**AIAA Orange County (California) Section**

**TARC 2013 – November 25, 2012**



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| **Rocket Design Principles** |  |
| **These general rules of thumb are from the Info Central web site. They were general rules – not tailored to the TARC challenge – so we removed some that would just serve to confuse. The original list can be found at:**  [**http://www.info-central.org/?article=122**](http://www.info-central.org/?article=122)  **First, please read the fine print:**   1. There are many different solutions to the rocket design challenge. Rules of Thumb simply provide a solid starting point that many have found useful in the past, and that will, in many cases, provide a suitable solution for your design problem today. 2. Rules of Thumb are guidelines. They're not laws. They are nominal solutions that usually, in many cases, most of the time, get the designer in the right ballpark. Once a rocket designer's judgement has been formed by lots of experience, some Rules of Thumb can be stretched, bent, stood on their head, or ignored completely. 3. Using Rules of Thumb certainly does not take the place of stability tests, or attention to safety. Proof of stability and a constant focus on safety are the most fundamental and unchangeable Rules of Thumb I know. 4. If you know Rules of Thumb that are not mentioned here, please send them to us via our [contact form](http://www.info-central.org/index.php?article=99) or through the forums at [Rocketry Online](http://www.rocketryonline.com) and they could appear in a future update with your name as the contributor. Comments are always welcome.   **General Design**  **Paint Selection**  Whatever your choice, use a primer, finish and clear coats that are compatible. Many times this means sticking to the same brands-e.g., Krylon primer, Krylon finish coat, and Krylon clear coat. Test a scrap piece of material with your intended finishes beforehand. Process it just as if it's your rocket - fill, sand, primer, sand, base coat, sand, color, sand, mask, second color, sand, top coat. If there is any kind of adverse reaction, or the finish doesn't turn out like you thought, it's easy to start over on a piece of scrap.  **Airframe**  **Diameter And Length Of The Rocket**  The ratio of rocket length to diameter, sometimes referred to the aspect ratio, should be from 10 - 20:1. For example, a six inch diameter rocket would mean a length of 60 -120 inches.  **Fins**  **Fin Dimensions**  A fin that is 2 diameters of the airframe in root length and span and a chord length of about 1 diameter will be effective.  **Fin Shape or Planform**  The shape you see more than any other is called the clipped delta, and is known for its effectiveness. The clipped delta resembles a parallelogram, with the fin swept somewhat to the rear. The root and chord lines are near parallel, and the leading and trailing edges are near parallel. There are many, many shapes that will get the job done. Some look cooler to me than others. One of the most efficient fin designs looks like a simple rectangle attached to the tube.  **Shaping the Fin**  The leading edge of the fin should be rounded, the trailing edge shaped like a V. The chord edge should remain square.  **Number of Fins**  Three fins will almost always do the job. Four fins work too, but only marginally better as far as improving CP. Some have said that four fins reduce wind-induced spin.  **Recovery**  **Sizing The Parachute (your payload MUST return on a 15” parachute)**   * You want your rocket to descend at about 15 feet per second under nominal conditions. Slow it up over playa and concrete. * Use 3.5 square feet of chute per pound of recovered rocket weight. * Determine chute size by doubling the square root of the weight of the rocket. For example, a 16 pound rocket would use a 2X4=8' chute. A 49 lb rocket would use a 2X7=14' chute. * Streamers should be 10 times as long as they are wide. * Drogue recovery descent should be about 50 ft/sec. * A full-hemispherical canopy has very little performance gain over the more efficient and less bulky quarter-spherical--the top-half of a full-hemispherical chute.   **Recovery Harness Strength**  Tensile rating for recovery materials should be at least 50 times the static weight of the rocket.  **Length of model rocket shock cord**  Make shock cords for model rockets a minimum of 2 to 3 times the overall length of the rocket. Middle or high power rockets should use tubular nylon at least 5 times the rocket length.  **Wadding**  Use enough wadding to fill 2 x the diameter of your BT. Any more is probably overkill. Any less may allow hot particles through to hit your chute. Do not pack it tight  **Knots, Loops and Sharp Bends in Shock Cord or Bridle**  Knots, sharp bends, including sewn loops, in the tubular nylon or flat webbing will weaken its load capacity by 50%.  **How Tight is Tight?**  Many people use masking tape to finesse the fit between an airframe and a coupler that must separate at deployment. A common question is: how tight do I want it to be? Use enough masking tape so that you can pick the rocket by the nose cone without the rocket coming apart. If you vigorously shake the rocket up and down, and don't see any movement off the coupler, you've probably got too much tape on, Jack.  **Stability**  **Margin of Stability**  The CG should be forward of the Center of Pressure by 1-2 calibers. A caliber is simply the diameter of the bird. One caliber of stability is also known as a margin of stability. In other words, in a four inch rocket, the CG must be ahead (closer to the nosecone) of the CP by 4 - 8 inches. More than .5 but less than 1 margin of stability (less than one caliber) and a rocket is "marginally stable'. More than two calibers of stability is known as "over stable". An over stable rocket will tend to dramatically turn into the wind. A marginally-powered, over stable rocket can end up almost horizontal.  **Adjusting the Center of Gravity**  To move the CG forward, add weight to the nose, lengthen the rocket, or lessen the weight in the aft end of the rocket. To move the CG aft, (for example, if your rocket is overstable), do the reverse.  **Adjusting the Center of Pressure**  To move the CP aft (more stable), increase the size of the fins. To move the CP forward, decrease fin size.  **How Long is Too Long**  A rocket must maintain its rigidity in flight. Any tendency to bend will be magnified in flight resulting in a kinked tube and likely a failed flight. If you hold a rocket horizontal by its tail section and notice any curvature in the rocket, your bird probably isn't stiff enough.  **Propulsion**  **Sizing the Motor**  In selecting a motor to power your rocket, you need to have at least a 5:1 thrust to weight ratio.  **Motor Mount Size**  Build your rocket for the largest motor you might want to fly in it. You can always adapt down, you can never adapt never up. Also consider the length of the motor. 54mm motorsfor example range from soda-can sized cases to 36" or more in length. If your mount is short, you will never be able to fly the longer motors in that rocket.  **Launch Operations**  **Launch Rod Diameter (TARC supplies a ¼” launch rod, but we can bring our own pads with any size rod as long as it is safe)**  By motor size:   * Single A, B, and C motors: 1/8" Launch Rod * Single D, and E motors, C clusters: 3/16" Launch Rod * Single F, G, and H motors, D and E clusters, with a body tube dia less than 2.6": 1/4" Launch Rod * Single F, G, H, I w/ 2.6" to 4.0" body: 7/16" Launch Rod * Single I and J motors: 1/2" Launch Rod * Over J and/or body tube over 4" dia: 1" Rail   By Rocket weight:   |  |  | | --- | --- | | **Rod Diameter** | **Maximum rocket (lbs)** | | 1/4" | 5 lb | | 3/8" | 10 lb | | 1/2" | 15 lb | | 5/8" | 30 lb | | 3/4" | 40 lb | | 7/8" | 55 lb | | 1" | 75 lb |   Note: Many believe that a rail should be used with any rocket weighing more than 15-20 pounds.  **Minimum Speed for Stable Flight**  44 fps (30mph) is generally accepted as a minimum safe speed for stable flight and is good for winds up to 5 mph. Faster speeds are necessary to achieve stability in windy conditions so add 9 fps (6 mph) for each additional 1 mph of wind speed. (Contributed by Terry Markovich, TRA 6811)  **Mounting launch lug(s)/button/s**  When mounting a single lug , cover the center of gravity with the lug. Always mount at least two rail buttons. When mounting two lugs or buttons, mount the lower piece at the rear of the airframe. The second should be on or just behind the center of gravity. | |