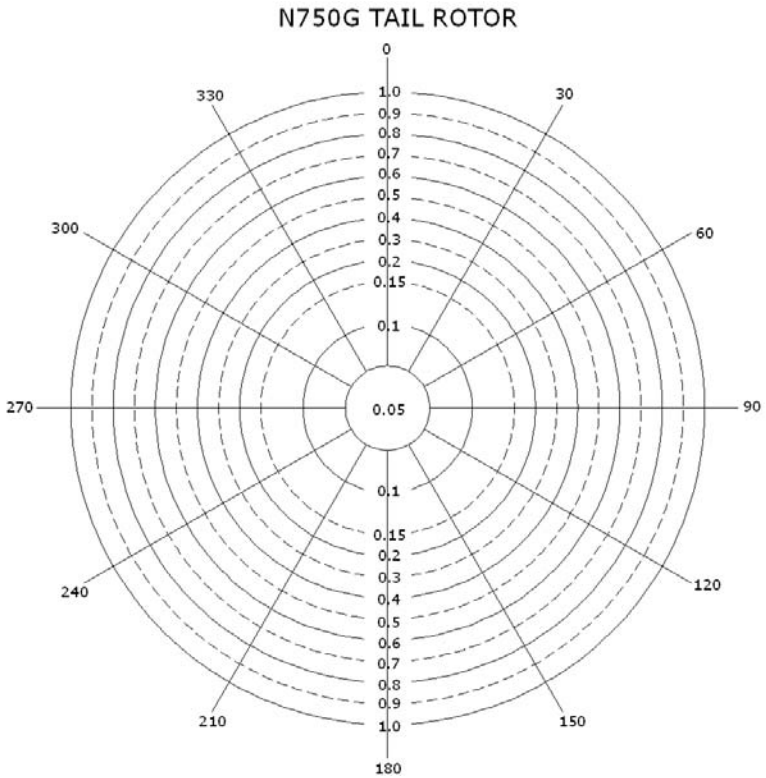
N750G TAIL ROTOR DYNAMIC BALANCE

Sunday, 15 January, 2012 – I've developed a wicked tail vibration that causes the tip of my VHF antenna to oscillate at least half an inch. It's a blur. The tail fins also vibrate way too much. As a result I decided to tune up my tail rotor and drive. I started by cobbling together a magnetic base and mount for a dial indicator I had laying around. I looked at the runout at the center of each of the three driveshaft sections and found they were all at least 0.010 out. After trying a number of methods to tweak the shafts back into alignment I found that wrapping a rag across the shaft at the center and pulling down worked best. It spread the load across the width of the rag and didn't scratch the tubing. I got them all down to .005 or less.

That leaves two areas to go; the first is the coupling at the rear of the driveshaft. By its design, there is some slop so it can accept slight alignment errors which means that it can wiggle around a bit. I'm not sure how much that might be contributing to the vibration. The biggest contributor is undoubtedly the tail rotor assembly itself. I'm not sure why it would change, or if it's been that way for a while. As a pilot I didn't notice it until Hap Miller called it to my attention. At any rate, it's time to fix it. That requires a vibration analyzer so I took a deep breath and purchased a used Pro-Drive. They all work more or less the same way and generate a vibration magnitude and direction which can be plotted. This information tells you where the center of mass is in relation to the center of rotation. The only down side of this unit is that it's designed for the Rotorway exec, so their charts are semi useless. As a result I had to make my own. The chart for the tail rotor is quite simple. Here's my first version:



The balancer will take an average of a number of readings and give me the magnitude in IPS and the direction in degrees, which I can plot on my graph. Then I'll need to experiment to see what effect adding weights to the few places available does to the balance. Eventually I can add that information to this graph.

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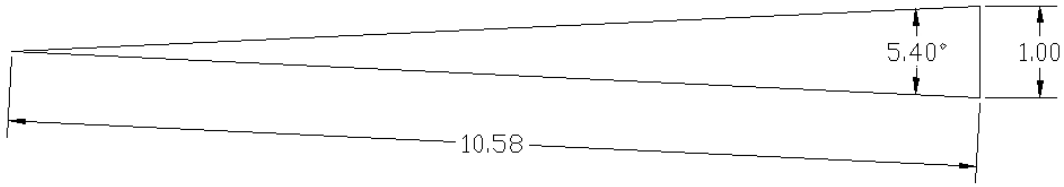
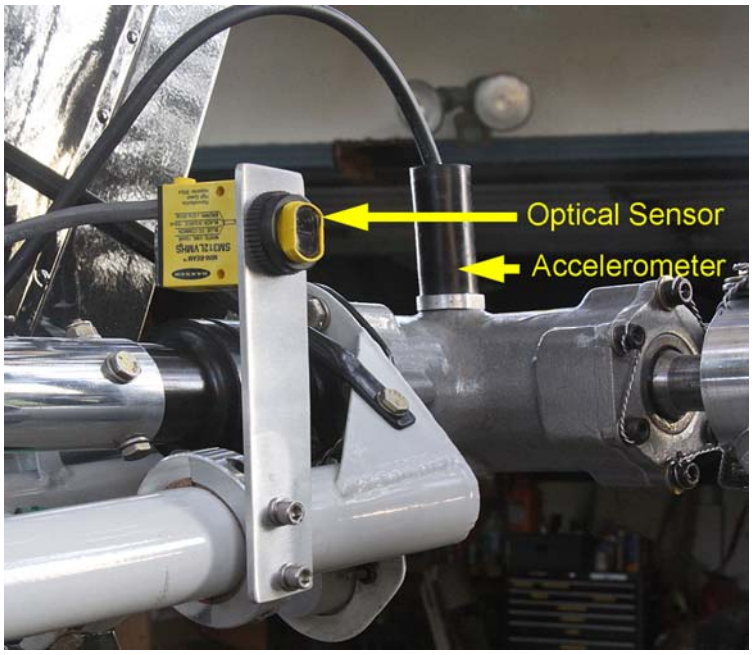
The first order of business was to mount the optical sensor and the accelerometer. I have the part number for the optical sensor so I could look up the specs. This sensor needs a pulse that is at least 0.3 milliseconds long. I'll be using a 1-inch wide target so I needed to do the math to find out where to place the sensor in relation to the hub. The tail rotor rotates at 3000 RPM so it makes 50 revolutions per second or one revolution every 20 milliseconds. If I did my math correctly that means that a blade will take 0.3 ms to cover an angle of 5.4 degrees. As the blade moves 5.4 degrees the 1-inch wide reflector tape needs to be no father from the hub than 10.58 inches. Any farther and it will go by too fast for the sensor.



3000 RPM /60 = 50 Hz
50 Hz = 20 ms per rev
Sensor needs .3 ms minimum pulse width
360/(20/.3)=5.4 degrees
1-inch tape must be less than 10.5 inches from hub to meet sensor's minimum pulse width requirement



The optical sensor is the yellow module at the top of the bracket. It sends out a visible red light and then looks for the reflection. An LED at the rear lights when it sees the reflector.

The accelerometer is mounted to the filler port on top of the gearbox. I chose this orientation because the tail can more easily flex up and down than fore and aft.

The clamp is from Grainger's and lined with cork so it won't scratch my finish.

The location meets my 10.5 inch criteria and the unit functions perfectly. With this setup the zero axis on my chart will occur when the blades are almost horizontal, which is fine.

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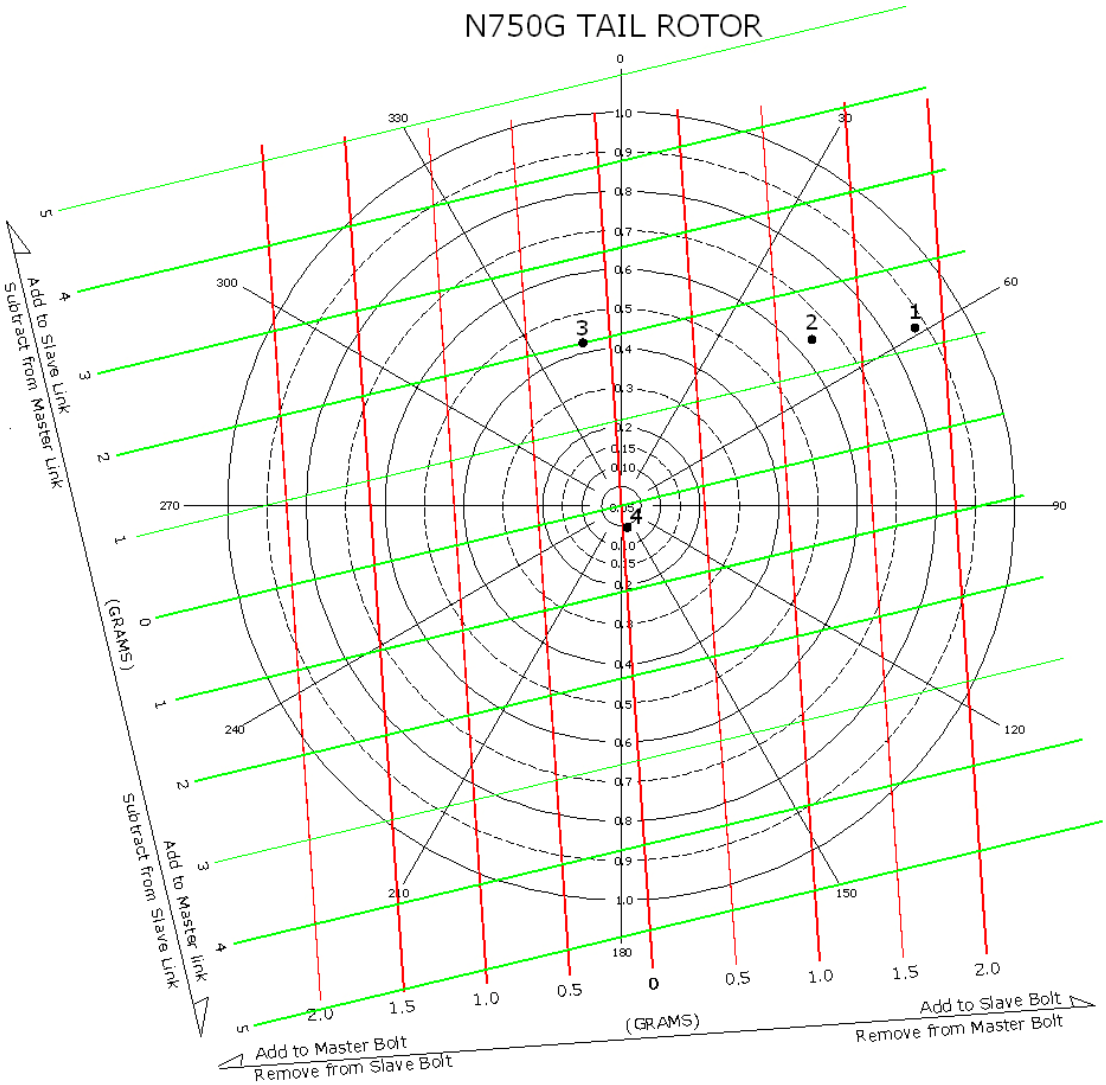

Here's the result of my balance effort (after several false starts):

1) Baseline
2) Added 1.0 grams to master bolt
3) Added another 1.0 grams to master bolt
4) Added 2.3 grams to master link

The first reading I took was 0.88 IPS at 59º. I then took a guess and added weight to the master blade and arrived at point #2. Another gram on the same blade took me to point #3 and those points formed a nice straight line. That told me that moving weight from blade to blade would move me along that axis. Adding more weight to the master would take me further from the center of mass so I took another guess and added 2.3 grams (a couple of washers) to the master link. I lucked out and ended up with 0.06 IPS. The next step is to replace the safety wire and see where I end up. I'll try to use the same amount of wire on each side.

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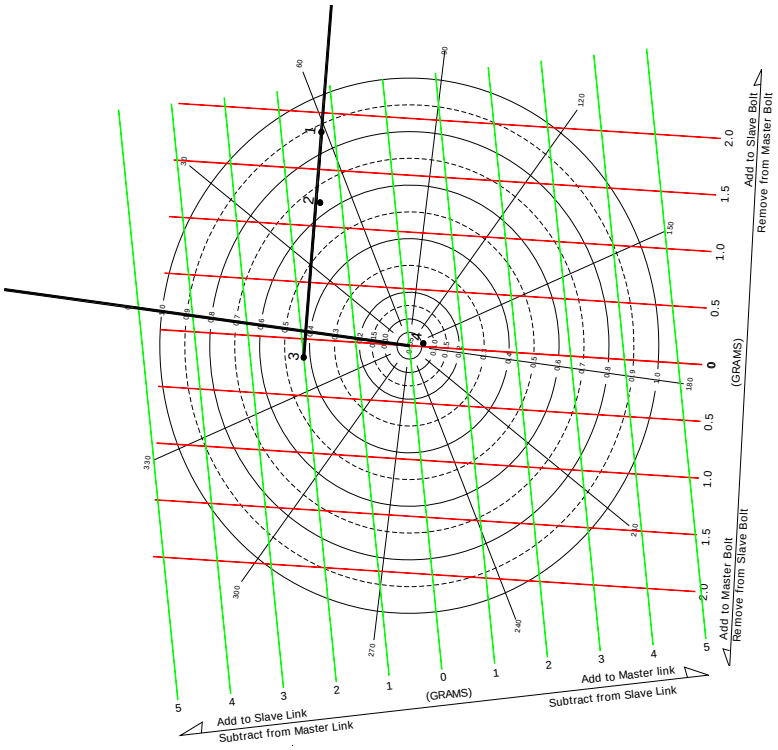
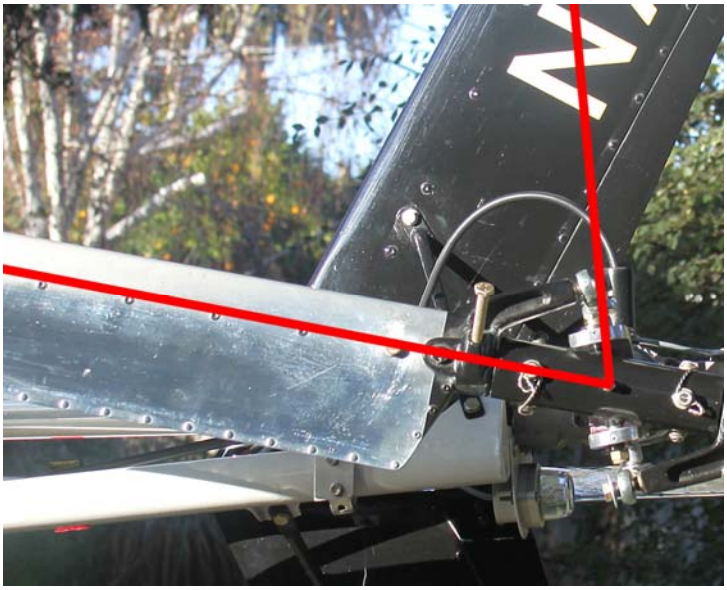


If I rotate the graph so that the zero axis is lined up with the optical sensor trigger point (see below) you can see that the first three data points line up with the blade axis. As I added weight to the master blade I moved the center of mass down that line closer to the center of rotation. Once I got to point #3 I needed to move the center of mass at right angles to the blade axis which I did by adding weight to the end of the master blade's pitch arm (See next page.)



The accelerometer is mounted vertically on top of the gearbox and is sensitive to acceleration along its axis. The graph's zero axis is determined by the point where the reflective tape on the master blade triggers the optical sensor as you see in this picture.

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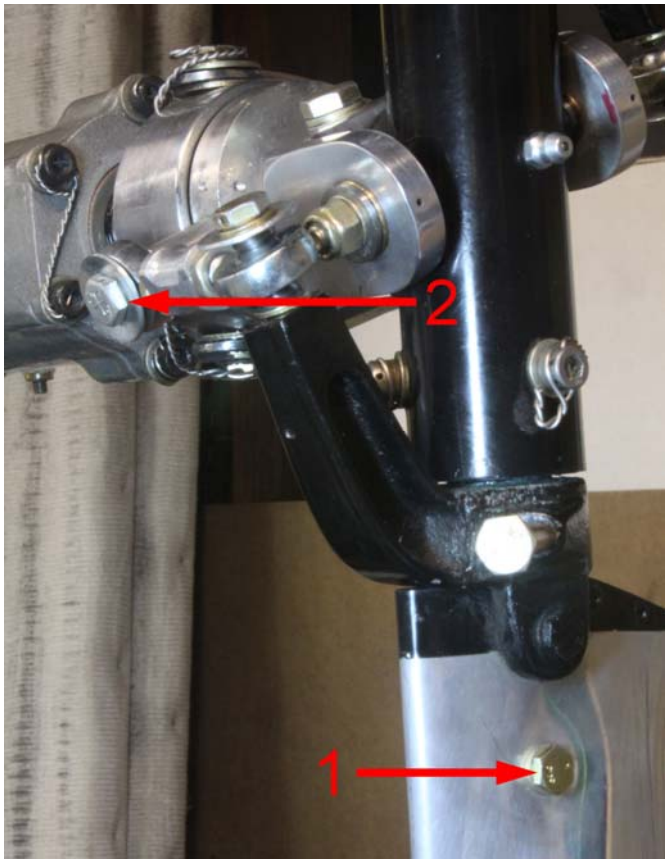
My weights were thick AN washers which weigh about one gram a piece. I have a triple-beam balance scale that has come in very handy while attempting to calibrate the graph.

Friday 22 January – It's taken me over a week to get the tail rotor balanced since I'm working all day and only have time for one quick run in my driveway after work on the days when I get home early. Urban life has its advantages but this isn't one of them.

I found that the trick to this was to take very small steps and only one at a time, and carefully document each one. I was lucky since my guesses were correct, especially that last one. I hope the vibration stays this low after I replace all of my safety wire.

The red and green lines on the graph are perpendicular to the axis caused by moving weight from blade to blade and from link to link. Once I determined the angle I scaled the lines in grams based on the measurements I took. The more times I do this the more accurate I should be able to make the chart.



When I refer to weight on the master of slave bolt I'm referring to the bolt pointed to by arrow-1. When I refer to the link I'm referring to the bolt pointed to by arrow-2. The master blade is the one with the reflective tape on the inner side facing the optical sensor.

Sunday 29 January, 2012 – I was careful to make each pair of safety wires as identical as I could. After installing all the safety wires my tail rotor vibration is .09 IPS at 155°. Pulling about half a gram off the master link might improve things even more, but this is good enough for now.