This booklet is written for you, the new rocketeer, to provide a source of basic information about model rocketry. The things you will want to know before, during, and after your first flights are explained to help you get the most fun from your new hobby.

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INTRODUCTION

Model rockets provide the excitement of full-scale rocket launches with safety and economy. Model rocketry had its beginning in 1958. More than thirty-five million times someone has pressed the "launch" button to start a safe and successful space mission.

No matter what your age or rocketry experience, miniature astronautics, or model rocketry as it is usually called, offers challenging activities for you. Single-stage flights just for fun get you started and help you learn the basics of the hobby. Soon you will find yourself learning all about how and why model rockets operate and accumulating a wealth of knowledge about rockets in general.

Before you know it you will be launching rockets with several stages that really work. Your rockets can be carrying payloads, too.

Making gliders which combine the fun of airplanes with the excitement of rocketry can be a rewarding challenge to your skills as a craftsman.

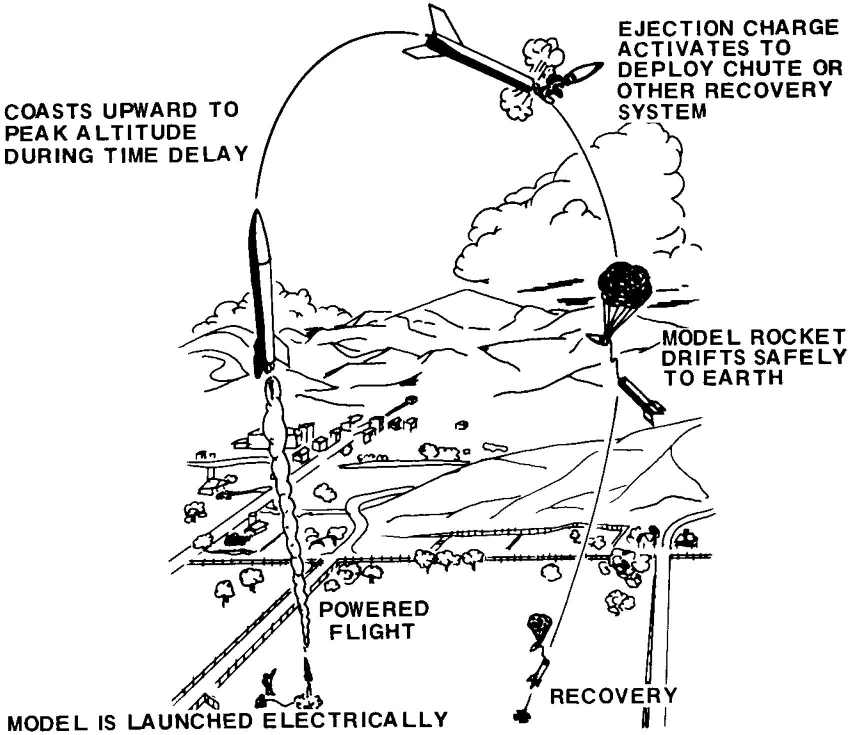
Technical reports, **Model Rocket News**, and payloads such as telemetry sensors and transmitters, cameras, and movie cameras emphasize the science involved in model rocketry. Model rocketry lets you have fun and become a rocket expert at the same time.

MODEL ROCKET FLIGHT PROFILE

From the moment you pick out your first kit you are taking off on a unique and thrilling new hobby. The time spent in carefully reading the instructions and following them reach their payoff when you put your model rocket on the pad. Your "bird", as you now familiarly think of your model rocket, is about to make its maiden voyage.

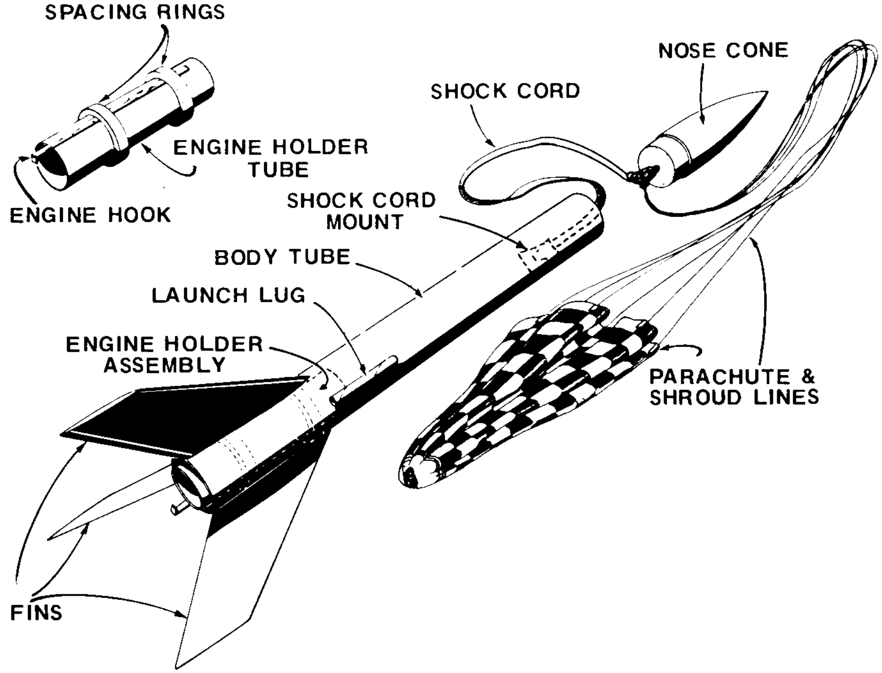
As you carefully prep your bird, attach the micro-clips to the igniter, and ready the launch control unit, you go over a checklist of critical items. When everything is "Go", you insert the safety interlock key into the control unit. Check the area . . . Sound off the verbal portion of the countdown . . . 5 . . . 4 . . . 3 . . . 2 . . . 1. Lift off!

Your bird streaks skyward on the thrust of its engine. Soon the thrust stops and smoke begins to come out of the nozzle as the delay and smoke tracking element of the engine functions. After the precise number of seconds required, the tiny ejection charge kicks out the parachute as your rocket arcs over at apogee. The parachute supports the rocket as it gently floats back to the ground.



Prep your rocket again, insert a new engine, and it's back to the launch pad for another mission.

PARTS OF A MODEL ROCKET



Model rockets vary greatly in appearance and purpose, but whether for sport and recreation or scientific experiment, most models use certain basic components. The arrangement of these components is shown in the diagram. The functions of these components is explained below.

Nose Cone.
The front end of a rocket. Usually shaped for low air resistance.

Recovery System – Parachute, shroud lines, shock cord.
Parachute slows rocket descent. Shock cord absorbs shock of parachute's opening.

Body Tube.
Basic airframe of the rocket.

Launch Lug.
Tube to guide rocket while it is still on launch rod during lift-off.

Engine Holder.
Securely holds engine in proper position during flight.

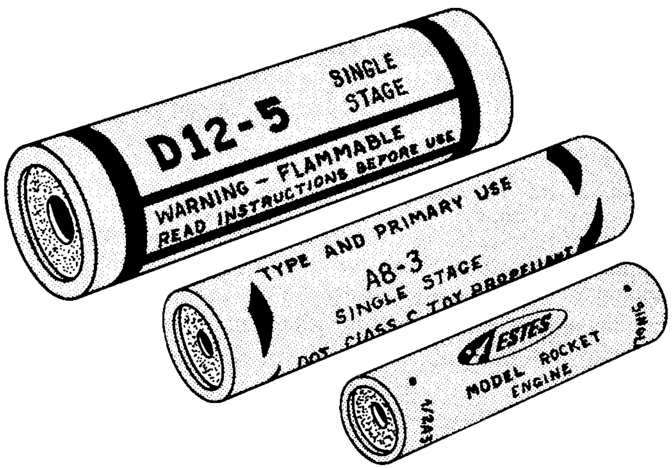
Engine.
Pre-packaged solid propellant device which provides the power for flight.

ENGINES

Model rocket engines are precision engineered and carefully manufactured power plants for model rockets. Each type of engine is designed for a specific type of mission.

Your rocket will perform best with certain engines. The recommended engines are listed on your kit instructions and with the description of your kit in the Estes catalog.

Several sizes of engines are available. The tiny T Series engines can power the Mini-Brute model rockets and many standard solid propellant model rockets when used with a suitable adapter. The "standard size" engines are used to power most model rockets. These engines can even launch some "D power" birds when used with the proper adapter. D engines are available for maximum altitude flights with the rockets which are built to accept them.



Safety, reliability, and performance are engineered into every engine. Estes Industries subjects a minimum of three percent of each production run of engines to precise tests to measure peak thrust, total impulse, duration of thrust, duration of smoke tracking and delay element's operation, and strength of ejection charge.

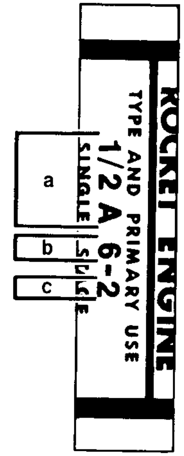
A wide variety of pre-manufactured engines is available. The 1/4A and 1/2A engines provide power for low altitude flights. The A engines provide twice the power of 1/2A engines and are fine for general flying. The B engines provide twice the total impulse of A engines. C and D engines are available for flights requiring more power.

ENGINE CODING FOR QUICK-N-EASY IDENTIFICATION

1. **Label color indicates recommended use of the engine.**

   GREEN . . . . Single stage rockets
   PURPLE & BLUE . . Top stage of multi-stage rockets
   RED . . . . . Booster and intermediate stages of multi-stage models

2. **Code designation stamped on the engine gives useful and important information on its performance capabilities.**
   a. This portion indicates total impulse or total power produced by the engine.
   b. This portion shows the engine's average thrust in newtons and helps you choose the right engine for your rocket's flight.
   c. This number gives you the delay in seconds between burnout and ejection. Lets you choose the engine with the delay time you want for any flight.

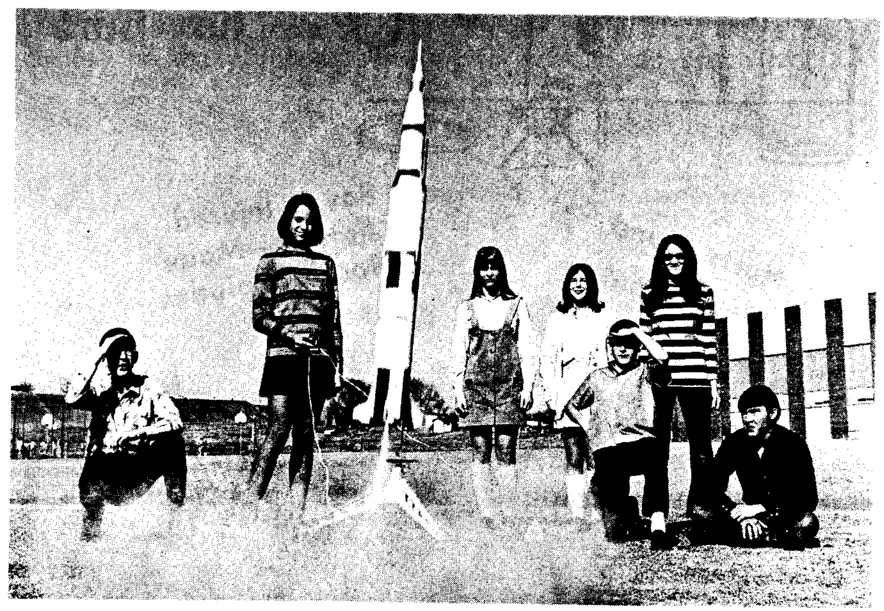


Igniters and complete instructions are included with Estes engines.

TYPES OF ROCKETEERS

Model Rocketeers

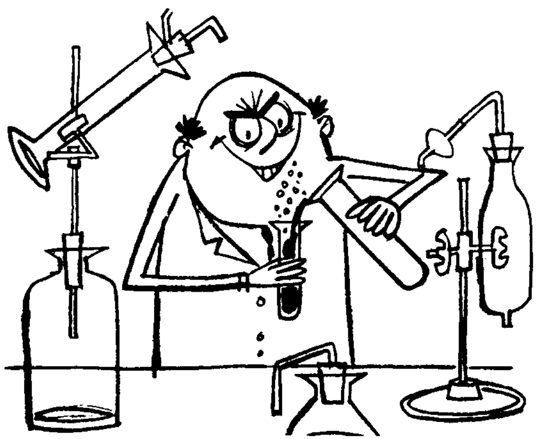
You, as a model rocketeer, are part of a "club" of one million individuals around the world who are active in this great hobby. You are able to safely launch "birds" which are capable of reaching altitudes of from 60 to 2,000 feet and can go more than 300 miles per hour.



Amateur Rocketeers ("Basement Bombers")

Amateur rocketeers make their own propellants. These propellant mixtures are often more powerful (higher specific impulse or more stored energy per ounce of propellant) than model rocket propellant, but they are not safe for use by the general public. The American Institute of Aeronautics and Astronautics about 1960 estimated that if you make your own fuel, you have one chance in seven of killing yourself or receiving a permanent injury for each year you engage in amateur rocketry. It just isn't worth it to be an amateur rocketeer. You don't have the technical training, the extensive experience, or the elaborate safety equipment necessary to safely make your own propellants, and your chances of living long enough to get these on your own are too small to make it worthwhile to be an amateur. With safety-proven, commercially manufactured model rocket engines you can do about anything you could with amateur rocketry, and you can do it in complete safety. Over thirty-five million successful model rocket launches have proven that model rocketry is a safe hobby.

JUST A FEW OF THE MANY...



Rocket explodes; boy hurt

Hurts Hand in Accident

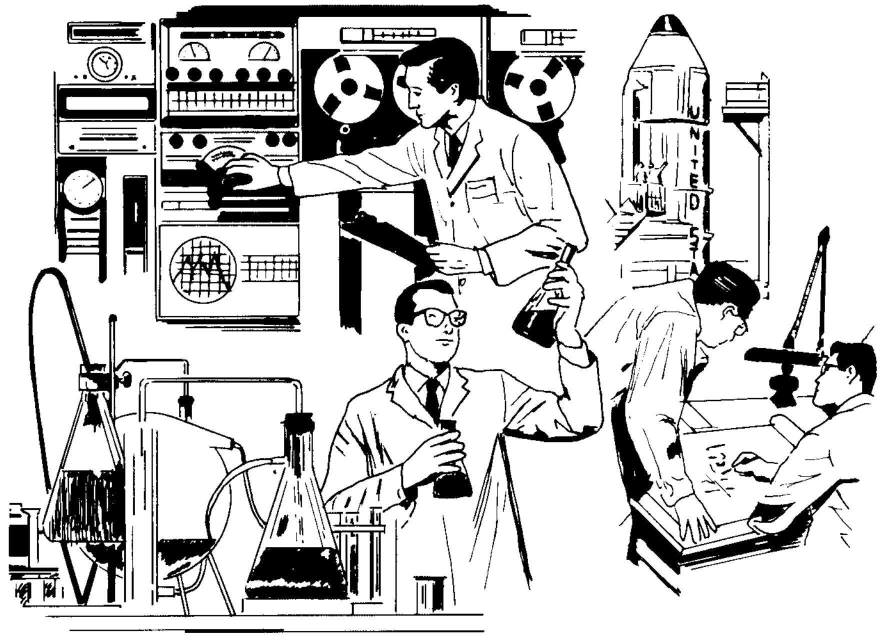
Boy, 4, Injured As Home-Made Rocket Explodes

Boy Injured Friday By Homemade Rocket Explosion

Experimental Rocket Fuel Injures Youth

Professional Rocketeers

The professional rocketeer has a good technical education and extensive experience. Many specialties such as electrical engineering, chemical engineering, and mechanical engineering are needed by NASA. Professional rocketeers use elaborate safety equipment when mixing propellant.



The craftsmanship skills, the mathematics, and the science you learn as a model rocketeer can be the beginning steps on the path to becoming a professional rocketeer. If you work hard enough, you may be lucky enough someday to work in our space program.

MODEL ROCKET SAFETY CODE

Revised 2/4/70

1. **Construction** – My model rockets will be made of lightweight materials such as paper, wood, plastic, and rubber, without any metal as structural parts.
2. **Engines** – I will use only pre-loaded factory-made model rocket engines in the manner recommended by the manufacturer. I will not change in any way nor attempt to reload these engines.
3. **Recovery** – I will always use a recovery system in my model rockets that will return them safely to the ground so that they may be flown again.
4. **Weight Limits** – My model rocket will weigh no more than 453 grams (16 ozs.) at liftoff, and the engines will contain no more than 113 grams (4 ozs.) of propellant.
5. **Stability** – I will check the stability of my model rockets before their first flight, except when launching models of already proven stability.
6. **Launching System** – The system I use to launch my model rockets must be remotely controlled and electrically operated, and will contain a switch that will return to "off" when released. I will remain at least 10 feet away from any rocket that is being launched.
7. **Launch Safety** – I will not let anyone approach a model rocket on a launcher until I have made sure that either the safety interlock key has been removed or the battery has been disconnected from my launcher.
8. **Flying Conditions** – I will not launch my model rocket in high winds, near buildings, power lines, tall trees, low flying aircraft, or under any conditions which might be dangerous to people or property.
9. **Launch Area** – My model rockets will always be launched from a cleared area, free of any easy to burn materials, and I will only use non-flammable recovery wadding in my rockets.
10. **Jet Deflector** – My launcher will have a jet deflector device to prevent the engine exhaust from hitting the ground directly.
11. **Launch Rod** – To prevent accidental eye injury I will always place the launcher so the end of the rod is above eye level or cap the end of the rod with my hand when approaching it. I will never place my head or body over the launching rod. When my launcher is not in use I will always store it so that the launch rod is **not** in an upright position.
12. **Power Lines** – I will never attempt to recover my rocket from a power line or other dangerous places.
13. **Launch Targets & Angle** – I will not launch rockets so their flight path will carry them against targets on the ground, and will never use an explosive warhead nor a payload that is intended to be flammable. My launching device will always be pointed within 30 degrees of vertical.
14. **Pre-Launch Test** – When conducting research activities with unproven designs or methods, I will, when possible, determine their reliability through pre-launch tests. I will conduct launchings of unproven designs in complete isolation from persons not participating in the actual launching.

As a member of the Estes Model Rocketry Program, I promise to faithfully follow all rules of safe conduct as established in the above code.

Signed ______________________________

This Solid Propellant Model Rocketry Safety Code Is Approved by The National Association of Rocketry and the Hobby Industry Association of America.

DEGREE OF CHALLENGE

Quite a variety of kits are available. Some kits are easy to build. A few kits involve fairly complex construction steps which require the type of craftsmanship that comes only with experience. To help you decide which kits you can build, each kit has been rated for its Degree of Challenge. The easier the kit is to build, the lower the degree of challenge number.

DEGREE OF CHALLENGE IN ASSEMBLING THE KIT:	1 = EASY 2 = FAIRLY EASY 3 = AVERAGE	4 = DIFFICULT 5 = VERY DIFFICULT

Some great beginner's kits are the Astron Alpha, the Alpha III, the Astron Mark, the Astron Sky Hook, the Astron Scout, and the Astron Big Bertha. As your model building skills improve, you can pick such sharp models as the Astron Drifter, the Astron Starlight, the Saros, and the Interceptor. Payload-carrying models such as the Astron Constellation, Astron Delta, Astron Scrambler, and the Astron Omega are very useful. The Astron Trident, the Orbital Transport, the Mars Snooper, the Mars Lander, the Arcas, the Honest John, the Saturn 1 B, and the Saturn V are challenging and rewarding models for the experienced modeler.

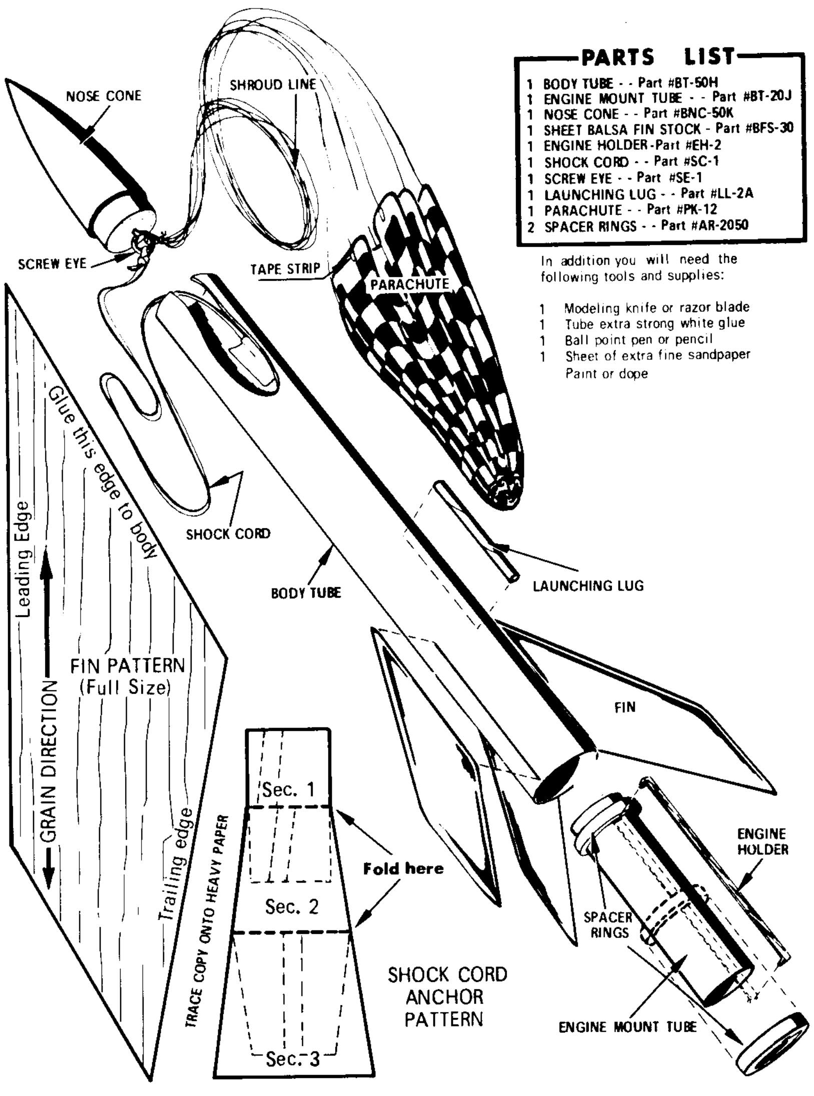
Model rocketry has something to offer everyone. High performance models are capable of high speeds and acceleration in excess of 20 g's (20 times gravity of Earth).

Whether you are building a beautiful, fully-detailed scale model of a NASA rocket such as the Saturn V, a multi-staged rocket to launch payloads to extreme altitudes, a carefully-trimmed glider, or a basic sport model, follow directions exactly and build with care. A carelessly-built model will not fly as well as one that is built the right way.

YOUR FIRST ROCKET

The construction of the Astron Alpha is shown here to illustrate the way a typical model rocket is built. The assembly techniques used in this and other model rockets are explained in greater detail on the following pages.

To build the Astron Alpha you will need the parts listed below. The Alpha is available from Estes Industries as a complete kit (Kit K-25) with detailed instructions for easy assembly. A similar model is available with plastic nose cone and plastic fins for those who wish to use a kit which takes less time to assemble.



PARTS LIST

- 1 BODY TUBE - - Part #BT-50H
- 1 ENGINE MOUNT TUBE - - Part #BT-20J
- 1 NOSE CONE - - Part #BNC-50K
- 1 SHEET BALSA FIN STOCK - Part #BFS-30
- 1 ENGINE HOLDER-Part #EH-2
- 1 SHOCK CORD - - Part #SC-1
- 1 SCREW EYE - - Part #SE-1
- 1 LAUNCHING LUG - - Part #LL-2A
- 1 PARACHUTE - - Part #PK-12
- 2 SPACER RINGS - - Part #AR-2050

In addition you will need the following tools and supplies:

- 1 Modeling knife or razor blade
- 1 Tube extra strong white glue
- 1 Ball point pen or pencil
- 1 Sheet of extra fine sandpaper
- Paint or dope

BASIC CONSTRUCTION TIPS

If you don't build your rocket right, it won't fly well! This simple statement takes some rocketeers a long time to learn. The best advice a beginner can receive and use is "FOLLOW THE DIRECTIONS".

Follow the directions **exactly** if you want your rocket to be the best! The kit designers are experts in their field. Do it their way. After you have a lot of experience, you may find ways of improving on their designs, adding little extra touches that make a fine rocket into the best rocket of its type.

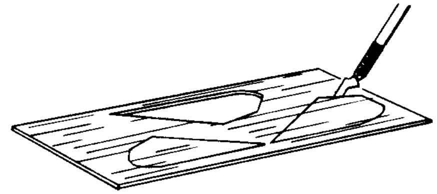
Some Basic Building Tips

1. Follow the directions exactly.

This means just what it says.

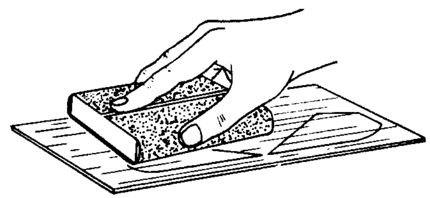
2. Cut all parts to the right size.

Always take the few extra seconds needed to make sure that all parts will fit right. Even if the parts in the kit are die-cut, test them to be sure that you can make them fit just right.



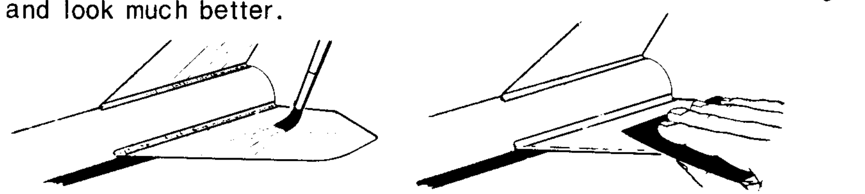
3. Sand all parts properly.

This rule sounds easy, and it is, but everyone gets in a hurry sometimes. Don't get in such a big hurry that you sand parts unevenly. While most rockets will fly OK without any sanding of the balsa parts, a good sanding job makes them look better and fly a lot better.



4. Don't be stingy with sanding sealer.

While you may not use sanding sealer on all of your sport (flying just for fun) models, learn to use several coats of sanding sealer and several sanding jobs on each balsa part. Building this way takes a little longer, but your rockets will fly a lot higher and look much better.

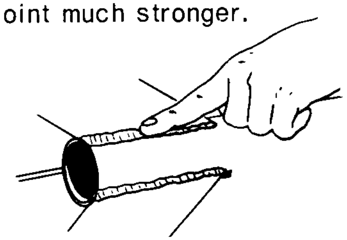


5. Use plenty of glue.

A liberal application of glue is the basis for any good joint. Ordinary white glue is best for balsa-to-balsa, balsa-to-paper, or paper-to-paper joints. When using plastic parts, use the correct type of plastic solvent or plastic cement. The kit instructions should tell you exactly what to use.

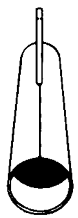
6. Apply glue fillets.

After you have made a good glue joint for each balsa and/or paper joint, let it dry thoroughly, then apply a glue fillet (thin layer of glue in joint smoothed out onto both surfaces making the joint). This makes the joint much stronger.



7. Make sure that the fins are on straight.

Unless your model is one of the few which require that the fins be mounted in an unusual way, always double-check the fin alignment for **each** fin before the glue dries on that fin.

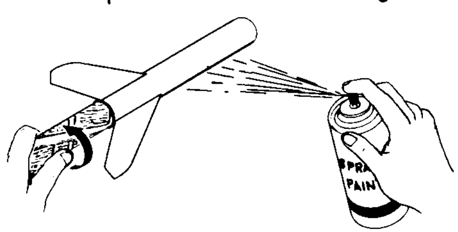


8. Check to be certain that you have done everything necessary before applying the paint.

Most of the mistakes you may make, such as forgetting to glue the launch lug in place, are fairly easy to fix before the paint is applied. After the paint goes on, the job becomes much more difficult. In addition, it is hard to paint over a repair job made after the paint has dried and not have the repair show.

9. Never apply butyrate dope over enamel paint.

It is best to use only one type of paint on a model. Spray enamel is easy to use and presents an attractive finish. Butyrate dope is inexpensive and can provide a nice-looking finish.



MODEL ROCKET PERFORMANCE

The kits, engines, and components available from Estes Industries make possible models which offer the entire performance spectrum from low altitude sport models to high performance competition rockets. Each rocketeer can achieve the exact performance he wants by careful selection of kits, engines, and other materials. The Estes catalog provides complete specifications on each item to make selections easy.

How High Will Your Model Go?

The chart below shows the approximate altitudes that can be achieved with single stage rockets.

Engine Size	Altitude Range (depending on rocket size and weight)	Approximate Altitude in a typical 1 oz. model
1/4 A3-2	50' to 250'	100'
1/2A6-2	100' to 400'	190'
A8-3	200' to 650'	450'
B6-4	300' to 1000'	750'
C6-5	350' to 1500'	1000'

(Some high performance models will reach higher altitudes than shown above.)

Chief Factors Affecting Performance

Engine: The greater the total impulse (total "power") of an engine, the higher it can send a rocket. A wide variety of engines are available for different missions.

Weight: The lighter the rocket, generally the higher it can be launched. The weight listed in the catalog for each rocket kit does not include weight of the engine. Add the weight of the engine selected to the weight of the model to determine lift-off weight. Engine weights are in the catalog.

Drag: The resistance provided by the air through which the rocket moves is drag. The greater the drag, the lower the altitude the model rocket will reach.

The greater the frontal area of a rocket, the greater the drag produced will be. Rockets with large diameters generally will not go as high as rockets of smaller diameters using engines of the same total impulse.

Smooth finishes increase the altitude performance of rockets since rough surfaces generate more air turbulence (irregular motion) and hence more drag.

Stable rockets can fly higher than unstable ones because the wobbling motion experienced by a marginally stable rocket produces drag. Careful attention to minimizing drag can greatly increase the altitude capability of a rocket.

RELIABLE RECOVERY

You do not wish to see your rocket damaged because the recovery system did not operate properly. Failures of the recovery system are nearly always due to an error in building the model or in preparing it for flight.

Most model rockets use either a parachute or a streamer as the recovery device. The most common reason for recovery system failure on these models is the ejection of the engine instead of the parachute or streamer being deployed (ejected and opened). Make certain before each flight that the engine in your rocket is securely attached. If the engine is held by an engine hook, make sure the hook holds the engine firmly in place. If the engine is held in place by friction, wrap enough masking tape around the engine to secure a tight fit when the motor is fully inserted.

Always use enough recovery wadding to protect the parachute or streamer from the hot ejection gases. The flameproof recovery wadding serves as an insulating layer between the hot ejection gases and the recovery system and works as a gas seal and piston to help the ejection gases push the parachute or streamer out of the rocket's body tube. **Loosely** insert enough flameproof wadding to fill the entire body tube for a distance equal to twice the body tube's diameter.

Remember, a well-built and properly prepared recovery system is necessary to obtain the dozens of great flights your rocket is capable of delivering.

LAUNCHING

After your rocket has been carefully built, given an attractive paint job, and tested to confirm its stability, it is ready for the big moment – **the launch!**

Launch Area

Pick a large field away from power lines, tall buildings, tall trees, or low flying aircraft and free of easy to burn materials. Always follow the safety rules.

Your launch range should be free of trees or tall bushes. Having to get your "bird" down from the only tree around (one of the common "Rocketus eatumupus" species) can take time which you would rather spend in launching.

The launch area should be large enough. Generally, the length of the shortest side of the launching field should be one-fourth of the maximum height you expect your rocket to reach.

Supplies

One of the best ways to keep all of your launching supplies together is to keep them in a range box. Some of the Estes starter sets come in durable field boxes with a handle and compartments. A variety of sturdy, all-metal range boxes are available from Estes. Select the one that fits your needs and your pocketbook.

Make a checklist of supplies that **you** want to keep in your range box. Be sure to include:

1. The electrical portion of your launch system
2. Your launch pad
3. Engines
4. Spare igniters
5. Recovery wadding
6. Glue for repairs
7. Masking tape for making sure the engines fit properly
8. The key for your launcher
9. A copy of the Estes catalog for checking which engines are OK for each rocket
10. Anything else you need

You may even have room to carry one or more rockets safely in your range box.

Make certain that your launcher is working properly (batteries OK, micro-clips clean, etc.). Be sure that you have the safety interlock key for your launcher as well as the launch rod and blast deflector plate.

Check your engines to be positive that you have the right types. Select engines from the list of those suitable for use in your rocket. Base your choices on the size of your flying field and the wind speed. The larger the field, the more powerful the engine you can select. The higher the rocket is at apogee, the longer it will take to return to the ground so the farther it can drift before touchdown. The faster the wind, up to 20 miles per hour, the less powerful the engine you select to avoid a long hike when recovering your rocket or possible loss of your rocket.

Make sure that the igniters are stored in your range box near your engines.

ESTES®
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ROCKET DESIGNERS PLAN SHEET

PARTS LIST

NOTES

NAME OF ROCKET

SCALE

DRAWN BY

DATE

ESTES®

A SUBSIDIARY OF DAMON

Model Rocket FLIGHT DATA SHEET

PUBLISHED AS A SERVICE TO ITS CUSTOMERS BY ESTES INDUSTRIES, PENROSE, COLORADO 81240

NAME

ADDRESS

CITY STATE

ZIP

USE ONE FLIGHT DATA SHEET FOR EACH MODEL
FOUR FLIGHTS MAY BE RECORDED ON EACH SHEET

SAMPLE MODEL ROCKET FLIGHT DATA SHEET

COUNTDOWN CHECKLIST

Flight #1 Flight #2 Flight #3 Flight #4	Parachute or Streamer	Flight #1 Flight #2 Flight #3 Flight #4	Feather-weight or Tumble	Flight #1 Flight #2 Flight #3 Flight #4	Boost-Glide
□□□□	12) Pack flameproof recovery wadding into the body tube. Insert the parachute or streamer.	□□□□	10) Fit the engine in the body tube carefully so that the recovery system will function properly.	□□□□	12) Check payload section (if used) and slide it into position.
□□□□	11) Install the nose cone or payload section. Check condition of the payload (if any).	□□□□	9) Install an igniter in the engine.	□□□□	11) Set trim adjustments for desired flight path and for existing weather conditions.
□□□□	10) Apply masking tape to the engine(s) to achieve a tight friction fit in the body tube(s). When launching a multi-stage rocket be sure that the engines are in their proper relative positions and that a layer of cellophane tape is wrapped tightly around each engine joint.	□□□□	8) Place the rocket on the launcher. Clean and attach the micro-clips.	□□□□	10) Check engine for proper fit in body tube.
□□□□	9) Install an igniter in the engine.	□□□□	7) Clear the area, check for low flying aircraft, alert recovery crew and trackers.	□□□□	9) Install an igniter in the engine.
□□□□	8) Place the rocket on the launcher. Clean and attach the micro-clips.	□□□□	6) Arm the launch panel.	□□□□	8) Place the rocket on the launcher. Clean and attach the micro-clips.
□□□□	7) Clear the area, check for low flying aircraft, alert recovery crew and trackers.	□□□□	5)	□□□□	7) Clear the area, check for low flying aircraft, alert recovery crew and trackers.
□□□□	6) Arm the launch panel.	□□□□	4)	□□□□	6) Arm the launch panel.
□□□□	5)	□□□□	3)	□□□□	5)
□□□□	4)	□□□□	2)	□□□□	4)
□□□□	3)	□□□□	1)	□□□□	3)
□□□□	2)	□□□□	LAUNCH!	□□□□	2)
□□□□	1)			□□□□	1)
□□□□	LAUNCH!			□□□□	LAUNCH!

Flight Numbe	
Date of Launc	
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Payload	Descr
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	3rd S
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Humidity
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Visibility
Remarks

Altitude	Estima
	Track Informa
	Compute
Flight Duratio	
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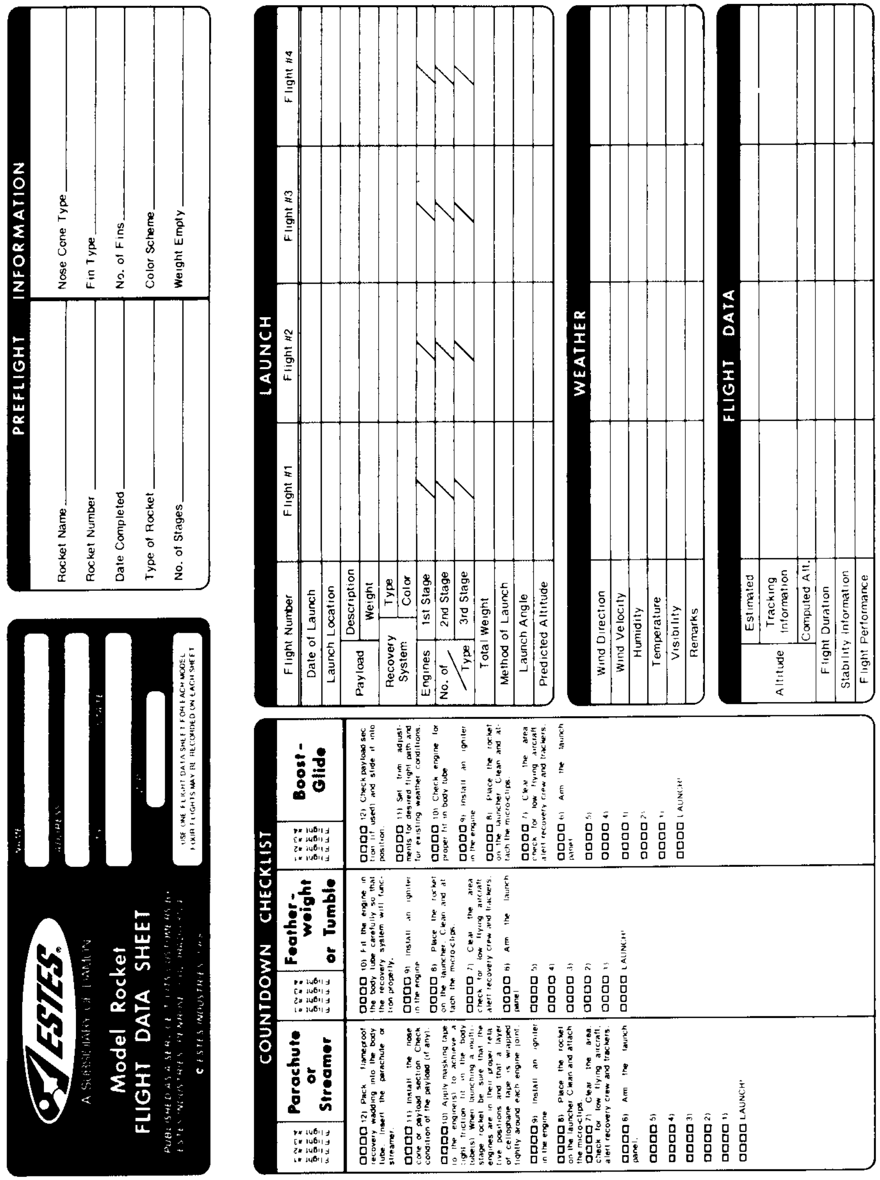
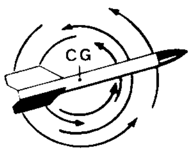


STABILITY

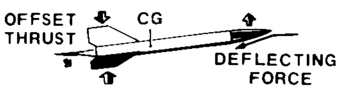
One of the first things a model rocket designer learns is that a vehicle will not fly unless it is **aerodynamically stable**. By stable we mean that it will tend to keep its nose pointed in the same direction throughout its upward flight. Good aerodynamic stability will keep the rocket on a true flight path even though some force (such as an off-center engine) tries to turn the model off course.

If a model is not stable, it will constantly turn its nose **away** from the intended flight path. As a result, it will try to go all over the sky, but end up going "nowhere". An unstable rocket will usually tumble to earth after the engine burns out, damaging the model and being a potential hazard to spectators.

When a free-flying object rotates, it always rotates around its balance point. (The proper term for the balance point is the **center of gravity**, abbreviated as C.G.) Thus, the balance point (C.G.) is the pivot for all forces trying to turn the rocket.

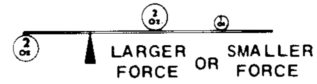


The thrust of the engine, the action of air on the fins, and the action of air on the nose are the most significant forces affecting the path of a rocket in flight. If the thrust of the engine is not in line with the axis of the rocket (as would result from the engine mount not being centered), this force would try to push the rocket to one side instead of straight forward. This can start the rocket tumbling in mid-air. A lateral (sideways) force on the nose cone, as could be caused by a poorly-made nose cone, a nose cone which is mounted crooked, or a wind from one side, also tends to cause the rocket to go to one side instead of forward. These forces are opposed by the aerodynamic forces acting on the fins. These corrective forces tend to keep the rocket moving forward in its proper flight path. The farther away from the center of gravity the forces act, the greater is their effect.



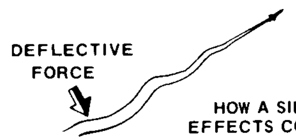
FORCE ACTING ON FINS OPPOSES OTHER FORCES

As long as the forces on the fins of the rocket are great enough to counteract the forces on the nose and any off-center thrust, the rocket will fly straight. If the fins are too small and/or too close to the center of gravity, there will not be enough force to counteract the force on the nose. As a result the nose will swing out to the side, and the model will try to chase itself around the sky.



(small force x long distance = large force x small distance)

The model rockets which you build from kits will be stable if you follow the instructions carefully. You should learn to test your model rocket for stability, however, to detect such construction errors as fins on wrong so that you will be skilled at it when you test the rockets you build from your own designs. Learning to design your own model rocket is not hard, but should be done with care so the rockets will perform well and will be safe fliers. Study Estes Industries Technical Reports TR-1, "Rocket Stability", and TR-9, "Designing Stable Rockets", before beginning to design your own rockets.

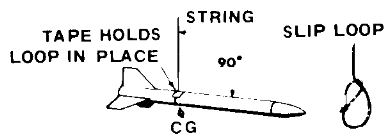


HOW A SIDE FORCE VISIBLY EFFECTS COURSE OF NORMALLY STABLE ROCKET

TESTING FOR STABILITY

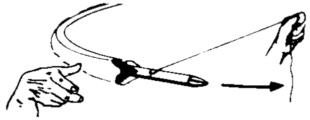
The easiest way of testing the stability of a model is to fly it – without launching it. This is done by attaching a string to the model and swinging it through the air. If the string is attached at the rocket's CG (center of gravity), its behavior as it is swung through the air will indicate what it will do in powered flight.

Make the test on your model by forming a loop in the end of a six to ten foot string. Install an engine in the rocket. (The center of gravity is always determined with an engine in place.) Slide the loop to the proper position around the rocket so the model balances horizontally. Apply a small piece of tape to hold the string in place.



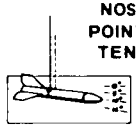
With the rocket suspended at its center of gravity, swing it overhead in a circular path. If the rocket is very stable, it will point forward into the wind created by its own motion. Some rockets which are stable will not point forward of their own accord unless they are started straight. This is done by holding the rocket in one hand with the arm extended and then pivoting the entire body as the rocket is started in the circular path. It may take several attempts before a good start is achieved.

"STARTING" A BIRD



If it is necessary to hold the rocket to start it, an additional test should be made to determine whether the model is stable enough to fly. Move the loop **back** on the body until the tube points down at a 10° angle **below** the horizontal. Repeat the swing test. If the model will keep its nose pointed ahead once started, it should be stable enough to launch.

DOUBLE CHECK A BIRD WITH QUESTIONABLE STABILITY AS FOLLOWS:



MOVE STRING BACK 'TILL NOSE OF BIRD POINTS DOWN AT TEN DEGREES – REPEAT THE SWING TEST

BIRD SHOULD STILL "FLY" NOSE FORWARD

Be careful when swinging a rocket overhead: A collision with a nearby object or person could be serious. Always do your testing in an open, uncluttered area.

Don't try to fly a rocket that has not passed the stability test. Most unstable rockets loop around in the air harmlessly. However, a few marginally unstable models will make a couple of loops and then become stable due to the lessening of the propellant load. When this happens, the model can crash into the ground at high speed. A person standing in the wrong place could get hurt.

If your rocket does not pass the stability test, it can usually be made stable. Two methods can be used: The balance point can be moved forward, or the fins can be enlarged. To move the balance point forward, attach nose cone weights to the base of the nose cone. Fins can either be replaced with larger ones or extra tabs can be glued to the rear or tip edges of the fins. (Some scale models use supplementary plastic fins.) After making your changes, test the model again to be sure it is now stable.

Refer to Technical Report TR-3 for additional information on stability.

ADD A NOSE CONE WEIGHT . . .

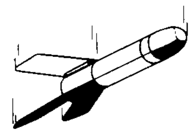
. . . OR ADD A TAB TO EACH FIN

RECOVERY SYSTEMS

The recovery system is one of the most important parts of a model rocket. It is designed to provide a safe means of returning the rocket and its payload to earth without damaging the rocket or presenting a hazard to persons on the ground. Also, the recovery system provides an area for competition when rocketeers hold contests to see whose rocket can remain aloft the longest. In addition, rocket recovery is an area for valuable experimentation and research as rocketeers develop new and better methods of returning their models gently to earth.

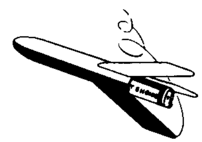
Most recovery systems in use today depend on aerodynamic drag to slow the rocket. Each changes the model from a streamlined object to one which the air "supports" to retard its descent. Six basic recovery methods are used by model rocketeers. Following is a brief description of each.

1. Featherweight Recovery
   (example: Astron Streak)



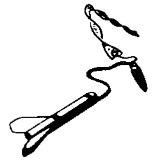
The model is very light (usually under 1/4 ounce without engine) and has a blunt nose. It is designed to be so light after the engine is ejected that it presents no hazard as it descends. The rocket is so light (after the engine is ejected) in relation to its size that it gently flutters to the ground. The spent engine is light in weight and aerodynamically unstable so it tumbles back to the ground unless a streamer is attached to it to further slow its descent.

2. Tumble Recovery
   (example: Astron Scout)

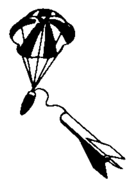


The force produced by the ejection charge pushes the engine backwards. The weight of the engine is then so far to the rear that the rocket is not stable and starts tumbling. This shift to the rear causes the center of balance (center of gravity) to be behind the center of pressure (point about which all of the aerodynamic forces appear to be centered). The tumbling motion of the rocket produces extremely high drag on the rocket so it falls slowly. Estes Patent Number 3,114,317.

3. Streamer Recovery
(example: Astron Mark II)



A streamer creates enough drag to keep the rocket from falling very fast. The larger the streamer, the slower is the descent of the rocket. Streamers can bring back a rocket gently without the long sideways drift with the wind which may occur with a parachute and a light model.



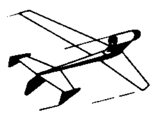
4. Parachute Recovery
(example: Astron Alpha)

The parachute is pushed out of the body tube by the action of the ejection charge. The parachute fills with air and creates tremendous drag. Since the rocket is attached to the parachute, the rocket floats back to the ground very gently.

5. Helicopter Recovery
(example: Astron Gyroc)

Vanes on the model are activated by the ejection charge. The vanes catch the air in a way that makes the rocket spin as it falls. This spin creates high drag which keeps the rocket from falling very fast.

6. Glide Recovery
(example: Astron Falcon)



A boost-glider is launched like a conventional rocket. The ejection charge causes the model to convert into a glider. The power unit (booster) may come down separately (as with a parachute) or may remain attached to the glider. The wings of the glider generate lift to cause the model to glide through the air rather than falling. Estes Patent Number 3,157, 960.

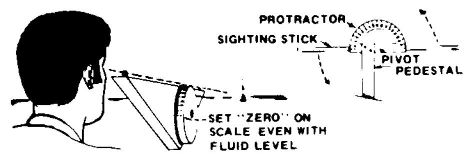
TRACKING

Every rocketeer wants to know how high his models fly. Many methods of determining a model's peak altitude have been tried, but only one method has proven itself. This method is known as triangulation.

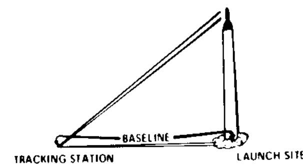
The simplest form of triangulation uses only one very simple tracking device. With it, the rocketeer measures the angle between the rocket on the launch pad and the line of sight to the rocket at its peak altitude. When this angle and the distance from tracker to launcher are known, it is very easy to determine the altitude.

The Estes Altiscope is one of the best, all-around, basic tracking devices.

When the operator at the tracking station is ready, the rocket is launched. He follows the rocket with his tracker as it rises. When it reaches its peak altitude he stops or locks the tracker. The indicated angle is then read from the protractor scale.



"ZEROING" IN ON THE ROCKET
WITH AN ALTISCOPE



The tangent of this angle is found by checking the tangent table.

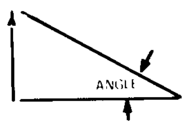
TABLE OF TANGENTS

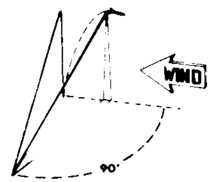
Angle	Tan.	Angle	Tan.	Angle	Tan.	Angle	Tan	Angle	Tan.
1°	.02	17	.31	33	.65	49	1.15	65	2.14
2	.03	18	.32	34	.67	50	1.19	66	2.25
3	.05	19	.34	35	.70	51	1.23	67	2.36
4	.07	20	.36	36	.73	52	1.28	68	2.48
5	.09	21	.38	37	.75	53	1.33	69	2.61
6	.11	22	.40	38	.78	54	1.38	70	2.75
7	.12	23	.42	39	.81	55	1.43	71	2.90
8	.14	24	.45	40	.84	56	1.48	72	3.08
9	.16	25	.47	41	.87	57	1.54	73	3.27
10	.18	26	.49	42	.90	58	1.60	74	3.49
11	.19	27	.51	43	.93	59	1.66	75	3.73
12	.21	28	.53	44	.97	60	1.73	76	4.01
13	.23	29	.55	45	1.00	61	1.80	77	4.33
14	.25	30	.58	46	1.04	62	1.88	78	4.70
15	.27	31	.60	47	1.07	63	1.96	79	5.14
16	.29	32	.62	48	1.11	64	2.05	80	5.67

Multiply the tangent by the distance from tracker to launcher (baseline distance) to find the altitude.

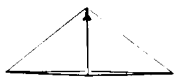
For example, if the angular distance was 30° at apogee, and the baseline was 200 feet long, the rocket reached a height of 116 feet (0.58 x 200 ft.).

A single tracker will give best results on calm days. Wind interferes with accuracy since models tend to tilt over into the wind as they fly. The result is that the rocket will not be straight over the launch site at peak altitude, but instead will be some distance over in the direction of the wind. To keep error due to wind drift to a minimum, locate the tracker at a 90° angle to the wind direction as shown.





In determining where to locate a tracking station, estimate the altitude your model will reach. The tracking station should be approximately this distance from the launcher (usually 500 to 1,000 feet). Measure the distance from launcher to tracker carefully to insure accurate altitude calculations.



More elaborate tracking systems and more elaborate mathematics can be used to gain greater accuracy when the rocket doesn't fly straight up. However, a simple tracking system will do the job very well when good models are flown on calm days. More complete information on basic altitude tracking and tracking systems is contained in Estes Industries Technical Report TR-3, "Altitude Tracking".

MULTISTAGING

Rockets are staged so that the payload can reach a high altitude. Using two engines, one after the other, permits a rocket to go higher than would be possible if only one engine (twice as powerful) were used. This is true because the first stage (engine, body tube, engine holder, and fins) drops off as soon as its propellant is used up and the second stage engine is ignited. Removing the first stage reduced the weight and drag which the second engine must overcome. The second engine starts functioning while the rocket is high in the air and moving fast.

The first stage of a multi-stage rocket is always ignited by standard electrical means. Second stage ignition occurs automatically upon burnout of the first stage. Figure 1A shows that the first stage engine has no delay or ejection charge. This gives instant ignition of the next stage at burnout.

FIG. 1A

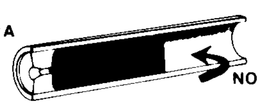
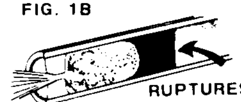
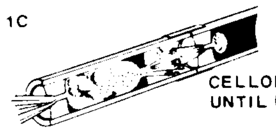


FIG. 1B



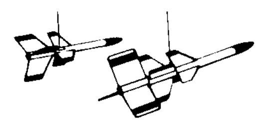
In figure 1B the propellant is partially burned, leaving a large combustion chamber. As the propellant continues to burn, the wall of propellant becomes thinner until it cannot withstand the high pressure inside the chamber. At this point the remaining propellant wall ruptures, and the high pressure exhausts forward toward the nozzle of the next stage, carrying hot gases and small pieces of burning propellant into the nozzle of the second stage engine. This action is illustrated in figure 1C.

FIG. 1C



For this multi-staging system to work, the stages should be held together until the upper stage engine has ignited. When this happens, the stages must then separate in a straight line.

Since two or more engines are mounted near the rear of a multistage rocket, it has a tendency to be tail-heavy. To compensate for this, extra large fins are used on the lower stage. Generally, the lower set of fins on a two-stage rocket should have two or three times the area of the upper set. Each additional stage requires even greater fin area.



When checking for stability, test first the upper stage alone, then add the next lower stage and test, and so on. In this way you can be sure that the rocket will be stable in each step of its flight, and you can locate any stage which does not have sufficient fin area. Always check for stability with the largest engines to be used in place.

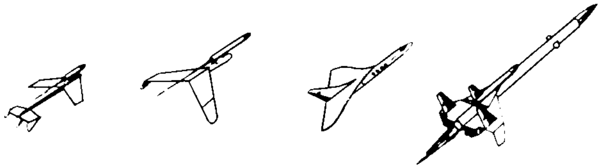
Lower and intermediate stages always use engines which have no delay and tracking charge, and no parachute ejection charge. There is no delay so that the next stage will receive the maximum velocity from its booster. The engines which are suitable are those which have designations ending in zero, such as the 1/2A6-0, A8-0, and B14-0.

In the upper stage an engine with a delay and tracking charge, and parachute ejection charge is used. As a general rule the longest possible delay should be used. Engines suitable for upper stage use are those with long delays such as the B6-6, A8-5, C6-7, etc.

BOOST GLIDERS

Boost-gliders are models which fly straight up like any other rocket. They glide back to earth, however, instead of coming down suspended from a parachute.

There are several types of boost-gliders. Conventional front engine, conventional rear engine, parasite rocket-glider, and flop-wing gliders have been built.



Although these types appear very different, many of the same principles apply to all. A boost-glider, as any other rocket, must be stable to fly upward. Estes Industries Technical Reports TR-4, ''Rear Engine Boost-Gliders'', and TR-7, ''Front Engine Boost-Gliders'', provide much additional information on this exciting area of model rocketry.

Few models are as spectacular in flight and as enjoyable to watch as a good boost-glider. The rocketeer looking for a challenge will find that developing improved boost-glide designs is one of the most rewarding areas of research in model rocketry.

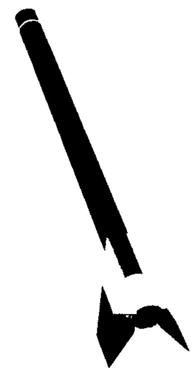
Since most boost-gliders require good craftsmanship and careful attention to detail, you should build and launch several basic model rockets before entering this challenging area.

SCALE MODELS

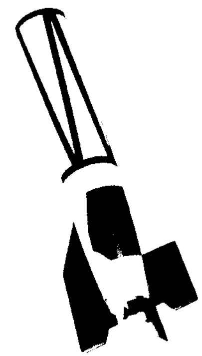
Scale models are, to many rocketeers, the ultimate in rocketry. Whether you agree with this or not, scale models are a lot of fun. They not only look sharp, they provide an excellent way to practice good craftsmanship. There's fun for everyone from the ''by-the-numbers'' kit builders to the real ''pros'' who scale their models ''from scratch''.

Examine these photos of some of the sharp Estes scale models and pick out the rocket you want to make next. Even if you are too proud of it to fly it, it will look great as the star of your fleet.

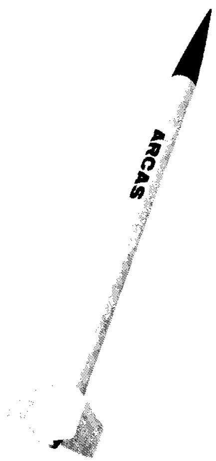
WAC CORPORAL
CAT. NO. K-11



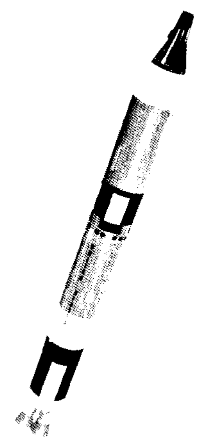
SANDHAWK
CAT. NO. K-51



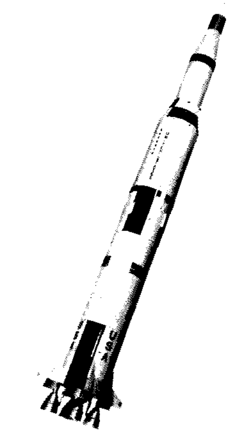
V-2
CAT. NO. K-22



ARCAS
CAT. NO. K-26



GEMINI-TITAN
CAT. NO. K-21

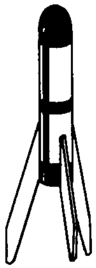


SATURN V
CAT. NO. K-36

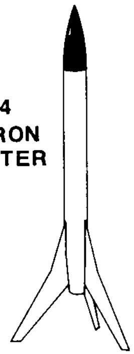
ADVANCED PROJECTS

Building and launching your first "bird" is fun! After this you are ready to move on to greater things. The logical next step is to build another basic kit (Degree of Challenge: 1). Building and launching these rockets is fun, and it helps you improve your skills as a modeler. It also helps you build up your fleet.

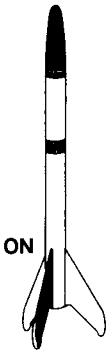
When you are ready, build a more advanced rocket. If your taste is for sharp little rockets, try the Astron Streak. The Astron Drifter is a great performance bird for competition in altitude or parachute duration, or for fine sport flying. The Astron Constellation is a sharp-looking payload bird.



K-4
ASTRON STREAK

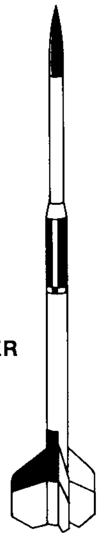


K-14
ASTRON
DRIFTER

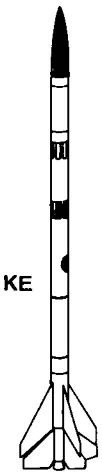


K-35
ASTRON
CONSTELLATION

If you prefer to go right into multi-stage rockets, build the great Astron Avenger (32 inches of altitude-seeking rocket) or the Astron Shrike, a great payload bird with pop-and-go staging.

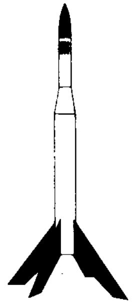


K-38
ASTRON AVENGER

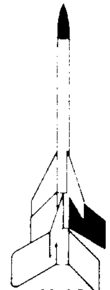


K-46
ASTRON SHRIKE

Building the powerful Astron Cobra payloader can be your entry into a cluster-power modeling. Far-out multi-staging can be achieved with the Astron Farside. Scale models such as the Aerobee 300, WAC Corporal, or the 30 inch long beauty, the Sandhawk, are a lot of fun to build and fly, and provide good practice for improving your craftsmanship skills.



K-10
ASTRON COBRA



K-12
ASTRON
FARSIDE

K-17
AEROBEE 300

K-11
WAC
CORPORAL

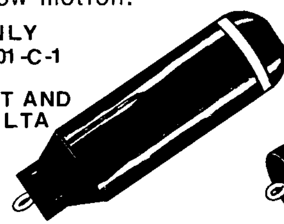
K-51
SANDHAWK

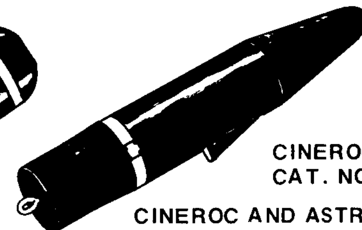
If you really want to become an expert model rocketeer, follow the steps suggested in Technical Report TR-8, "Model Rocketry Study Guide". This publication gives step-by-step guidance for learning terms, gaining construction skills, and achieving an understanding of the science principles involved in model rocketry. In addition, periodic practice tests are provided to let you check on your improvement. A comprehensive record sheet is provided for you to use in checking your progress. At the completion of the program you can take a special test to earn your official "Expert Rocketeer" certificate.

A single exposure camera, the Camroc, which takes black and white photographs can get you started in aerial photography. The Cineroc lets you take thrilling Super 8 color movies of each flight in semi-slow motion.

CAMROC ONLY
CAT. NO. 701-C-1

CAMROC KIT AND ASTRON DELTA ROCKET
CAT. NO. 701-RC-1





CINEROC ONLY
CAT. NO. 701-CM-8

CINEROC AND ASTRON OMEGA
CAT. NO. 701-RC-8

Temperature measurements of the atmosphere are only one of the scientific experiments which you can conduct with the Estes Transroc. This miniature telemetry transmitter can also transmit a beacon signal, measure and report light intensity changes (useful as a roll-rate sensor), or sounds as heard on board the rocket.

CLUBS AND CONTESTS

Flying your rockets with a friend can make model rocketry even more fun. With two, rocketry is twice the fun.

In addition to letting you take part in twice as many launches, having a fellow rocketeer lets you share ideas. You will be helping each other, and soon you may be in friendly competition with each other.

Others will see how much fun you are having and may try to join you. If you want it, soon you will have a club. Then you can have a real contest. As your club gets bigger, you may feel that you are ready to take on another club in a big meet.

"Model Rocket Contest Guide", a 16 page booklet published by Estes Industries, has many good ideas to help you put on a great contest. Ideas for getting publicity for the contest are included. It even provides rules for a wide variety of events.

ESTES MODEL ROCKET
CONTEST GUIDE
CAT. NO. BK-17

"Guide for Aerospace Clubs", another fine Estes publication of 29 pages, provides all the information you need to start a really good club and keep it going. You will never run out of ideas with this book to help you.

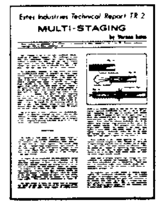
ESTES GUIDE FOR
AEROSPACE CLUBS
CAT. NO. BK-19

SCIENCE PROJECTS

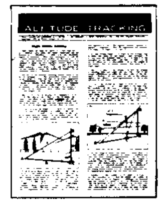
Your best ideas deserve to be shared. Why not enter them in the Design of the Month Contest? Full details on this contest can be found in your current Estes catalog. Enter each of your best ideas. You may win a prize. Many of the best ideas are published by Estes so others can benefit from them.

And don't forget the tremendous variety of science projects possible involving model rocketry. Anything from a simple explanation of how a model rocket engine works, done as an assignment, to a full scale research project involving aerodynamic studies, model rocket engine performance analysis, and/or optimization of a payloader design is possible. The list of things you can do is endless. Just remember to do your best on the one **you** choose.

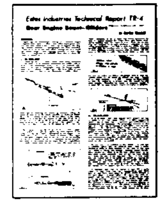
ROCKET STABILITY
CAT. NO. 651-TR-1



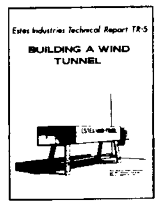
MULTI-STAGING
CAT. NO. 651-TR-2



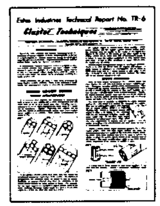
ALTITUDE TRACKING
CAT. NO. 651-TR-3



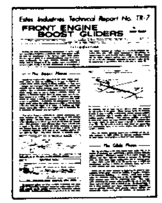
REAR ENGINE BOOST-GLIDERS
CAT. NO. 651-TR-4



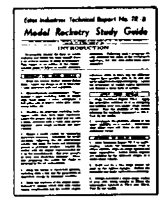
BUILDING A WIND TUNNEL
CAT. NO. 651-TR-5



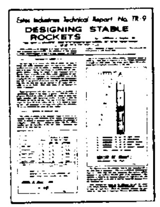
CLUSTER TECHNIQUES
CAT. NO. 651-TR-6



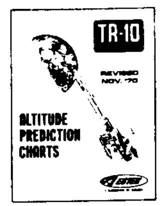
FRONT ENGINE BOOST-GLIDERS
CAT. NO. 651-TR-7



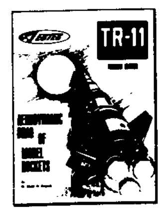
MODEL ROCKETRY STUDY GUIDE
CAT. NO. 651-TR-8



DESIGNING STABLE ROCKETS
CAT. NO. 651-TR-9



ALTITUDE PREDICTION CHARTS
CAT. NO. 711-TR-10



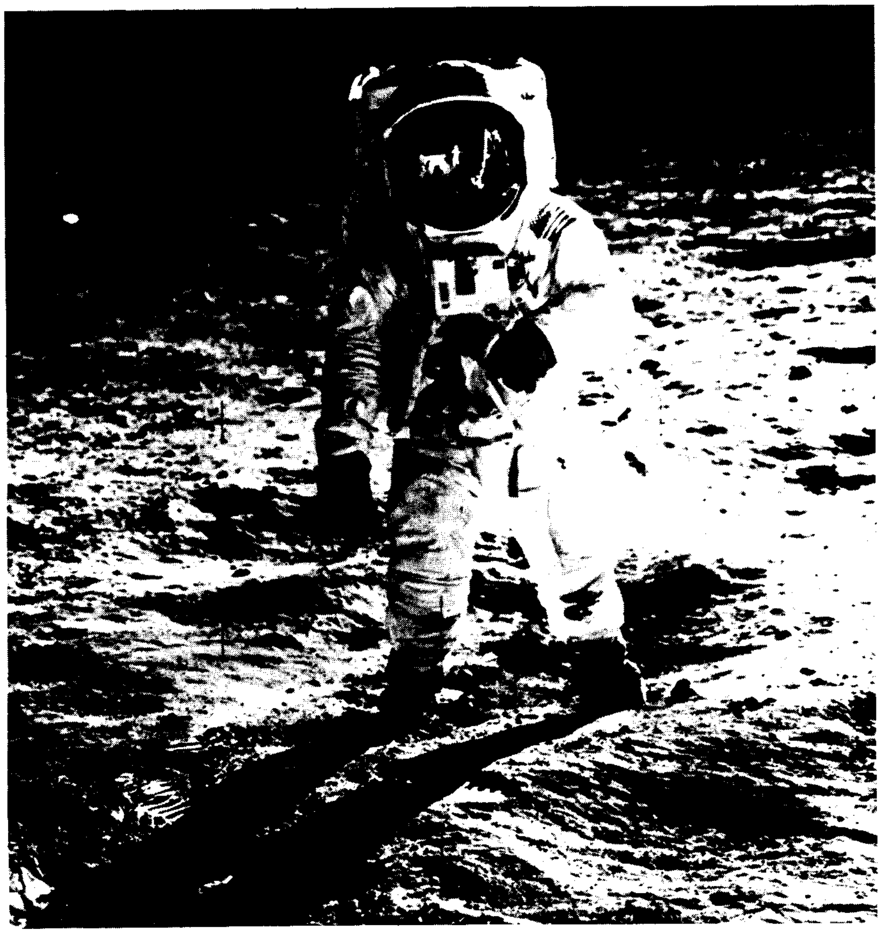
AERODYNAMIC DRAG OF MODEL ROCKETS
CAT. NO. 711-TR-11

SUMMARY

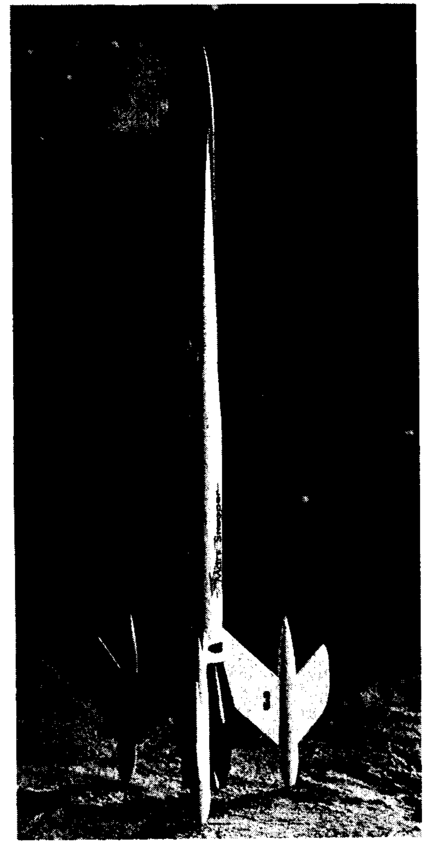
You should have an idea about what model rocketry is all about by now. Have fun building and flying your model rockets. Learn as much as you want to learn. You will find it very enjoyable because you are using what you are learning. In fact, the best rocketeers are very well-informed.

Your chances of being an astronaut are not great. The men (and women, someday) who become our astronauts are really very special people. They're smart, they have good educations, they are in excellent condition, and they are either highly qualified scientists or very capable test pilots. Who knows, if you try hard enough, you just might make the astronaut team.

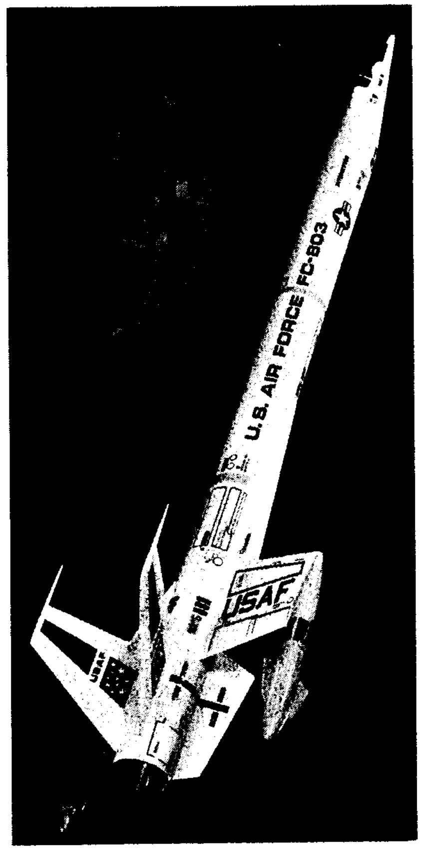
You will enjoy model rocketry, no matter what your goals. Follow the safety code, build your technical skills, increase your knowledge, and have fun!



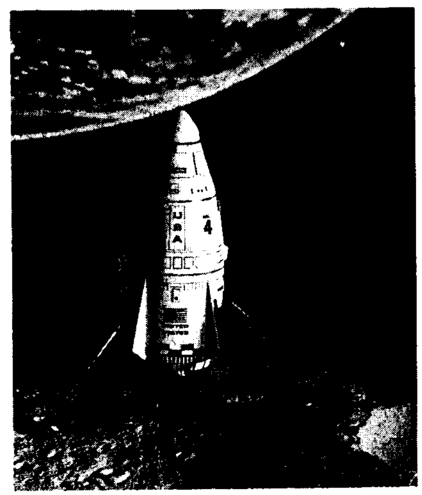
K-57 SKYDART



K-20 MARS SNOOPER



K-50 INTERCEPTOR



K-43 MARS LANDER