Team America Rocketry Challenge

Launching Students into Aerospace Careers

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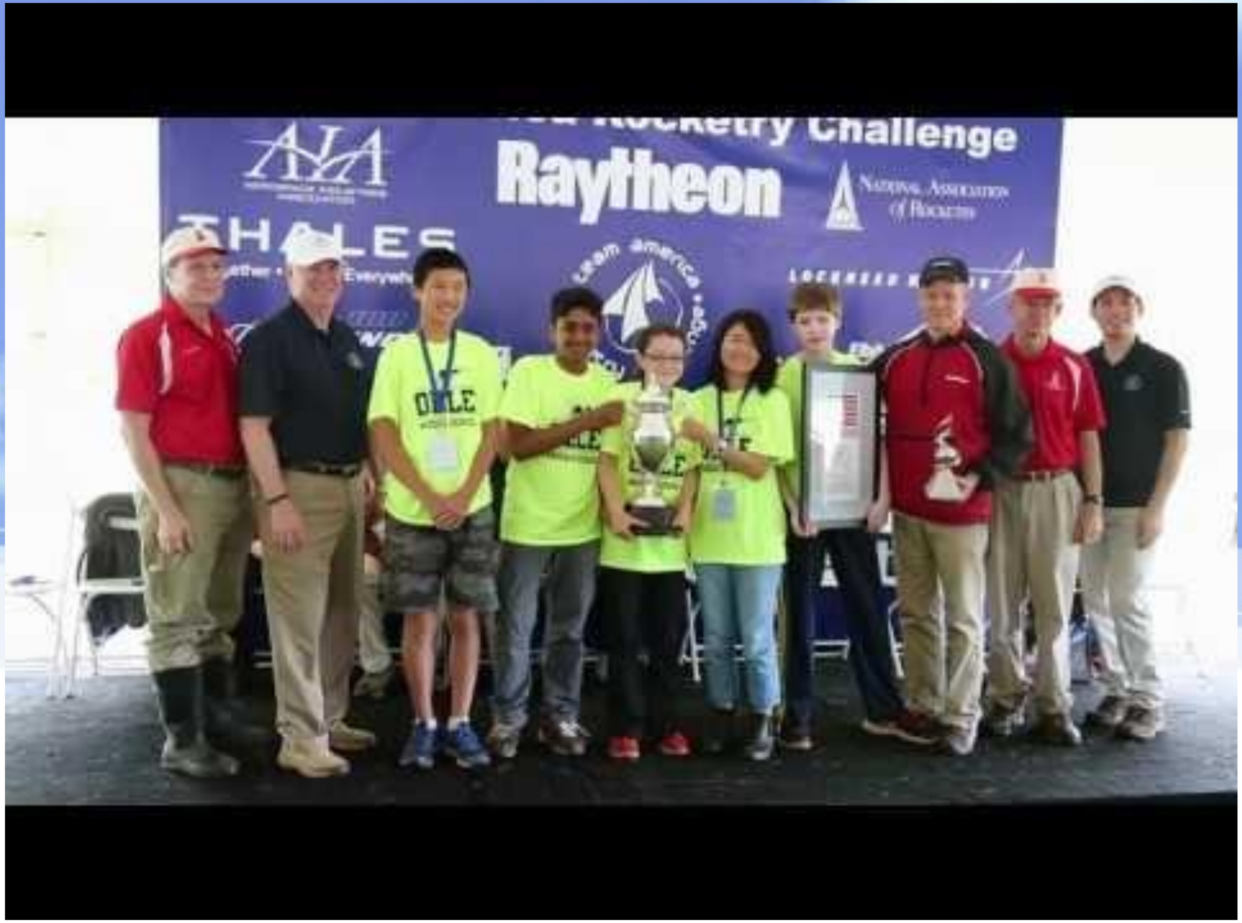
TARC Video

- https://youtu.be/TZZMcnH-WA8



What is the Team America Rocketry Challenge (TARC)?

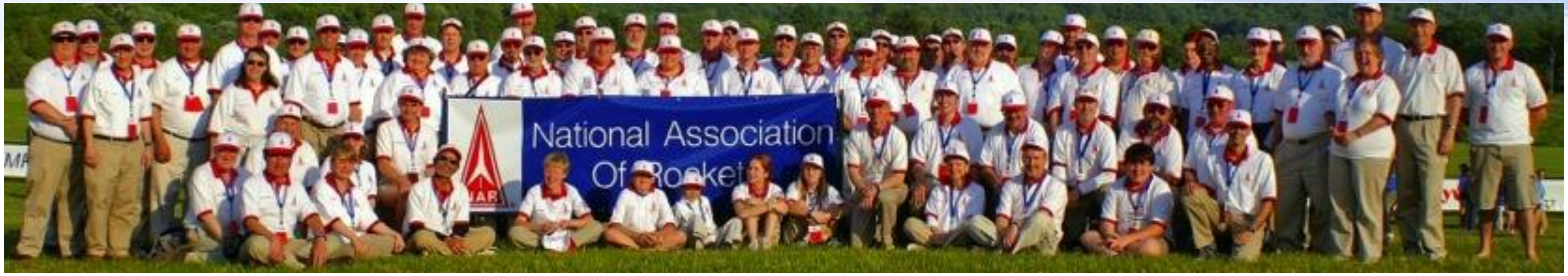
- The world’s largest student rocketry competition
- An educational program designed to encourage students in grades 7 through 12 to study math and science and pursue careers in aerospace
- A chance for students to design, fabricate, and fly rockets in a process modeled on the aerospace industry’s engineering cycle
- An opportunity for students to win a share of more than $100,000 in scholarships and prizes and a trip to compete internationally.

What is TARC? (continued)

- The Aerospace Industries Association's (AIA) flagship STEM education and workforce development program
- Created in 2003 as a one-time celebration of the centennial of flight; Response was so great the first year that AIA decided to continue it annually
- Sponsored by the AIA and the National Association of Rocketry (NAR)
  - **Funded by aerospace corporations and supported by NASA, the Department of Defense, and the American Association of Physics Teachers**

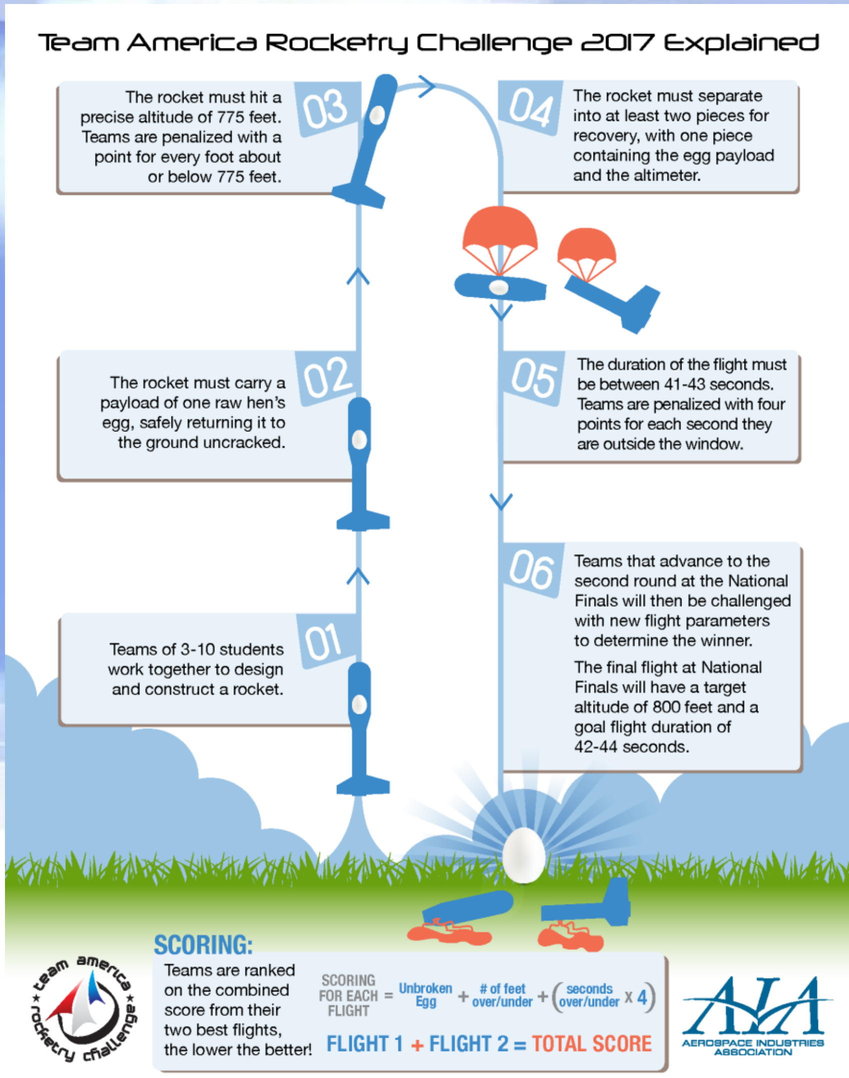
National Association of Rocketry

- The oldest and largest national non-profit consumer organization for rocket fliers
  - 6,200 members and 160 clubs, providing services to tens of thousands of non-member youth fliers
- Provides the hobby's Safety Code and does the national safety certification testing on rocket engines
- Represents the hobby's interests to national agencies and organizations such as FAA and NFPA
- Provides a $5 million liability insurance policy to members and to launch site owners



How does the challenge work?

- Students work in teams of three to ten
- Goal is to design a rocket that best meets challenge criteria that change each year
- Qualification flights locally, best teams attend National Finals in Virginia in May
- US winners travel to Paris for International Rocketry Challenge



What does TARC teach?

- Teamwork
- Physics
- Electronics
- Aerodynamics
- Weather/Meteorology
- Craftsmanship
- Experimental Technique
- System Design/Optimization

All rockets are entirely designed, built, and flown by student team members

Perspectives from teachers and students

- **Teacher, Maryland:** Students are more motivated when they are allowed the opportunity to work on a topic they are passionate about. Their success in this challenge has carried over into the classroom. Their overall grades have improved and it has given them a lot more confidence.

- **Teacher, Texas:** My school has seen a drop in Advanced Placement Physics in recent years. After the first experience with TARC, this class has gone from 8 students last year, to 14 students this year, to 32 students signed up for this upcoming school year. Thanks, you've saved my program.

- **Student:** Building my rockets with my team was a very rewarding and worthwhile activity. I gave up sleep, study time, and most of my weekends for this competition, and I don't regret it one bit. I plan on majoring in aerospace engineering this upcoming fall.

What Has TARC Done?

- Engaged >65,000 students in 14 years
  - From all 50 states, D.C., Puerto Rico and the U.S. Virgin Islands
- Ignited student interest in aerospace
  - 56% report increased interest in an aerospace career
  - 67% report increased interest in high school STEM classes
  - 85% intend to pursues college studies in a STEM Field
  - 94% found TARC worthwhile and would recommend the program

How do teams participate?

Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April		May	June	July
Sept. 1 Registration opens			**Dec. 2** Registration closes				**April 3** Qualification flight scores deadline	**April 7** Top 100 teams invited to National Finals	**May 12-13** National Finals		**June 22-23** Top team competes at Paris Air Show

- Register at rocketcontest.org by December 2
- Submit qualification flight reports by April 3
- Schedule included in the TARC Handbook
- Successful teams usually start work in the fall.

Are these rockets safe?

- **YES!** 500 million model rockets were launched over the last 50 years – safely
- Governed by the Safety Code of the National Association of Rocketry
- Must use only safety tested and certified pre-manufactured commercial solid fuel motors
- Must use paper, balsa, and plastic bodies – no metal
- Must have recovery devices and be reusable
- Must be ignited electrically from a safe distance
- Must be aimed straight up and not flown in high winds, dry grass, or near airplanes or power lines

How much does it cost?

- One of the most affordable STEM education programs
  - $125 entry fee (per team)
  - Total cost of ~$500/team
    - Includes rocket parts, motors, design software, entry fee
    - Exact cost varies depending on design/number of test flights
- Designed for access and scalability

What if I am not a rocketry expert?

- National NAR Mentor Network (400+ volunteers)
- Video training program on how to build and fly
- 70+ page TARC handbook
- Online rocketry forum (requires a yahoo account) for questions and networking with other teams
- narTcert program

narTcert

- NAR Rocket Teacher Certification Program (narTcert) trains teachers to have the skills to build and fly model rockets and the confidence to lead a rocketry lesson in the classroom.
- Online training program, followed by building a model rocket and and flying under supervision of a local NAR member mentor.
- No additional fees beyond NAR membership ($62), and cost of parts for your rocket (~$15-$39)
- Optional, not required to oversee a TARC team.

7 Steps to Success in TARC

1. Start Early
2. Start Simple
3. Plan First, then Fly
4. Work as a Team
5. Fly Straight
6. Practice
7. Keep it Safe

1. Start Early

- It takes longer than it looks
- Do your rocketry homework before you start designing, buying, and building
- Allow time for multiple designs, simulations and test flights – and fundraising
- Allow time to make and correct mistakes
- Allow time to have launches "scrubbed" by bad weather

2. Start Simple

- Don't start by building and flying your 'full up' final design rocket
- If new to rocketry, build and fly an inexpensive one-stage rocket kit first
- Practice test-flying your initial TARC design without altimeter and eggs
- Try it all together once you've mastered the basics of launching and recovery
- Use the simplest design that will achieve the desired goals – complexity adds failure modes

3. Plan First, Then Fly

- Use one of the two design and flight simulation software packages available to teams
- Watch the TARC training video on how to build a rocket and read the TARC Team Handbook
- Use rocketry resource sites on the Internet
- Consult with one of the 400+ volunteer NAR “mentors” for TARC teams
- Get online help on the NARTARC Yahoo Forum

4. Work as a Team

- Divide up the work load; one team member cannot and should not do the whole thing!
- Assign specific responsibilities to team members:
  - Design and simulation
  - Launch system
  - Airframe design and construction
  - Payload design and construction
  - Recovery system
- Select a <u>Program Manager</u> – team leader who is the designated student point of contact for TARC management

5. Fly Straight

- A straight flying rocket is a key to getting consistent flights
- Take extra care aligning everything: fins, external boosters, launch lugs...
- Use enough rocket motor power to get your rocket off the launcher fast
- Use a long, rigid launcher

6. Practice, Practice, Practice!

- Successful teams in the past averaged ~15 test flights
- Evaluate and correct for each thing that goes wrong in test flights
- Keep notes on all flights to figure out what the controlling variables are
- Practice in a variety of wind and weather conditions

7. Keep it Safe

- Follow the NAR Safety Code – every time
- Get a pre-flight check of any new rocket from an experienced rocketeer
- Fly in a large cleared area with no burnable grass or power lines – and with the land owner's permission
- Make sure everyone is paying attention before you count down and launch

In Conclusion…

- Rocketry is a proven means of educating and inspiring students for aerospace careers
- TARC is a structured, safe way to involve students in rocketry
- TARC has specific educational objectives, a track record of success, and big prizes

Websites

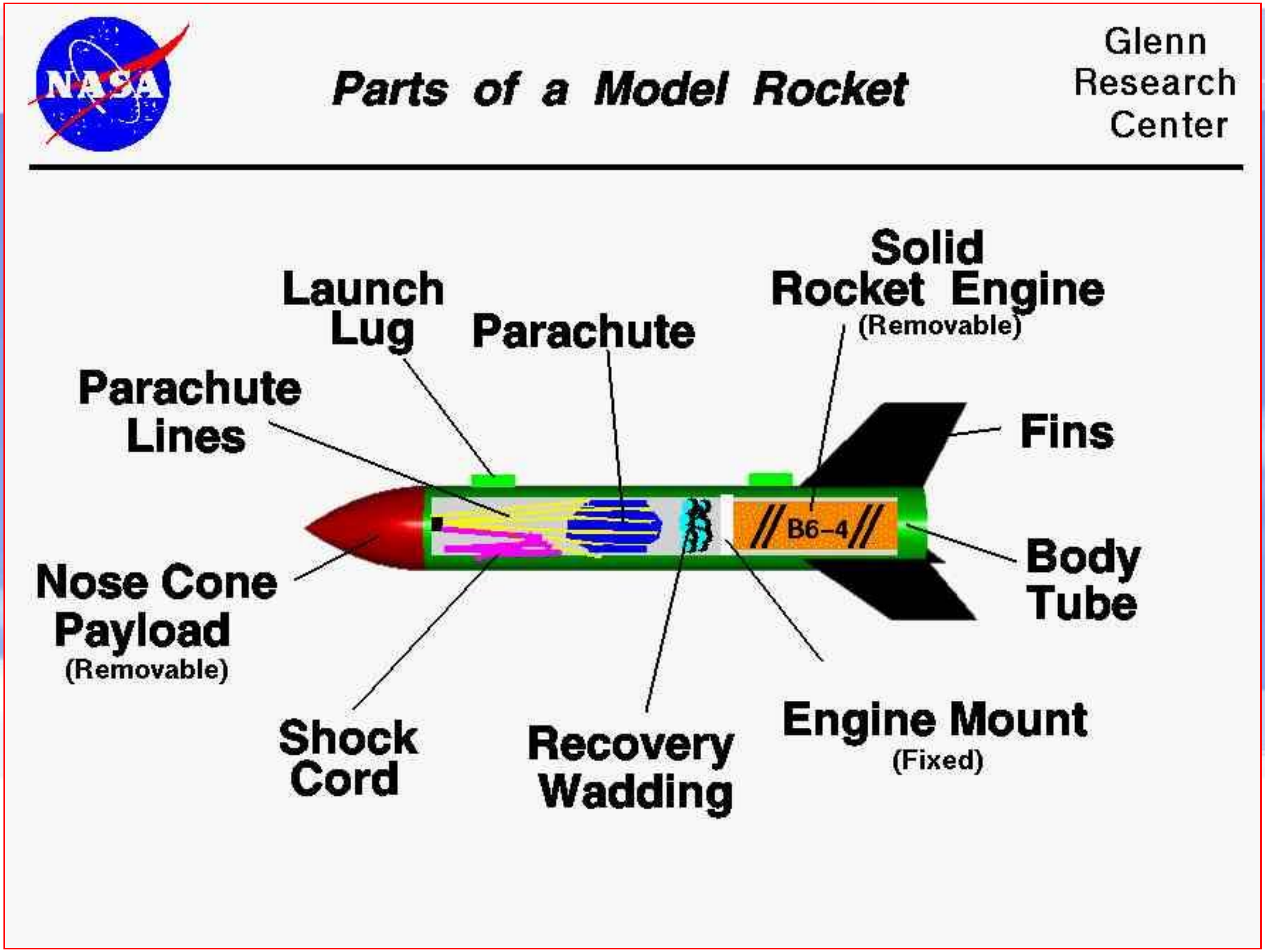
For information about TARC 2017, visit:

www.rocketcontest.org

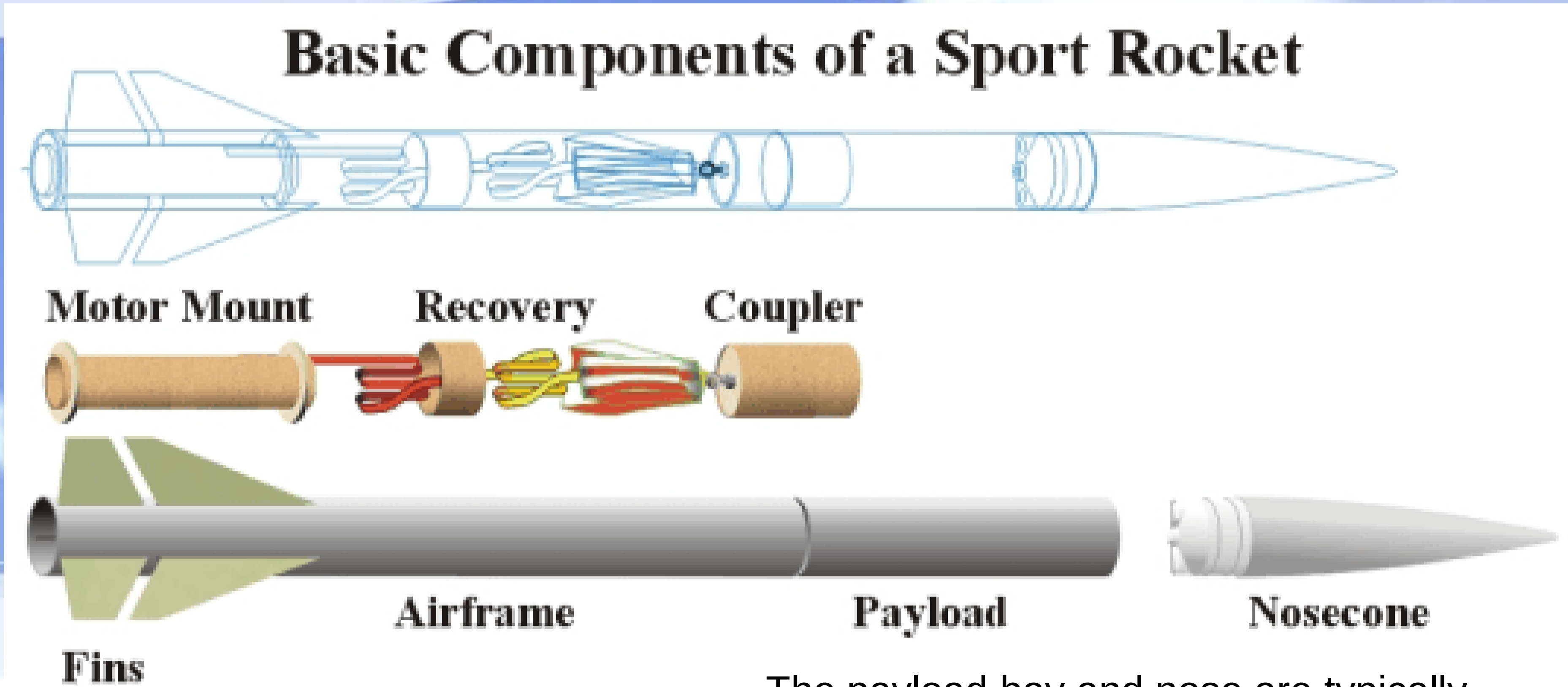
For information about rocketry, visit:

www.nar.org

Parts of a Model Rocket



Parts of a TARC Rocket

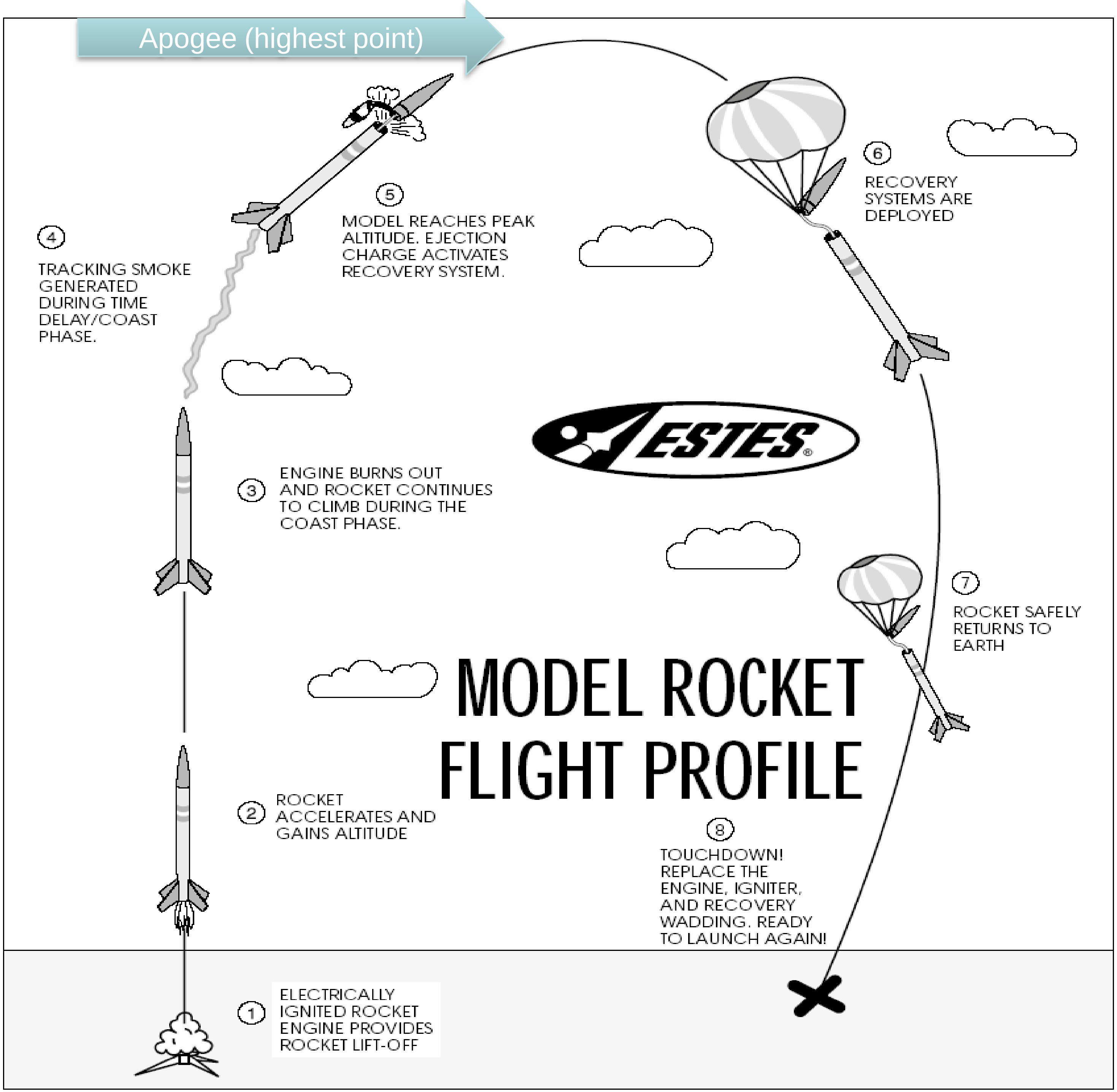


The payload bay and nose are typically used for housing the egg and altimeter.

Image courtesy of: http://www.flyrockets.com

What Are The Parts For?

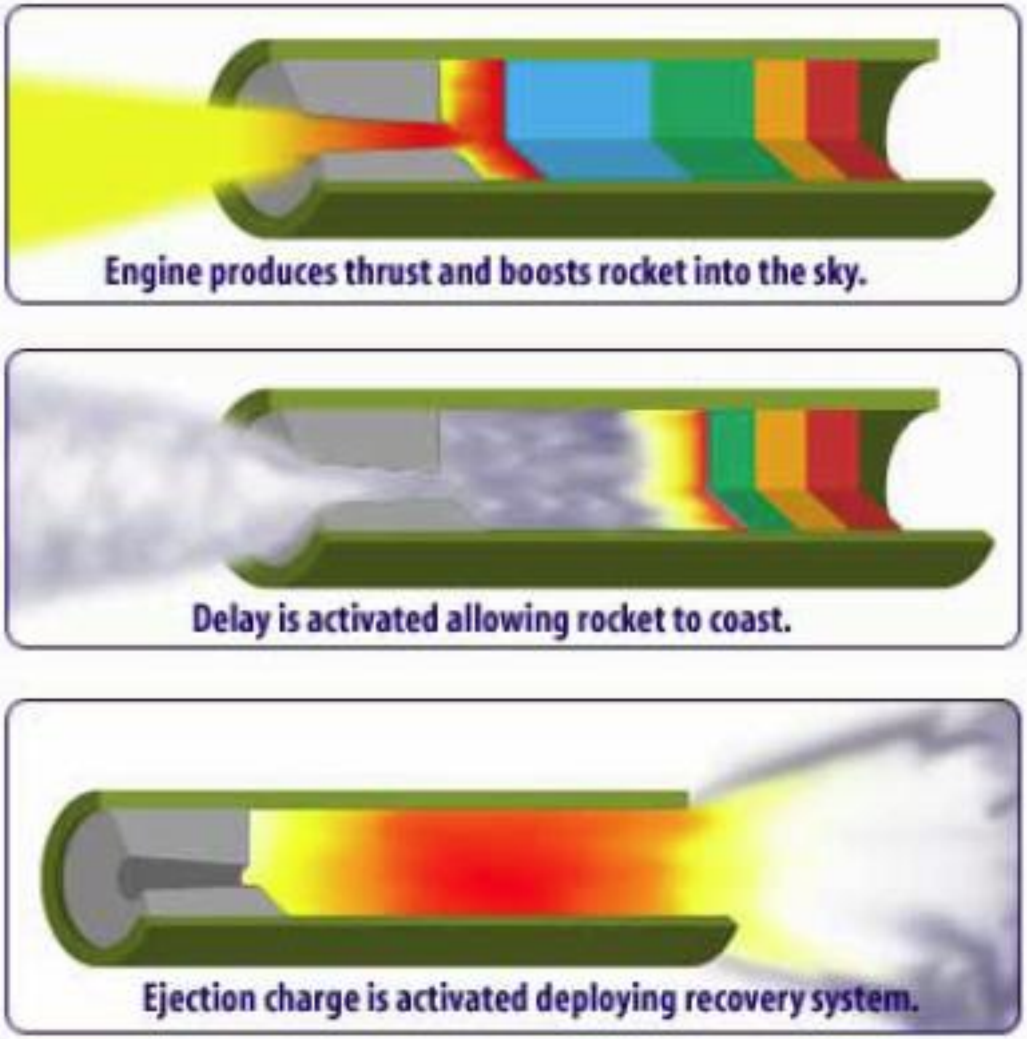
- The nose cone protects the payload and reduces drag
- The body tube holds the motor and recovery system
- The launch lug guides the rocket up the launch rod until it is flying fast enough for the fins to work
- The fins keep the rocket flying straight
- The rocket motor makes it go up
- The recovery system brings it down safely to earth


Apogee (highest point)
MODEL ROCKET FLIGHT PROFILE
ESTES
1 ELECTRICALLY IGNITED ROCKET ENGINE PROVIDES ROCKET LIFT-OFF
2 ROCKET ACCELERATES AND GAINS ALTITUDE
3 ENGINE BURNS OUT AND ROCKET CONTINUES TO CLIMB DURING THE COAST PHASE.
4 TRACKING SMOKE GENERATED DURING TIME DELAY/COAST PHASE.
5 MODEL REACHES PEAK ALTITUDE. EJECTION CHARGE ACTIVATES RECOVERY SYSTEM.
6 RECOVERY SYSTEMS ARE DEPLOYED
7 ROCKET SAFELY RETURNS TO EARTH
8 TOUCHDOWN! REPLACE THE ENGINE, IGNITER, AND RECOVERY WADDING. READY TO LAUNCH AGAIN!

The Rocket Flies Higher When...

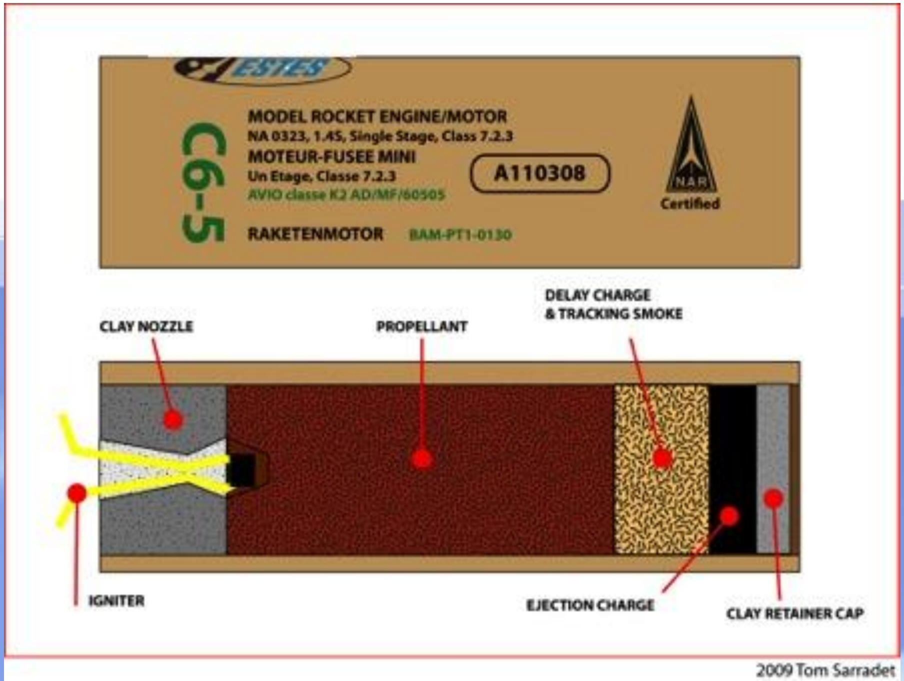
- The thrust is higher and lasts for longer
  - Motor has more total impulse
- The weight is low
- The drag is low
- It is stable and flies straight

Rocket Thrust (black powder)



Rocket Motors

- **A** – 2.5 N-sec
- **B** – 5 N-sec
- **C** – 10 N-sec
- **D** – 20 N-sec
- **G** – up to 160



- **B** – The letter indicates the **total impulse** (power) produced by the motor. Each letter increase represents doubling the power.
- **6** – The first number gives the **average thrust** of the motor in Newtons (a unit of force).
- **4** – The last number indicates the **delay seconds** between the end of thrust and the ejection charge.

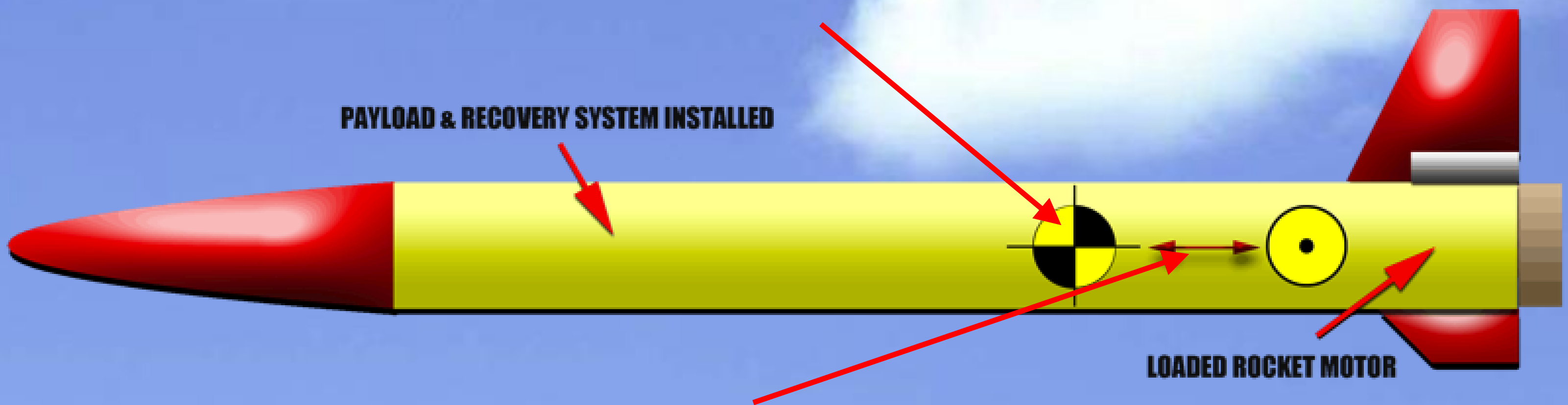
Rocket Weight

- Heavier rockets go lower with a given rocket motor than lighter rockets
- Rockets with too little motor power for their weight, or with excessively long delay times, will have bad flights

Motor Power Class	Typical Rocket Weight
1/2A	No more than 1 ounce
A	No more than 3 ounces
B	No more than 4 ounces
C	No more than 6 ounces
D	No more than 12 ounces
E	No more than 16 ounces
G	Up to 3 pounds

Rocket Stability

The **center of gravity (CG)** is where the rocket balances when loaded and ready for flight

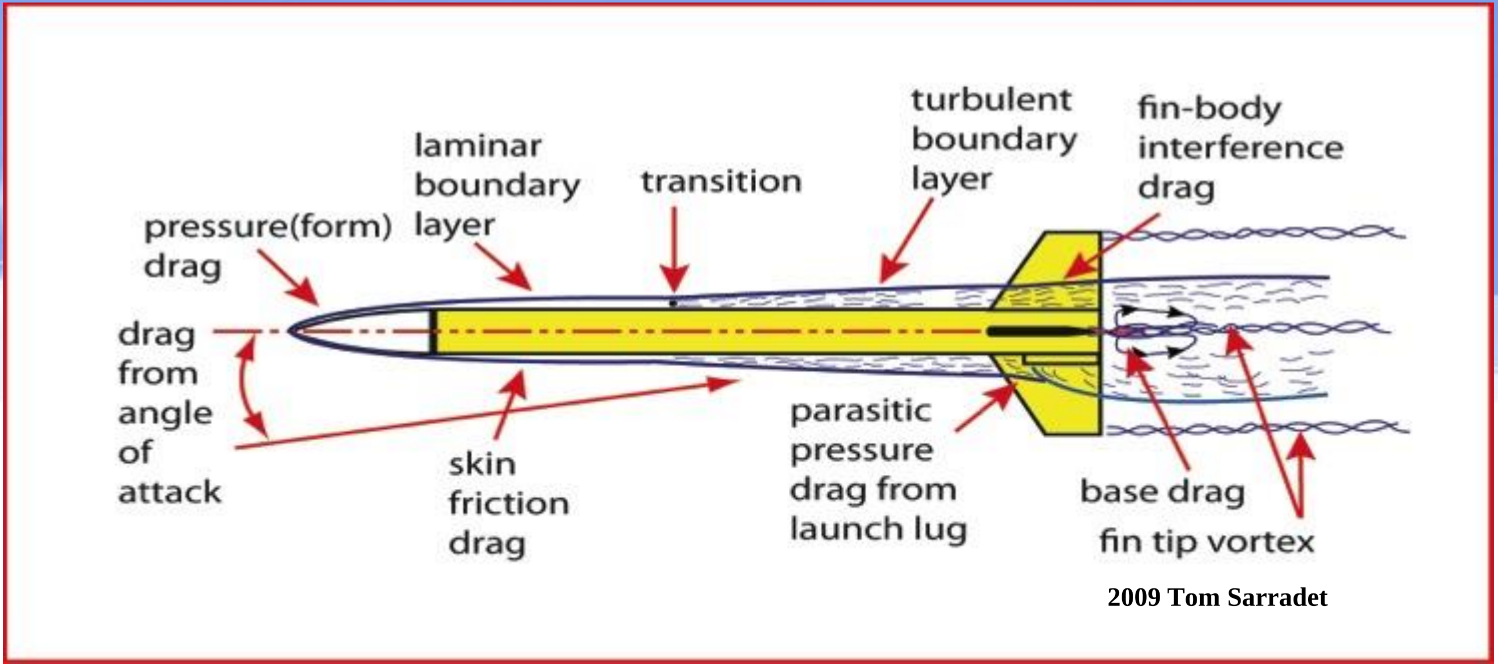


The average location of all the forces on the rocket from the passing air is called the **center of pressure (CP)**

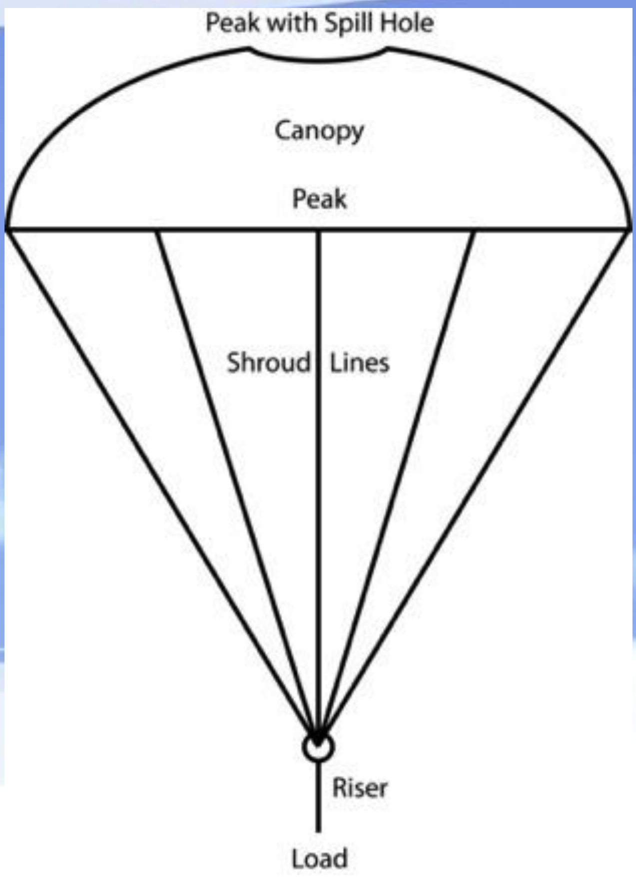
- The rocket will be stable when the CG is at least **one body tube diameter** in front of the CP
- To make a rocket stable use nose weight to move CG forward, or fin area to move CP back

Rocket Drag

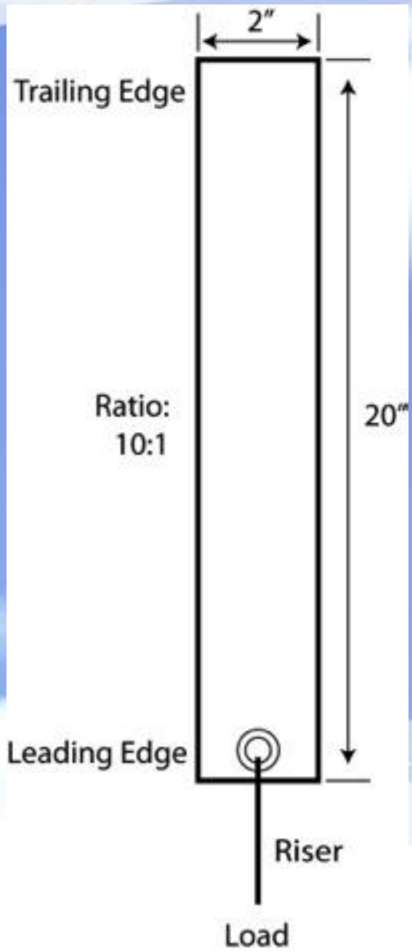
- Drag is aerodynamic friction from the flow of air over and past the surface of the moving rocket.
  - It slows the rocket down and reduces its altitude
  - It can be reduced with a smoother surface finish, smaller fins that are put on straighter, and a straight flight



Rocket Recovery



Parachute

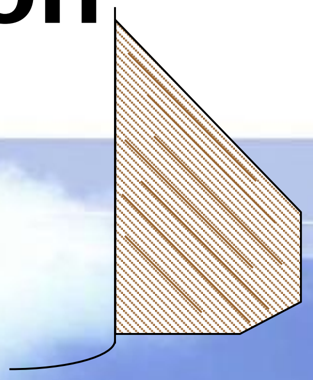


Streamer

- Rockets must have recovery devices to bring them down at safe speed
- Parachutes or streamers are usually used
- **Parachutes** are made of thin plastic; nylon cloth for heavy rockets
- **Streamers** are made of thicker plastic, or paper

Rocket Construction

- Made from paper body tubes, balsa fins, and plastic or balsa nose cones
- Building requires wood (yellow) glue, hobby (X-Acto) knives, fine sandpaper
- Wood grain and body tube spirals are filled with lightweight wood filler then sanded for surface smoothness
- Balsa wood fins must be cut with the wood grain oriented the right way
- If the fins and launch lug are glued on straight, the rocket will fly straight!



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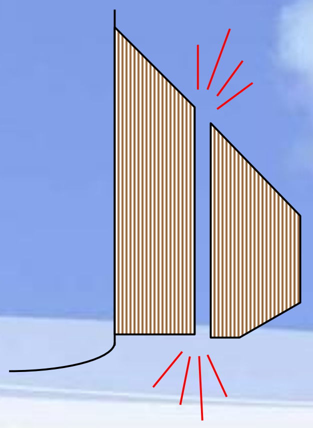
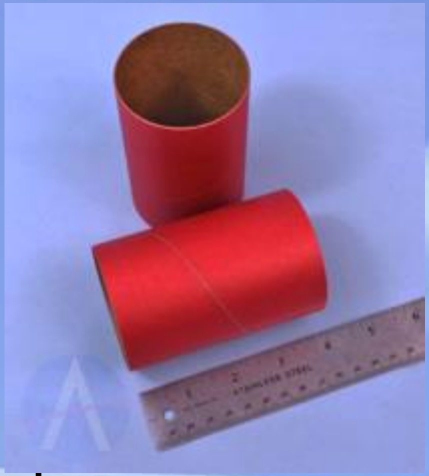


Not This...

team america rocketry challenge

Rocket Construction

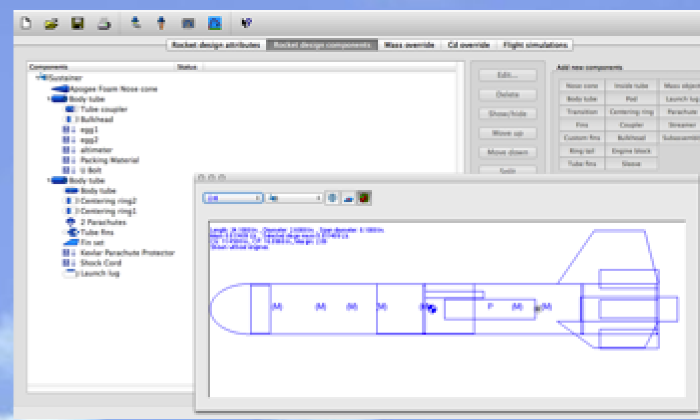


- Refer to the TARC Vendors page to get started.
- Many teams use standard BT-70, BT-80, or 3” paper body tubes, but some design their own or use fiberglass, plastic, etc.
- It is important for the teams to get an idea of which components they may want to use

Designing A Rocket

- Just as NASA doesn't build a full-scale rocket for testing, neither should your TARC team.

Begin by having students document their ideas in an engineering notebook



Next, the students should design and test their ideas inside a simulation package (refer to the TARC Vendors page)

Finally, the students should assemble their design and edit their simulation as needed

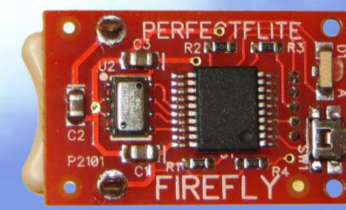
3D Technologies

- 3D CAD packages are freely available (Sketch Up, Creo, Solid Works, etc.)
- 3D printers cost as little as $500
- Many schools have invested in 3D technologies
- According to the TARC rules, as long as the students design and print the parts themselves, it is acceptable for use in the team rocket.

Launching

- Work with NAR clubs and mentors (refer to TARC website, “Documents and Forms” and the NAR website.
- Follow the NAR Safety Guidelines (Team handbook.)
- You can purchase launch systems, or make your own inexpensively.

Altimeter Use



- Three altimeters are approved for TARC:
  - FireFly (approx. $20 with discount), .12 oz, CR1025 battery, uses light to indicate maximum altitude
  - APRA (approx. $25 with discount), .56 oz, uses 12v battery
  - Pnut (approx. $45 with discount), .26 oz, built in battery, data transfer, telemetry, etc.
- Secure your altimeter, but allow air flow.
- Equal size air holes in rocket body needed
- Practice reading altitude