The following are from a series of articles I wrote for the "K-Factor", a monthly publication from the National Society of Radio-Controlled Aerobatics (NSRCA).

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Futaba 7UAx radio setup.

(January 1995)

This following information specifically covers the Futaba 7UA family, including: 7UAP, 7UAF, 7UAPS, 7UAFS. Some of the information applies to all computer radios. This month I will talk about ATV, Dual Rates, and how they interact. This information is not intended to replace the manual, just supplement it.

ATV (adjustable travel volume) is used to set the maximum amount of travel of a channel. When adjusting the ATV value, remember that there are two settings per channel, one for each direction of servo travel, ie: up and down, left or right. Access to both numbers is done by moving the stick/knob/switch being programmed. For instance, after selecting the ATV screen and moving the pointer to the desired channel, you will have to move the control for that channel from one side to the other to get to both numbers.

I prefer having my ATV set for near maximum throw, making any initial changes in control throw by changing the mechanical linkage on the plane. The reason for this is that if you reduce the throw by using ATV, you are reducing the precision of the entire system. If you cut your ATV (or DR) throw to 50%, you are now using a 512 (or less) radio, instead of the 1024 positions the radio is capable of doing. Also, you are wasting half the torque and precision of the servo, although the control response will be quicker (less distance for the servo to move).

I do use ATV initially to determine just how much throw is needed to perform the pattern. I may fly a dozen flights, doing every maneuver (including snaps) and adjusting the ATV until I determine the maximum throws needed. Then, I measure the maximum control surface deflection. I set all my ATVs and DRs to their maximum (110% on the older radios, 120% on the Super 7) and adjust the mechanical linkage until I have the same throw as previously measured. Err on the side of more throw. Then, I fly the pattern some more, making fine adjustments with the ATV.

Whether to use DR or not is a matter of preference. I don't use dual rates unless absolutely needed, except on rudder. I always set my rudder throw to max for stall turns, and set my low dual rate to allow me to hold knife edge with full rudder stick deflection. I presently use elevator dual rate to increse throw for spins.

It is important to realize that a change in ATV affects every other function relating to an individual channel. For instance, reducing the ATV setting of channel 2 (elevator) will reduce the travel on both sides of the dual rate switch, and also reduce the available travel when the snap switch is engaged. So, once an airplane has been setup, it is wise to make minor changes in travel with the dual rate instead, unless you need to change the throw in only one direction. The DR setting affects the total throw in both directions, while ATV allows you to set each direction independently, ie: more down than up, or more left than right.

Another thing worth knowing about ATV and DR is how they apply to trim authority. Trim authority (the amount the surfaces move with a given trim lever movement) increases or decreases with a corresponding change in the ATV. Cut the ATV from 100% to 50%, and the trim movement is also cut in half. If you leave the ATV at 100%, but cut the travel by using the DR setting, the trim travel does not change. For instance, using my Ace Datamaster to measure the pulse widths, here are some numbers from my four year old Futaba 7UAP:

(center was always 1.52ms)
ATV 100%, DR 100%
Full up = 1.95
Full down = 1.10
Trim up = 1.64
Trim down = 1.39

ATV 50%, DR 100%
Full up = 1.73
Full down = 1.31
Trim up = 1.58
Trim down = 1.46

ATV 100%, DR 50%
Full up = 1.73
Full down = 1.31
Trim up = 1.63
Trim down = 1.40

Notice that the total throw is the same whether the DR or ATV is used to reduce the throw, but the trim throw is directly affected by the ATV setting, but not by the DR setting. For the purposes of pattern flying, you are MUCH better off having a very small amount of trim throw, otherwise you my have difficulty trimming the plane to hold straight and level flight.

The following is just for comparison:

ATV 110%, DR 110%
Full up = 2.04
Full down = 1.02

110% is the max for both DR and ATV on the older 7UAP radio. The newer "Super Seven" allows you to go 120%, but (If I remember right) only on the first four channels.

If you have a Futaba 7UA radio, check your ATV and DR settings for every channel. If you have an ATV and/or a DR (high side) that is less than 75%, the precision gain by going to 100% or more, and a corresponding change in the mechanical linkage, may be worth the effort. The decision to change it is entirely yours, however.

Next month (if I get a chance) I will cover the ins and outs of two channel aileron setups. For instance, you CAN have aileron differential AND flaperons, you just gotta know how! Later on, I will cover the topic of mixing out roll and pitch coupling.

(February 1995)

Last month I began talking about the Futaba 7UAP line, and after re-reading it I decided that I probably need to back up and explain a few of the concepts pertaining to computer radios.

First of all, let's discuss basically how a computer radio works. The computer chips in our radios (and most computers, for that matter) are digital, which means that they deal with numbers. The stick positions, on the other hand, are analog (linear, or infinitely variable) and must be converted to a number before the computer can deal with it. The voltage from the stick pots are converted by an ADC (analog to digital converter) and the digital number is then read in by the computer. This process is where the concept of "steps", or "1024 technology" comes into being. The computer processes the stick positions and sends this information to the receiver/servos as 10 bit numbers, or a value from 0 to 1023.

Futaba often refers to their computer radios as "1024 stepless", which is a misnomer. What they are trying to say is that 1024 steps makes their system *seem* stepless. What this really means is that the radio can command a servo to go to a MAXIMUM of 1024 positions. Understanding the concept of "steps" will help you to understand the best way to program your radio and get the most performance from it.

I made some measurements with some equipment available to me where I work, and here is the information I discovered:

(Measurements were taken using a Futaba 7UAP and 7UAPS transmitters, FP-R129DP receiver, and an HP 5314 Universal Counter. Some figures rounded slightly.)

Terms used:
ATV: Adjustable Travel Volume
DR: Dual Rate
7UAP: refers to the older 7UAP/7UAF radios.
7UAPS: refers to the newer 7UAPS/7UAFS "Super Seven" radios.

Channel used: 2 (elevator)
Measured center = 1.525ms
Minimum pulse width change = 1.171us (further referred to as "system step")
Maximum pulse width range = 1.198ms (2.120 to 0.922)
1023 x 0.001171 = 1.198ms

Setup: ATV 110%, DR 110% (Max on 7UAP)
1 Subtrim step = 1.05 system steps
1 trim lever notch = 4.9 system steps
Full stick travel: 1.023 to 2.043ms (870 system steps)
Full trim travel: 1.396 to 1.651ms (218 system steps)

Setup: ATV 30%, DR 110%
1 Subtrim step = 0.25 system steps
1 trim lever notch = 1.35 system steps
Full stick travel: 1.388 to 1.663ms (235 system steps)
Full trim travel: 1.487 to 1.556ms (59 system steps)

So, what does all of this mean? Basically, the radio has a finite resolution that it is capable of, but only if the ATV and DR are set to their max. As you decrease either the ATV or DR, the resolution (number of positions the system can resolve to) decreases with it. In the above case (ATV 30%) you have only 235 steps, or 1/4 what the system is capable of. I should note here that I flew an Ace Micropro 8000 for a short while, and found out that at best it was a 256 radio. I COULD tell the difference!! My thumbs could not tell the difference, but the lack of resolution caused the plane to be difficult to trim for level flight.

Now, lets talk about servo resolution. While I don't have any measurements to report on (not yet) we can talk in general terms about servos and how they function. There is no such thing as a perfect servo. Servos have several characteristics that limit their resolution. One is deadband, or how much the input signal can change without the servo responding. Another is backlash, or how much slop is in the gear train. Yet another is "holding torque", or the how well the servo moves to a desired position under a load. The better the servo, the less will be the deadband and backlash, and the higher the holding torque.

The effect of each and every one of these characteristics can be minimized by using the full travel of the servo. For instance, if you have a radio set up to only move a servo 30 degrees, and the servo has 1/2 degree of deadband, then the deadband alone can account for a 1.67% error. Couple this with the fact that you are working with only 235 steps in that 30 degree range, and you can add another 0.4% max error for a possible total error of over 2%. (I won't bore you with the formulas here, trust me.) For a given control surface deflection, a servo has three times as much power (mechanical advantage) when set to travel 90 degrees as it does when it is set to go only 30 degrees, so the servo will work less and be able to move the control surface closer to the commanded position. And we haven't even begun to talk about linkage slop! The only downside to using the full travel of a servo is the transit time.

So, if you are still reading this and I haven't bored you to death yet, here are my recommendations:

- Use 5 cell (nominal 6v) battery packs to speed servos and increase torque.

- Use high quality control linkage hardware.

- Use long servo arms, and corresponding long control horns, to reduce the effect of slop in the linkage.

- When possible, use pull-pull cables to remove control linkage slop.

- Program the system to use the full travel of the servos, ie: max ATV and DR. Reduce control surface throw the old fashioned way: adjust the mechanical linkage.

- Use good quality, high speed servos to compensate for the increased transit times with the high ATV and DR settings.

Something else that I have done to my transmitter is to add a 5k resistor to each end of the trim pots. This cuts the trim authority in half, but makes smaller trim changes possible. I won't describe how to do this because I don't want everyone going inside their radio and damaging something. If you are knowledgeable and proficient at electronics you will be able to figure out how to do it anyway.

Other interesting facts:

- When using programmable mixers, the ATV setting of the source channel does not affect the destination channel. The DR setting and the mix percentage both affect the destination channel.

- The trim lever AND subtrim authority are affected by the ATV settings.

- An unused channel (6 or 7) can be mixed into the flight channels and used as either coarse or fine trim adjustments, depending on the mix percentage. Use 3% mix for fine adjustment, one notch equals slightly less than one system step.

- (7UAP) Full stick travel @ 110% ATV and 110% DR roughly equals 870 system steps. If full trim is included, then all 1024 steps are used, but with lost steps at ends (roughly 64 total). Full stick throw = 870 steps, full trim throw = 218 steps, total = 1088. 1088 - 1024 = 64 lost steps.

- (7UAP) Mix a channel into itself to get more movement with the stick, (max +16% mix) but with more lost steps at the end if including trim.

- (7UAPS) The max ATV settings for the first four channels are 120%, the rest are 110%. The max DR settings are 120%. If using two aileron channels, you should not go over 110% ATV on channel 1 since the other aileron channel (either 6 or 7) is limited to 110%.

- (7UAPS) When ATV and DR are set to 120%, stick movement gives the entire 1024 resolution, but only if the trim lever is centered and subtrim setting is 0. If the trim lever is not centered, then there will be lost travel at that end of the stick movement, ie: with full up trim, the servo will stop moving before the stick reaches the full up position.

I hope this information is helpful for someone. The main reason I am writing this is to help the average flier, most of whom are probably flying mid-range radios. I would like to write something about the JR 347 or 388, but don't have access to them. If anyone out there that has a JR radio wants to submit something, please do!

(MARCH 1995)

More on Futaba 7UAF/P

After I re-read my column from last month, I realized that although I talked about the Futaba 7ch radio, most of the recommendations I made applied to just about any radio / any plane. This month I will (finally) talk about two channel aileron setups on 7UA radios.

First, lets define 'differential' and 'flaperons'. Most people know what flaperons are: the control surfaces on the wing can move together as flaps, or opposite as ailerons. I have not seen much need for flaperons on pattern planes, although they can be deflected in small amounts as flaps to help trim a plane. They can also be deflected up to act as drag brakes during landing. Differential refers to unequal throw of the ailerons up/down. Differential is (in most cases) used to counter adverse yaw, especially on high wing/ high lift planes. On pattern planes, differential may be used to help a plane roll more on its axis.

There are several ways to setup ailerons on the 7UA. First, you can use just one aileron servo with linkage going to each aileron. However, most fliers, pattern especially, are using two servos. This simplifies mechanical linkage and gives a much tighter connection to the ailerons. The simplest way to do two aileron servos is by using a Y-harness, with both servos working from one channel. However, there is also the option of using two channels/two servos, and there are two ways to accomplish that.

Two channel control of the ailerons can be done by either enabling DIFF (differential) in the setup menu, or by enabling FLPR (flaperon). The second aileron channel is #6 if using FLPR, or #7 if using DIFF. There are reasons why you might pick one over the other. If using FLPR, you can use the ailerons as flaps. You may or may not want to do that, but if you decide to use them you can trim the neutral point of the ailerons up or down during flight which might aid you in trimming the plane. However, you can still get differential throw using the FLPR feature, you just have to adjust the FLPR rate settings for each aileron channel just like you would with the DIFF feature. One reason why you would select the DIFF feature is so that you can't inadvertently move the ch6 knob and throw the centers off. Another reason would be that you would want to use seperate flaps. Use whichever method you prefer.

I will describe the latter method of selecting FLPR, since the DIFF feature is a little more straightforward. First, bring up the menu screen and page over to the FLPR menu and turn on the feature. Now, you should get aileron output from channels 1 and channel 6. (The manual does not state which channel should be use for which aileron. It has been my experience that it does not matter.) Then you must set the direction for each servo. In this menu, you can also select the amount of throw for each servo, but leave all these values (four of them, just like ATV) set to 100%. I alway use the ATV settings to make any adjustments for throw, then use the FLPR rate adjustments to obtain differential throw, if needed.

When setting up the ATVs, start out by setting the ATV for both channels to 110% in either direction. Then use a deflection guage to determine which aileron is moving the least in any one direction. Adjust all the other ATV settings until both ailerons move this same amount in all directions. This gives you a starting point of equal throw left or right and zero differential. If you don't have a deflection guage, you can measure the throw by using a ruler at the trailing edge of the control surface, although it isn't nearly as accurate.

For the initial trim flights, use the dual-rate settings to adjust the total throw until you get the roll rate required. (If you don't have enough throw with DR at 120%, increase the throw in the mechanical linkage and start this process all over.) If you use the snap switch, adjust the control throws until you get the desired snap. (This is a whole subject in itself, which I may cover in the future). Once you get the throws where you want them, check the DR and snap settings for the aileron channel. If both of these are less than about 80%, you may want to reduce the throw in the mechanical linkage and start this process over. As I said in the January and February columns, I like to have my ATVs and DRs (high side) at 100% or higher which will give me the most resolution and torque at the control surfaces.

Remember, while channel 1 can have an ATV setting of 120% (super seven ONLY) channel 6/7 can only have a setting as high as 110%. So, don't use a setting of over 110% ATV on channel 1.

Some people prefer having more throw to one side than the other, ie: roll faster to the left than to the right. This has to be done using the individual ATV settings for each aileron channel. If you want to roll left quicker than to the right, use the DR setting to get the desired left-roll rate. Then, use the ATV settings to decrease the right-roll rate. You want to decrease the left aileron down-throw, and the right aileron up-throw. (Just don't 'throw up'). Use a deflection guage to measure each and match them to each other, ie: the up-throw on the right aileron matches the down-throw on the left aileron.

So far you should have zero differential. Most of the pattern type planes that I have flown required little, if any, differential throw. Most people define differential throw as having more up than down throw. This definition is only accurate if the right and left ailerons have the same throws, ie: left aileron up-throw equals right aileron up-throw, and down equals down. It is more correct to define aileron differential throw as the up-throw on one aileron being more than the down throw on the other, and vica-versa. If you think you need differential (again, this is another subject altogether) then change the FLPR rate (or DIFF if using that feature) settings of the channels, but always remember where you started so you can return if it doesn't work. It helps to keep some sort of log book with radio settings so you can always backup to any given point. The manual that comes with the Super Seven has a data sheet in the back that can be used to record all the parameters in the program memory.

Remember, there are now a total of 10 settings which affect the throw of the ailerons. There are four ATV settings, one for each direction of each servo. There are four similar settings under either the FLPR or DIFF menus. Then, there are the DR settings, both low and high. (Kinda makes you want to say FORGET IT, and just use a Y harness). In the end, however, you can be sure that you will have balanced throws on both surfaces, and can adjust for just about any situation.

By the way, did you know that the Super Seven is known as the 'Field Force Seven' in other parts of the world?

Mixing: 101.

This month, we will talk about using the two programmable mixers to correct roll or pitch coupling. Roll coupling is when the airplane rolls with application of rudder, and pitch coupling is when the airplane pitches with rudder input. When the airplane rolls in the same direction as the rudder input, this is referred to as 'proverse' roll, while the opposite is 'adverse roll'. When referring to pitch coupling, most people will say 'pitches to canopy' or 'pitches to belly'.

The causes of roll or pitch coupling are easier to understand than they are to fix. Roll coupling is caused by an improper amount of dihedral in the wing. Too much dihedral will cause proverse roll, and too little will cause adverse roll. If you can adjust the dihedral on the plane, this is the preferred way of correcting for it. Pitch coupling is usually caused by the placement of the stab being too high or too low on the tail. Too high will cause the plane to pitch to the belly, too low will cause the plane to pitch to the canopy. Adjusting the stab height would be the best way to cure this, although sometimes it can be cured by changing the wing and/or stab incidence. It is, however, very easy to mix out these tendencies, especially if the roll/pitch coupling is very minor.

One problem with the 7UAx series is that they only have two programmable mixers. If you have two aileron channels, you need to mix rudder into each one to correct for any rolling tendency. This does not leave a mixer to correct for any pitching problem. SO, I cheat a little. If I have roll coupling, I mix rudder into one of the aileron channels, and use the other mixer to correct for any pitch coupling. Get the roll coupling fixed before adjusting for the pitch coupling, since moving just one aileron may cause a slight pitch problem in itself. Keep in mind that we will probably be mixing less than 5%, so any movement necessary should be almost unnoticeable on the ground. If you need to mix more than that, you should probably think about fixing the problem on the plane instead of with radio mixing.

First of all, let me mention my philosophy when it comes to checking for rudder coupling problems. When I trim out a new plane, I always set the rudder travel for maximum throw on high rate. (I HATE flopped stall turns!!) I then fly the plane and determine just how much rudder is needed for knife edge, and adjust the low rate until full stick deflection barely holds altitude in knife edge. I then determine if I need mixing or not AT THE LOW RUDDER RATE. (I only use high rate for stall turns or spins). I fly the plane in knife edge flight and determine any coupling problems. It helps to have someone to write down which way the plane rolls or pitches while in knife edge flight. After I land, I figure out which way I need to mix things.

When mixing rudder into the other channels, you need to determine the polarity of the mix. I have never bothered learning how to determine this without actually plugging in values. If the mix polarity is + and it is the opposite of what you need, change it to a -, or vica-versa. You may also need to plug in a large value for the mix percentage to be able to tell which direction the servo is moving. Usually the mixing polarity will be the same for both sides when correcting for roll coupling, but will be opposite when correcting for pitch coupling. In other words, if there is an adverse roll coupling, you will need to have the ailerons move in the same direction as the rudder, for both sides of the rudder mix. But, for pitch coupling, you will have to have both sides of the rudder cause the elevator to move down if the plane pitches to the canopy. This is done by changing the mix polarity, each side of the source stick throw (rudder left or right) will be different. In some cases the plane may pitch to the canopy on one side, and pitch to the belly on the other side.

Once you have the directions figured out, then you can dial the mix percentage back down to around 5%. Fly the airplane some more, and adjust the mix percentages until you get a straight track in knife edge. Once you are done, you should be able to roll the plane on its side, kick full rudder stick (low rate) and fly knife-edge from one side of the box to the other without touching the right stick.

Remember, as part of your checkout procedure before you start your engine (you DO check your controls, don't you?) you will need to make sure that the PMIX switch is on.