Rocket Tuning Instructions

For use with Signal R2, running SignalSoft 1.5.6, with R2 hardware.

Welcome to the tuning instructions! These procedures will help your Thrust Vector Controlled rocket fly straight and stable. Rocket tuning takes place in the Signal app on an iPhone or Android device. Turn on Signal R2, open the app, and connect to your Signal R2 flight computer.
This process can take several minutes, it may be helpful to turn off the buzzer in the System Prefs section. Then tap the “Tuning” button to begin.
If you have questions or find something confusing, please email support@bps.space - TVC rockets can be tricky, and BPS is here to help!

1. **Weigh the fully loaded rocket**
    a. With the motor loaded, and parachutes packed, place the rocket on a scale. Ideally, its mass will stay the same between now and launch.
    b. Using the Signal app, enter this value, in kilograms, in the “Loaded Mass” text box

2. **Find and mark the CM (center of mass)**
    a. Try to balance the rocket sideways on your finger. Once the rocket is balanced, mark the location of your finger on the rocket. A piece of tape or a rubber band will work.

3. **Measure the distance between the CM and Thrust Vectoring mount**
    a. Find the distance between the two and record it in your notes. We’re measuring the distance between the CM and the TVC-airframe screws - the point at which the TVC mount is connected to the airframe.
    b. Enter this distance, in meters, in the “COM-TVC” text box

4. **Create two equidistant “hang points” from the CM**
    a. Here we’re prepping the rocket to be hung sideways from two strings, and we need to mark where the attachment points will be
    b. Each string should be at least 15 centimeters away from the CM, and both of their distances from the CM should be the same
    c. Mark the points with a piece of tape or rubber band, just like the CM
    d. Enter this distance, in meters, in the “String-COM” text box

5. Tie the end two long strings around the rocket body at the hang points

a. Try to use thin strings, fishing line, or something with very little resistance to bending.
b. Make sure they're nice and tight!

6. Hang the rocket from the ceiling or a flat surface

a. First, ensure the two strings are parallel to each other. Measure their distance apart near their attachment points on the rocket. It should be exactly twice the "String-COM" distance.
b. Next, ensure the rocket is parallel with the ground. Make sure the distance from the rocket to the ceiling is the exact same for both strings.
c. Enter this distance, in meters, in the "String Length" text box

7. Rotation testing

a. Now it's time to rotate the rocket around its CM!
b. Using both hands, turn the rocket 10-20 degrees around it's CM, then let go. Ideally there should be no horizontal movement, just rotation
c. Let the rocket go back and forth a few times, then start a timer at on of the peaks of the oscillation.
d. Let the rocket rotate back and forth a full 10 times during the timer, then stop it at the end of the 10th rotation. For reference, check out this video. In the video, a translation test is also performed, but that test is no longer required.
e. Divide the time that those rotations took by 10. This give us an accurate average time that each full rotation took. For instance, if your rocket rotated 10 times in 18.5 seconds, the average rotation time would be 1.85 seconds
f. Enter this averaged time, in seconds, in the "Rotation Time" text box

8. Average thrust

a. Depending on the average thrust of your motor, the stability of your rocket will change. Using the average thrust, we can complete the tuning process. Try to use motors with very small thrust spikes at the beginning of the burn, or with pretty flat thrust curves.
b. The average thrust for most commercial motors can be found either on the motor packaging itself, or on http://www.thrustcurve.org/
c. If the average thrust is not listed in Newtons(N), please convert it to Newtons for the tuning app.
    i. Convert from pounds here
    ii. Convert from kilograms here
d. Enter the average thrust, in newtons, in the "Average Thrust" text box

9. Tune it!

a. You may want to save a screenshot or record all the values before tuning the vehicle
b. Tap the “Tune” button at the bottom of the Signal app
    i. If any of the values seem off or are out of the safety bounds, the app will let you know. If you’re still having trouble at this step, please contact support@bps.space
c. On the Tuning Results page, you’ll see the Inertia of the vehicle, as well as the PID gains that are recommended for your flight. The values we really care about here are the PID gains.
d. To configure Signal for flight, press the button below to send the PID gains to the flight computer
    i. If Signal is not turned on or has disconnected from your phone, you’ll need to write down the PID gains
    ii. Reconnect to the flight computer, tap “Thrust Vectoring”, and manually enter the new values here
e. Once Signal is configured, it’s helpful to go back to the home screen and tap “Thrust Vectoring” to confirm Signal has the right values configured for flight
f. You’re ready for flight! If you have any questions, or are unsure about a part of this process, please contact support@bps.space

10. That’s it!

Your rocket is now tuned to fly with thrust vectoring! This tuning will remain constant so long as the weight, center of mass, and motor stay roughly the same. Small changes are fine, like adding or removing small cameras.
You can also use the generated P, I, and D values as starting points for experimentation! If you’d like to gain a better of understanding of how PIDs work, and what each value does, this video is a great place to start.