checked during flight.

Notes:

1. Trimming must be done in calm conditions.
2. Make multiple tests before making adjustments.
3. If any changes are made, repeat previous steps and verify or re-adjust if necessary.
4. The model should have been perfectly aligned during construction. If not, fix it before continuing with the flight trimming.
5. Static balance the model prior to flying it.
   - Setting the C of G between 25% and 30% of the MAC is a good starting point. See the diagram at the end of the document for details.
6. All vertical dives must be done at a low throttle setting.

TO TEST FOR	TEST PROCEDURE	OBSERVATIONS	ADJUSTMENTS
1. Control neutrals.	Fly the model straight and level.	Adjust transmitter trims for hands-off straight and level flight.	Adjust clevises to centre transmitter trims.
2. Control throws.	Fly model and apply full deflection of each control in turn.	Check response of each control.	Aileron: Hi-rate, 3 rolls in 3 to 4 seconds. Lo-rate, 3 rolls in 6 seconds. Elevator: Hi-rate to give a smooth square corner. Lo-rate to give a loop of approximately 50 meters diameter. Rudder: Hi-rate approximately 30 to 35 degrees deflection for stall turns, Lo-rate to maintain knife-edge flight.

TO TEST FOR	TEST PROCEDURE	OBSERVATIONS	ADJUSTMENTS
3. Centre of gravity. (Method 1)	Roll model into a near vertically banked turn.	a. Nose drops – Nose heavy b. Tail drops – Tail heavy	a. Add weight to tail. b. Add weight to nose.
Centre of gravity. (Method 2)	Roll model inverted.	a. Lots of down elevator required maintaining level flight. – Nose heavy b. No down elevator required to maintain level flight, or model climbs. – Tail heavy	a. Add weight to tail. b. Add weight to nose.
Centre of gravity. (Method 3)	Perform a landing on Idle throttle setting.	a. If it is difficult to maintain a constant rate of decent. b. If the model does not have enough elevator authority to flair on finals.	a. Tail heavy - Add weight to nose. b. Nose heavy - Add weight to tail.
Centre of gravity. (Method 4) *(Preferred method)*	Also see Test 11 below.		
4. Decalage.	Power off vertical dive, cross wind (if any). Release controls when model is vertical (elevator must be neutral)	a. Model continues straight down. b. Model starts to pull up (nose up). c. Model starts to tuck in (nose down).	a. No adjustment required. b1 . Reduce incidence. b2. Mix down elevator to throttle. c. Increase incidence.
5. Wing Balance. (Coarse adjustment)	Fly the model straight and level, upright into wind. Pull up sharply to a vertical climb.	a. Model continues straight up. b. The model veers to the left of vertical. c. The model veers to the right of vertical.	a. No adjustment required. b. Add weight to right tip. c. Add weight to left tip.

TO TEST FOR	TEST PROCEDURE	OBSERVATIONS	ADJUSTMENTS
	Repeat the test flying the model inverted into wind	a. Model continues straight up. b. The model veers to the left of vertical. c. The model veers to the right of vertical.	a. No adjustment required. b. Add weight to left tip. c. Add weight to right tip.
6. Elevator alignment.	Measure neutrals and maximum throws of each elevator in both directions.	a. Up and down throws the same for each elevator half. b. Different throws.	a. No adjustment required. b. Adjust ATV if separate elevators are used, or adjust control horn length to equalize throws.
7. Aileron alignment.	Fly the model straight and level into wind, roll the model inverted and maintain level flight. Apply no aileron correction.	a. Model does not roll. b. Model rolls to the right. c. Model rolls to the left.	a. No adjustment required. b. Lower the right aileron. c. Lower the left aileron.
8. Dihedral.	Fly the model straight and level into any wind, apply rudder and watch for any tendency for the model to roll. Also check the effect during knife-edge flight. a. Test in both directions. b. Make changes in increments of no more than 3mm at a time. c. Don’t worry about the nose pitching down or up.	a. The model does not roll. b. The model rolls in the direction of the applied rudder. c. The model rolls in the opposite direction to the applied rudder. (Adverse roll)	a. No adjustment required. b. Reduce dihedral. c. Increase dihedral. d. Or use programmable mixes on the radio (Rudder- Master, Aileron - Slave) .

TO TEST FOR	TEST PROCEDURE	OBSERVATIONS	ADJUSTMENTS
9. Side / Right thrust.	Fly the model away from you and into wind. Pull gradually into a vertical flight and climb to at least to normal manoeuvre height. (Watch for deviations to the left or right as it slows down)	a. Model continues straight up. b. Model veers left. c. Model veers right.	a. No adjustment required. b. Add right thrust. c. Reduce right thrust. When the model slows down a lot, it will veer off to the left. This is normal.
10. Up / down thrust.	Fly the model cross wind, at a distance of around 100m, (elevator trim should be neutral as per test number 3), throttle back quickly.	a. No sudden pitch changes. b. Model pitches up. c. Model pitches down.	a. No adjustment required. b. Reduce down thrust. c. Increase down thrust.
11. Pitching in knife-edge flight. (Method 1)	Fly the model on a normal pass and roll to knife-edge flight, maintain height with top rudder. (Do this test in both left and right knife-edge flight)	a. There is no pitch to the canopy or the undercarriage. b. The model pitches to the canopy. c. The model pitches to the undercarriage.	a. No adjustment required. b. Alternative cures: 1. Move the C of G aft. 2. Increase wing incidence. 3. Add down trim to ailerons. c. Reverse the above. Or use programmable mixes on the radio.
11a. Knife-edge tracking. (Method 2)	Fly the model on a normal pass and roll to knife-edge flight, maintain height with top rudder. (Do this test in both left and right knife-edge flight)	a. There is no pitch to the canopy or the undercarriage. b. The model pitches to the canopy in both knife-edges. c. The model pitches to the undercarriage in both knife-edges. d. The model pitches in opposite directions in each knife-edge.	a. No adjustment required. b. Lower both ailerons slightly - approximately 2 turns. c. Raise both ailerons slightly - approximately 2 turns. d. Use mixing from rudder to elevator to fix the problem.

TO TEST FOR	TEST PROCEDURE	OBSERVATIONS	ADJUSTMENTS
12. Power off tracking. Test 1	Fly the model level into wind, reduce power to idle and watch for any roll off to either side.	a. No roll to either side. b. The model rolls left. c. The model rolls right.	a. No adjustment required. b. Mix 2% to 3% right aileron to low throttle, enough to neutralize the roll. c. Mix 2% to 3% left aileron to low throttle, enough to neutralize the roll.
12a. Power off tracking - Rolling. Test 2	Fly the model high at a distance of approximately 100m into or across wind but sideways to yourself, push it into a vertical dive, watch for any tendency to roll whilst in the dive.	a. The model shows no tendency to roll. b. The model rolls to its left. c. The model rolls to its right.	a. No adjustment required. b. Mix some right aileron to low throttle, enough to neutralize the roll. c. Mix some left aileron to low throttle, enough to neutralize the roll.
12b. Power off tracking- Pitching. Test 3	Fly the model high at a distance of approximately 100m across any wind but sideways to yourself, push it into a vertical dive, watch for any tendency to pitch up or down whilst in the dive.	a. There is no pitching, the model continues straight down. b. The model pitches up, towards the canopy. c. The model pitches down, towards the undercarriage.	a. No adjustment required. b. Mix 2% to 3% down elevator to low throttle. c. Mix 2% to 3% up elevator to low throttle.

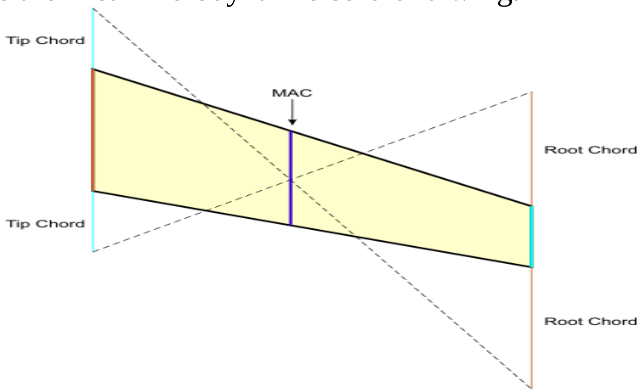
General Notes:

1. Mass Distribution
    - Electric Powered Models
      Position the battery packs as close to the thrust line as possible to ensure that the model rolls axially.
    - Minimize moments of inertia by keeping the heavy components (Servos, batteries) close to the CG.

2. Landing Set-up.
   To prevent tip stalling and bouncing on landing, set both Ailerons UP (Reverse Flaps) by approximately 5–7mm. This will introduce washout in the wing profile that will ensure that the root of the wing will stall before the tip, thus preventing tip stalling.
   The other benefit is that the aircraft angle of attack will increase, due to the negative camber introduced by the ailerons pointing up. The aircraft will fly slightly nose high and it will make it easy to do 3 pointer landings without any bouncing. Some elevator mixing is required to ensure that the model does not climb or pitch nose down when activating the "Reverse Flap". Use the "Airbrake" mix on the transmitter for this function.

3. Hinge Lines
   For maximum efficiency of the control surfaces, minimize the hinge line gaps.

4. Mean Aerodynamic Cord (MAC)
   The diagram below can be used to determine the Mean Aerodynamic cord of a wing.



There are many programs on the Internet to calculate CG, MAC etc. This is a good RC modelling program: https://www.ecalc.ch/cgcalc.php .

As your flying skills improve and you become more familiar with the model flying characteristics, you will discover flying tendencies that were unnoticed before. Refine the trimming and transmitter programming to optimise the model's flying characteristics and your flying skills.

If a trim condition changes noticeably, inspect all airframe and control components carefully to determine the cause of the change.

Remember the 3 **"P**s**"**

Practice & ***P***erseverance makes ***P***erfect **……**

Notes: