**AIAA Orange County (California) Section**

**TARC 2013 - November 25, 2012**

Your rocket must be single stage and should be of your own design. You cannot use a kit that was designed to carry an egg with the only modification being to add an altimeter. The motor will provide thrust to carry your rocket to altitude; an integrated ejection charge on the end of the motor opposite the nozzle will push your parachute out. Most model rockets will consist of two or three separate pieces, which either need to stay together, separate and be tied together with a shock cord, or come down on separate parachutes.

1. The rear section with fins and motor
2. A central section with payload and altimeter – if there is a payload or altimeter
3. A nose cone (hollow nose cones can also carry a payload, but are a poor place for an altimeter because of the turbulent air flow around the nose cone)

Most model rockets without a payload will separate between the body tube and nose cone to allow the parachute to deploy. Most model rockets with a payload will separate between the rear section and payload to allow the parachute(s) to deploy. If you are using one parachute, the two pieces must remain linked together with your shock cord. If you are using two parachutes, each piece must come down on a separate parachute. In the 2013 TARC contest, the section of the rocket with the egg payload and altimeter must use a 15” parachute. The other section may use any safe means (e.g. any size parachute or streamer). “Safe” means the descent is slowed to minimize injury to the rocket AND the people on the ground (3.5 to 4.5 meters per second [11.5 to 14.8 feet per second]) is considered a safe rate of descent.



 

Image modified from: <http://www.vanderbilt.edu/USLI/media_rocket.shtml>

Image from: <http://www.rocketmime.com/space/rckt_asm.html>

You will probably need most of these parts for your TARC rocket

|  |  |  |  |
| --- | --- | --- | --- |
| **PART** | **USE** | **COMMON MATERIALS** | **COMMENTS** |
| Body Tube (airframe) | Main structure of the rocket | Cardboard – comes in thin and thick wall | Thick wall is sturdier, but weighs much more |
| Coupler | Extend length of body tube | Cardboard | A coupler is a short piece of what looks like a body tube, but fits inside |
| Nose Cone | Forward end of the rocket | Plastic or Balsa Wood | Plastic nose cones weigh more, but are hollow and could be used for payload or parachute |
| Fins | Stability | Plywood | We have 1/8” plywood and the tools for you to cut them out |
| Motor Tube | Holder for the engine | Cardboard | The inner diameter of your motor tube must match the outer diameter of your motor. 24mm and 29mm are common sizes |
| Centering Rings | Center engine tube in the body tube | Cardboard, Plywood | Most motor tubes are smaller than the diameter of the airframe – centering rings hold the motor tube in the center of the air frame |
| Bulkhead (or Bulkplate) | Block between the payload and the ejection charge from the motor | Plywood | Usually used at the after end of the payload. Protects the payload and altimeter from the ejection charge and can be used with an eyebolt to attach the shock cord |
| Eyebolt | Attachment for the shock cord | Metal (small amounts are OK) | Position in the center of the bulkhead |
| Tail Cone or Boat Tail | After end of the rocket | Plastic or Balsa Wood | Provide for a smoother airflow at the after end with less turbulence and more even pressure inside motor |
| Transitions | Change diameter of body | Balsa wood or plastic | Use if the outer diameter of the air frame changes (e.g. your payload section is wider than other parts of the rocket |
| Parachute | Recovery | Plastic or Nylon | Use for safe recovery – you may need two |
| Parachute Protector | Recovery | Kevlar | Used to protect the parachute from the motor ejection charge |
| Swivel | Recovery | Metal – with ball bearings | Keeps the shroud lines from twisting during descent – from fishing supplies is OK |
| Shock Cord | Recovery | Kevlar and Nylon | Attaches the parachute to the airframe, and keeps sections together |
| Launch Lug | Launch | Cardboard | Slides over the launch rod when the rocket is launched |
| Payload protection | Payload | Memory foam, sponge, packing material | Best to experiment – previous AIAA OC teams have used memory foam successfully |

Common thin walled (light weight) body tubes

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Name** | **Inside Diameter** | **Outside Diameter** | **Weight (18” length)** | **Use** |
| BT-5 | .518” (13.2mm) | 0.544” (13.8mm) | 0.205oz (5.8g) | Body Tube, 1/2A Engine Tube (14mm) |
| BT-20 | 0.71” (18mm) | 0.736” (18.7mm) | 0.286oz (8.1g) | Body Tube, A-B-C Engine Tube (18mm) |
| BT-50 | 0.95” (24.1mm) | 0.976” (24.8mm) | 0.384oz (10.9g) | Body Tube, D-E-F-G Engine Tube (24mm) |
| BT-55 | 1.283” (32.6mm) | 1.325” (33.7mm) | 0.705oz (20g) | Body Tube |
| BT-60 | 1.595” (40.5mm) | 1.6” (40.6mm) | 0.635oz (18g) | Body Tube |
| BT-70 | 2.18” (55.4mm) | 2.27” (56.3mm) | 1.291 oz (36.6g) | Body Tube |
| BT-80 | 2.558” (65mm) | 2.6” (66mm) | 1.975oz (56g) | Body Tube |
| 3” Thin Wall | 2.93” (74.4mm) | 3” (76.2mm) | 2.903oz (82.3g) | Body Tube |
| 29mm | 1.14” (29mm) | 1.176” (29.9mm) | 0.459oz (13g) | F-G-H-I Engine tube (29mm) |

Common thick walled (heavy weight) body tubes

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Name** | **Inside Diameter** | **Outside Diameter** | **Weight** | **Use** |
| 2.56” | 2.56” (65mm) | 2.63” (66.8mm) | 5.573oz (158g) – 30” | Body Tube |
| 3.00” | 3” (76.2mm) | 3.1” (78.7mm) | 7.972oz (226g) – 34” | Body Tube |
| 29mm | 1.14” (29mm) | 1.21” (30.7mm) | 2.399oz (68g) – 34” | F-G-H-I Engine Tube (29mm) |
| 38mm | 1.525” (38mm) | 1.635” (41.5mm) | 4.162oz (118g) – 24” | G-H-I-J Engine Tube (38mm) |

There are many good sources for parts on the Internet. Below are a few that we have used in the past, are relatively local, and have consistently provided good service:

**Body Tubes, Couplers, Launch Lugs**:
 <https://www.discountrocketry.com/model-rocket-parts-body-tubes-couplers-launch-lugs-c-7_17.html>

**Thin walled body tube (airframe) and engine tube sources:**<http://www.apogeerockets.com/Building_Supplies/Body_Tubes/Low_Power_Tubes>

**Thick walled body tube (airframe) and engine tube sources:**Body tube (some pre-slotted): <http://www.madcowrocketry.com/category_s/1824.htm>
Motor tubes: <http://www.madcowrocketry.com/category_s/1833.htm> <http://www.apogeerockets.com/Building_Supplies/Body_Tubes/High_Power_Tubes> <http://www.madcowrocketry.com/category_s/1824.htm>

**Couplers:**
Thin Wall: <http://www.apogeerockets.com/Building_Supplies/Body_Tube_Couplers/Standard_Couplers>
Thick: <http://www.apogeerockets.com/Building_Supplies/Body_Tube_Couplers/High_Power_Couplers> <http://www.madcowrocketry.com/category_s/1829.htm>

**Nose Cones and Transitions:**
<https://www.discountrocketry.com/model-rocket-parts-nose-cones-transistions-c-7_14.html>

**Nose Cones:**<http://www.madcowrocketry.com/category_s/1834.htm> <http://www.apogeerockets.com/Building_Supplies/Nose_Cones/Low_Mid_Power_Nose_Cones?page=2>

**Centering rings and engine mounts:**
 <https://www.discountrocketry.com/model-rocket-parts-centering-rings-engine-mounts-c-7_18.html>

**Centering rings:**<http://www.madcowrocketry.com/category_s/1836.htm> <http://www.apogeerockets.com/Building_Supplies/Centering_Rings/Low_Power_Centering_Rings> <http://www.balsamachining.com> -> Kits and Bldg Supplies -> Centering Rings & Engine Blocks

**Bulkheads (bulkplates):**<http://www.madcowrocketry.com/category_s/1837.htm> <http://www.apogeerockets.com/Building_Supplies/Bulkheads/Balsa_Low-Power> <http://www.apogeerockets.com/Building_Supplies/Bulkheads/Plywood_Mid-_High-Power>

**Tail Cones or Boat Tails and Transitions:**<http://www.balsamachining.com> -> Cones and Transitions <http://www.apogeerockets.com/Building_Supplies/Transition_Pieces>

**Parachutes:**
TARC Elliptical: <http://fruitychutes.com/buyachute/tarc-low-and-mid-power-chutes-c-6/15-tarc-2013-competition-chute-p-63.html>
TARC Flat: <http://www.apogeerockets.com/Building_Supplies/Parachutes_Recovery_Equipment/Parachutes/Low_Power/15in_Nylon_Round_Parachute>

**Parachute Protectors:**<http://www.madcowrocketry.com/category_s/1826.htm>
<https://www.discountrocketry.com/model-rocket-parts-parachutes-recovery-c-7_28.html> <http://www.apogeerockets.com/Building_Supplies/Parachutes_Recovery_Equipment/Reusable_Wadding>

**Shock Cord:** <http://www.apogeerockets.com/Building_Supplies/Parachutes_Recovery_Equipment/Shock_Cord>

**Launch Lugs:** <http://www.apogeerockets.com/Building_Supplies/Launch_Lugs_Rail_Buttons/Launch_Lugs>

**Design Software:**Rocksim (most used): <http://www.apogeerockets.com/Rocket_Software/RockSim_Educational_TARC>
Open Rocket (Free – similar to Rocksim but limited): <http://openrocket.sourceforge.net/>
SpaceCad: <http://www.spacecad.com/>

Motors: TARC teams are limited to motors no larger than “F” which goes up to 80 Newtons of thrust. One pound of thrust is equivalent to 4.45 Newtons, and one Kilogram of thrust is equivalent to 9.8 Newtons. A safe rule of thumb is that the motor provide a minimum thrust equivalent to 5X the weight of the rocket. So your 650g rocket would need a motor that would provide a minimum of 3.2 Kg or roughly 32 Newtons of thrust. That is the minimum size for safe liftoff – to attain the desired altitude will probably require a different thrust motor.

The propellant used in our commercially available hobby rocket motors is black powder, common in the smaller motors up to “E” (maximum 40 Newtons). These motors are usually single use motors, which means that the entire motor that you purchase goes into the rocket as-is, and you discard the entire motor after its use. Some “E” and most “F” motors are “reusable” which means the motor you purchase needs assembly into a casing. After you fly your rocket, you discard the motor part and clean and reuse the casing. Larger motors are usually APCP, or Ammonium Perchlorate Composite Propellants

Motors we can use in TARC come in standard diameters:
13mm motors are “mini” size (e.g. ½ “A”) and too small to use in TARC rockets
18mm motors are the most common model motors in “A” – “C” thrust categories
24mm motors are common for “D” and “E” single use motors and some “F” reusable motors
29mm motors are very common for “F” reusable motors
For TARC, a lightweight rocket can probably hit the 750 foot altitude with an “E” motor. Heavier weight rockets will require a cluster of smaller motors, or a single “F” motor. Teams have won with clusters of smaller motors, but you need to make certain that all motors are ignited or the rocket will fly at an angle and your thrust will be wasted pushing the rocket sideways rather than up – so you miss the target altitude.

The manufacturers that are most common are Estes and Quest for the single use motors up to “D” and “E”. Aerotech makes “D”, “E”, and “F” motors in 24mm and 29mm sizes, both single use and reloadable. Cesaroni makes “E” and “F” reloadable motors in 24mm and 29mm sizes and are very consistent.

Estes Motors – see <http://www.estesrockets.com/rockets/engines/c11-and-d> (“C” and “D”) and <http://www.estesrockets.com/rockets/engines/e-engines> (“E”)
Quest Motors – see <http://www.estesrockets.com/rockets/engines/e-engines> (up to “D”)
Aerotech Motors –see the Aerotech catalogue at: <http://www.aerotech-rocketry.com/products.aspx>
Cesaroni Motors – see Pro 24 and Pro29 at: <http://pro38.com>

REMEMBER: The motor you select MUST be on the approved TARC 2013 motor list. And in California, it must be on the certified motor list for the state of California. And in California there are additional restrictions for rockets over 500g in weight.

There are many places on line that you can purchase motors. But motors cannot be shipped via air, and often vendors charge Hazardous Materials charges of up to $25 per shipment in addition to shipping charges. At our local launches, vendors such as “What’s Up Hobbies” (<http://stores.whatsuphobby.com/StoreFront.bok>) and Discount Rocketry (<http://www.discountrocketry.com>) attend many of the launches and you can purchase motors without shipping charges.

From the NAR web site: <http://www.nar.org/NARmotors.html> )

**How To Interpret Rocket Motor Codes**

Sport rocket motors approved for sale in the United States are stamped with a three-part code that gives the modeler some basic information about the motor's power and behavior:



1. A letter specifying the total impulse ("C");
2. A number specifying the average thrust ("6");
3. A number specifying the time delay between burnout and recovery ejection ("3").

**Total Impulse**

Total impulse is a measure of the overall total energy contained in a motor, and is measured in Newton-seconds. The letter "C" in our example motor above tells us that there is anywhere from 5.01 to 10.0 N-sec of total impulse available in this motor.

In a typical hobby store you will be able to find engines in power classes from 1/8A to D. However, E, F, and some G motors are also classified as model rocket motors, and modelers certified for high power rocketry by the NAR can purchase motors ranging from G to O.

Since each letter represents twice the power range of the previous letter, total available power increases rapidly the further you progress through the alphabet.

|  |  |
| --- | --- |
| Letter Designator | Impulse Range |
| 1/8 A | 0 – 0.3125 Newtons |
| 1/4 A | 0.3126 – 0.625 Newtons |
| 1/2 A | 0.626 – 1.25 Newtons |
| A | 1.26 – 2.5 Newtons |
| B | 2.501 - 5.0 Newtons |
| C | 5.01 – 10.0 Newtons |
| D | 10.01 – 20.0 Newtons |
| E | 20.01 – 40.0 Newtons |
| F | 40.01 – 80.0 Newtons |

**Average Thrust**

Average thrust is a measure of how slowly or quickly the motor delivers its total energy, and is measured in Newtons. The "6" in our example motor tells us that the energy is delivered at a moderate rate (over about 1.7 seconds). A C4 would deliver weaker thrust over a longer time (about 2.5 seconds), while a C10 would deliver a strong thrust for a shorter time (about a second). Note, however that the average thrust printed on the motor may differ greatly from the actual average thrust of the motor. You should check the engine data sheets at <http://www.nar.org/SandT/NARenglist.shtml> for an accurate value. Just click on the motor designation for a particular motor to get a sheet with the actual as-tested numbers for every NAR certified motor.

As a rule of thumb, the thrust duration of a motor can be approximated by dividing its total impulse by its average thrust.

Keep in mind that you cannot assume that the actual total impulse of a motor lies at the top end of its letter's power range -- an engine marked "C" might be engineered to deliver only 5.5 Newton-seconds, not 10.

**Time Delay**

The rocket is traveling very fast at the instant of motor burnout. The time delay allows the rocket to coast to its maximum altitude and slow down before the recovery system (such as a parachute) is activated by the ejection charge.

The time delay is indicated on our sample motor is 3 seconds. Other typical delay choices for C engines are 5 and 7. Longer delays are best for lighter rockets, which will coast upwards for a long time. Heavier rockets usually do better with shorter delays -- otherwise the rocket might fall back down to the ground during the delay time.

Motors marked with a time delay of 0 (e.g., "C6-0") are booster engines. They are not designed to activate recovery systems. They are intended for use as lower-stage engines in multi-stage rockets. They are designed to ignite the next stage engine immediately once their own thrust is finished. Often their labels are printed in a different color to help prevent you from using them in a typical rocket. In a multi-stage rocket, you would usually select a very long delay for your topmost engine.

**NOTE: Determine which motors you will need and order them early. They’ll take 1-2 weeks from vendors on the internet, and a month or more from vendors at launches. Later in the season they can take even longer. And you’ll want to get several motors with the same lot number for consistency.**

Whenever you launch your rocket you will want to collect as much data as possible. We recommend filling out a form, such as the one on the next page, for every flight. You can then go back and analyze your data and make changes as needed to fine tune altitude and time. And to determine what adjustments you need to make not only for time and altitude, but also for variations in weather.