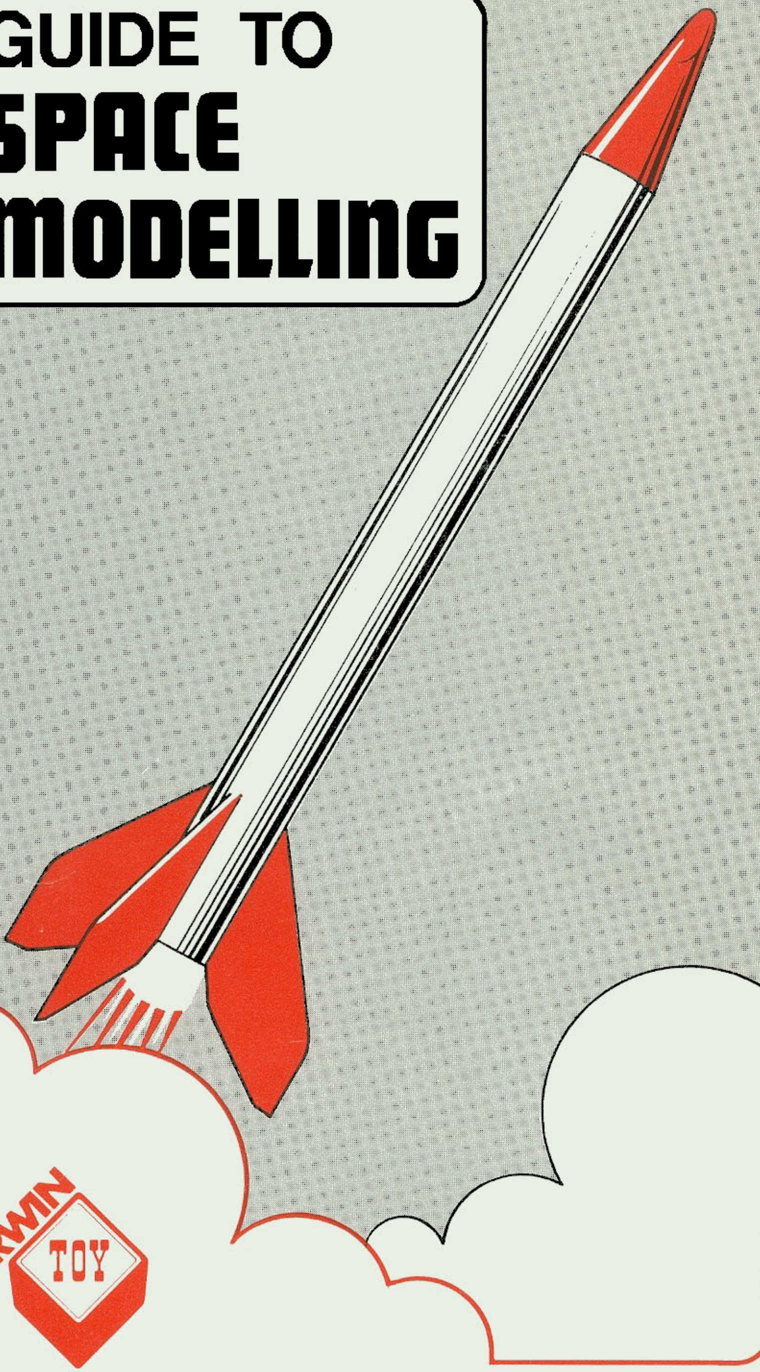
CANAROC

GUIDE TO SPACE MODELLING



IRWIN TOY

CAT. NO. 54059

STARTER BOOK

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INTRODUCTION

Space Modelling, or Model Rocketry as it is usually called, is becoming one of the world's most popular hobbies. Backed by the best safety record of any hobby or sport, space modelling has attracted enthusiasts of all ages, as well as wide acceptance within school curriculums. Space modelling is easy and inexpensive to become involved in.

This has been written as a complete guide for the person just starting in the hobby to introduce the fundamentals, as well as serving as a guide for further challenging activities.

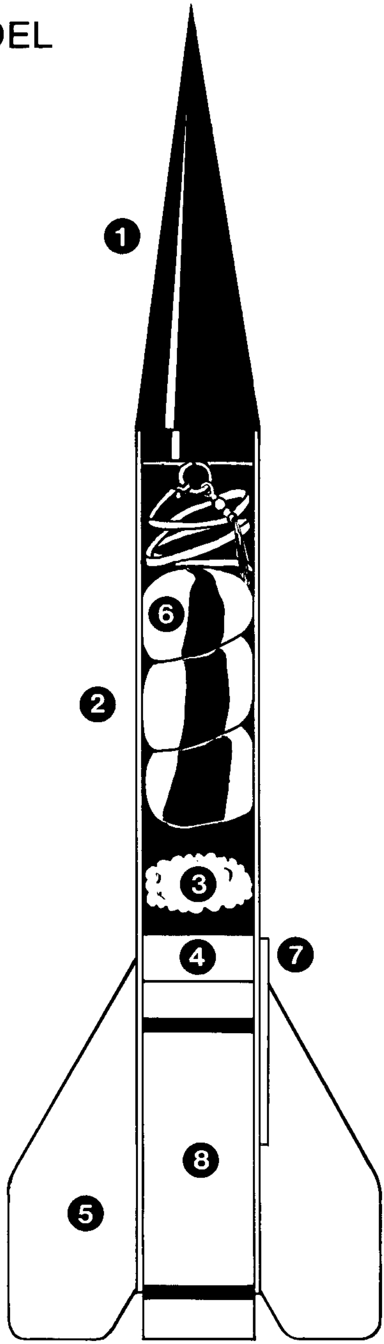
The beginning space modeller should start with some of the basic models then graduate to the challenge of Boost/Gliders, Competition Flying, Research and Development, and Scale Modelling. After graduating from building and flying kits, the modeller can learn to design his own models while learning about aerodynamics and stability.

Any starting modeller can learn a lot from those modellers in a Club. Contact your local hobby dealer for information about organized space modelling activities. If there is not yet any organized activity, then talk to your hobby dealer about helping you start a Club. Once you have your own group, hunt around for others and conduct joint launches and competitions.

Space modelling is an exciting sport hobby. We hope that this guide will be the start of many enjoyable space modelling activities.

FUNDAMENTALS OF SPACE MODELLING

PARTS OF A SPACE MODEL



1. Nose Cone
The forward end of a rocket. Acts to reduce the pressure and allow the airflow to transition smoothly to the rest of the rocket. It is usually made from balsa wood or plastic.

2. Body Tube
The outer airframe of the rocket. All other parts are connected to this piece. It is constructed of a light-weight, tightly wound paper tube.

3. Wadding
Flameproof material that protects the recovery system from the hot ejection gases of the engine. As well, it serves as a piston to push forward the recovery system.

4. Engine Block
Acts as a bulkhead to keep the engine from moving forward in the tube.

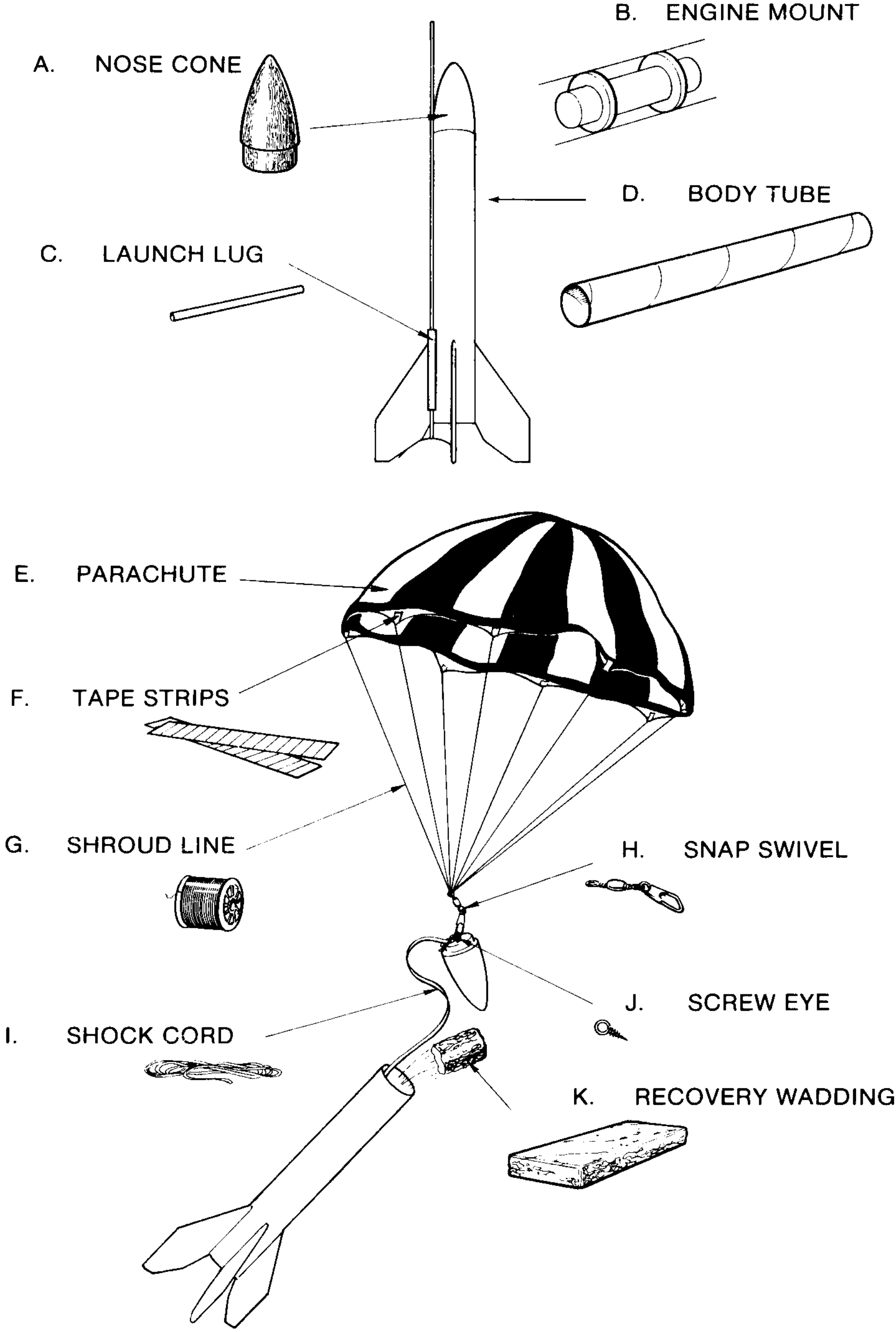
5. Fins
Serve to stabilize the rocket. They act like feathers on an arrow. Generally made from balsa wood, although plastic may be used.

6. Recovery System
Usually a plastic parachute or a paper streamer. Serves to slow the model during descent. It is deployed at apex by a charge in the engine and ejected from the model.

7. Launch Lug
A thin slender tube that is attached to the side of the model. It slides over the 'Launch Rod' to guide the model during the first few feet of flight.

8. Rocket Engine
Solid propellent unit that serves to propel the model, supply smoke tracking, and eject the recovery system. Completely non-metallic, reliable, and safe to use.

PARTS OF A SPACE MODEL



FLIGHT OF A SPACE MODEL

1. IGNITION
The rocket engine is started electrically by a 'hot wire' located in the engine nozzle.

2. LIFT-OFF
The rocket engines accelerate the model from the launcher.

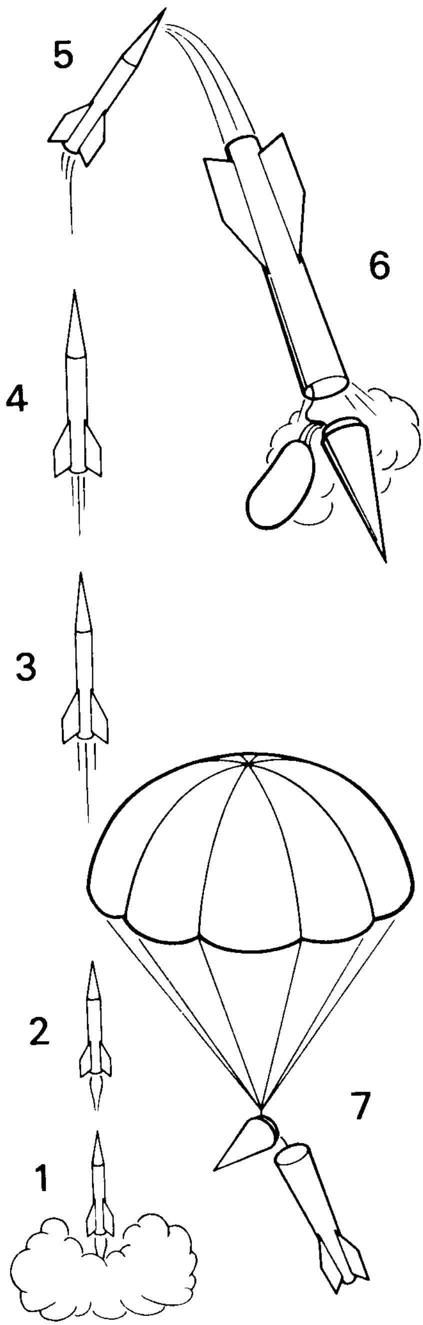
3. BURNOUT
Occurs when all of the propellant is burnt. At this point the rocket is at maximum velocity of 400-600 km/h.

4. COASTING PERIOD
During the burning of the 'Smoke Tracking and Delay Charge' the model is allowed to decelerate and reach maximum altitude.

5. APOGEE
The model slows down, arcs over, and begins returning to the ground.

6. RECOVERY SYSTEM EJECTION
the 'Ejection Charge' in the engine ignites and pushes hot compressed gas forward into the rocket body. This pressurizes the tube and blows off the nose cone, ejecting the recovery system.

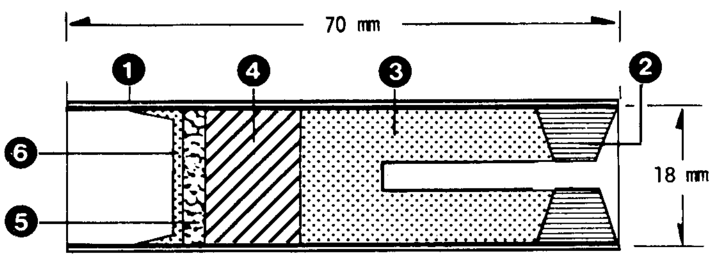
7. SOFT LANDING
The recovery system having deployed, the rocket descends slowly for a soft landing, ready to be flown again.



THE ENGINE

The space model engine is the life-blood of the hobby. It is the safety, reliability and low cost of the engine that has given space modelling its incomparable safety record and caused it to be a hobby enjoyed by people of all ages. In over 100 million launchings there has been no reported serious injuries or accidents. The safety of the space model engine is as a result of its design and construction. The use of a tightly wound paper casing, rather than metal, eliminates any danger in the event of a malfunction. Since the engines are factory loaded under controlled conditions, the modeller never needs to deal with dangerous explosives. The quality control in the manufacturing maintains strict performance characteristics of engines. Space model engines are capable of only one flight. No one should ever attempt to reload an engine as the casing may not stand the stress of another burn. There is little to gain by reloading an engine as it could never be as good as a factory loaded original.

PARTS OF AN ENGINE



1. CASING: A very strong flame-proof tube made of tightly wound paper. It houses all the engine components.

2. NOZZLE: A hole specially shaped to provide maximum thrust from the burning propellent.

3. PROPELLANT: A special mixture of chemicals, prepared and loaded into the casing under controlled conditions. The solid propellant is designed to provide a controlled thrust profile.

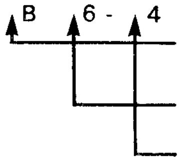
4. DELAY CHARGE: A smoke producing material that produces no thrust. It sets the time between the thrust phase and the ejection of the recovery system.

5. EJECTION CHARGE: Loosely packed charge that blows out the top of the engine when ignited. This pressurizes the body tube and ejects the recovery system.

6. RETAINER CAP: A paper or clay cap that holds the ejection charge in place.

THE ENGINE CODING SYSTEM

In Canada and the United States, the system used to code an engine type is a letter, followed by a number, a dash and another number.

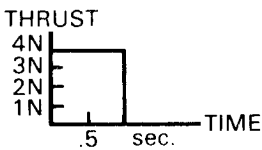


The letter gives the power category of the engine. Each consecutive letter is twice the power of the previous (a B engine has twice the power of an A).

The average thrust of the engine in newtons (metric unit of force).

Number of seconds of time delay after burnout. A "O" means there is no time delay or ejection charge (a booster engine).

The engine "power" is rated by categories of "Total Impulse". The total impulse is the total area under the "Thrust-Time" curve, and in its simplest case would be equal to the average thrust times the burn time. In the case of an imaginary engine with the "Thrust-Time" curve shown in the diagram, we see that it has a constant (also its average) thrust of 4 newtons and a burn-time of 1 sec.



Total Impulse = (4 Newtons) x (1 second)
= 4.0 Newton-Sec.
which corresponds to the area under the curve.

ENGINES are categorized as follows: —

¼A: 0.00 - .625 NS	C: 5.01 - 10.00 NS
½A: .626 - 1.25 NS	D: 10.01 - 20.00 NS
A: 1.26 - 2.50 NS	E: 20.01 - 40.00 NS
B: 2.51 - 5.00 NS	F: 40.01 - 80.00 NS

It is important to note the significance of the total impulse value. It is the engine with the greatest total impulse, not the greatest thrust, that will give a model its best altitude. It is also important to realize that every engine in a particular category, "B" for example, has the same power regardless of the average thrust.

RECOVERY SYSTEMS

The recovery device allows the slow descent of a model, thus preventing a safety hazard, and allows the model to be recovered undamaged, to be flown again. The following are the main forms of recovery systems:

PARACHUTE RECOVERY:

This is by far the most common method of recovery. Parachutes are made from a thin plastic film cut to six or eight sides; a shroud line is attached to each corner by a tape strip. Commercially made parachutes come complete with colored patterns, shroud lines, tape strips and instructions on how to make the parachute.

Most beginning modellers have a tendency to use chutes that are larger than necessary for general sport flying. As a result they often suffer the consequence of their model rockets drifting away in a breeze. The majority of space models up to 500 mm long and weighing about 50 gm can be safely recovered with a 300 mm parachute.

STREAMER RECOVERY:

Streamer recovery is also very common. It is used in light-weight models and when flying in high winds and/or small fields. The streamer is usually made from fire-resistant colored crepe-paper strips. They provide sufficient drag to slow the descent of the model, but without the drift of parachutes. Streamers 50 mm by 1 meter will safely recover a rocket of 30 gm and less. For larger models, streamer recovery may still be used providing larger or multiple streamers are used. Extra-strong fins will reduce the possibility of impact damage.

GLIDE RECOVERY:

The Canaroc Nomad is an example of a glide recovery model. While the Nomad separates into two pieces, one gliding and the other on a streamer, models can be built that completely rely on gliding for recovery of the entire vehicle. These models always boost like a normal model and only glide on recovery.

TYPES OF SPACE MODELS

SPORT MODELS: "Just Fun" models that are built and flown for the sheer pleasure of it!

PAYLOAD MODELS: These have a separate compartment that may be used to loft payloads, i.e. radio transmitters, lights for night launches, or competition payload weights.

MULTI-STAGE MODELS: An effective method of achieving greater altitudes is to "stage" engines; just like NASA does on "The Big Ones."

CLUSTER ENGINE MODELS: Where greater initial thrust is needed at lift-off for a big model or a heavy payload, 2 or 3 engines can be ignited at once. This is a great challenge, even for the best flyers.

BOOST-GLIDERS: Boost the glider straight up, separate the pod at ejection, and the glider returns in a graceful, circling glide. A successful Boost-Glider will challenge your skills, not only at rocketry. but at practical aerodynamics as well.

SCALE MODELS: No space modeller is ever too advanced to build a really good scale model of a sounding rocket or space vehicle. Exact replicas, in miniature, will challenge even the best modeller.

COMPETITION MODELS: Models such as the ORION IV offer straight, clean high performance without "frills." Models such as this are meant to achieve the best performance for the job they are intended for.

FUTURISTIC MODELS: The Canaroc Star Fleet is an example of what imaginative models can be built for display or flight. Start your own fleet with the Canaroc Kits, then use your imagination and create your own Star Ship designs!

CONSTRUCTION TECHNIQUES

CONSTRUCTION POINTERS

FINS

Fins for space models should NEVER have the GRAIN of the balsa wood PARALLEL to the body tube (Fig. 1). If this is done , then the fin will be very weak and likely to snap on the first impact.

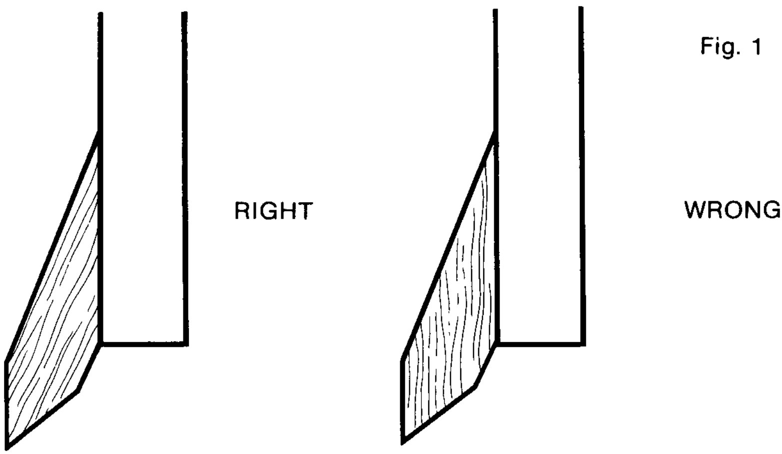


Fig. 1

When cutting fins from sheet balsa, do not attempt to complete the cut in one stroke. Rather, take many light strokes until the cut is complete.

Balsa grain has a tendency to 'catch' the blade of a knife to cause it to run with the grain. Thus, when cutting at an angle to the grain, make the direction of movement of the blade such that if the blade slips into the grain (as it often does), it will slip **away** from the fin being cut, rather than into it. (Fig. 2)

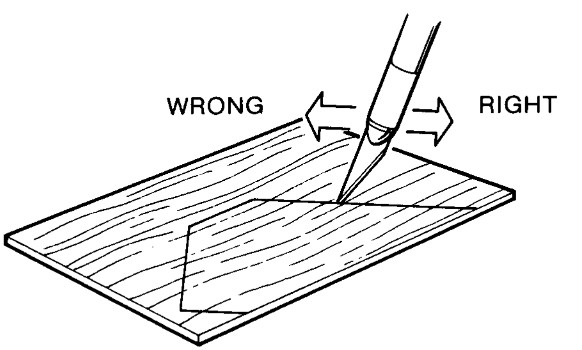


Fig. 2

When all the fins have been cut stack them together to see if they are all the same size. If there is any difference between them, then lightly sand each side of the fin with a sanding block until they are identical.

For best performance, the fin cross-section should be shaped to the symetrical airfoil shown by rounding the leading edge and tapering the trailing edge of the fin. (Fig. 3)

The root edge (the edge that glues to the body) should be sanded flat. It is quicker and easier, to simply round the leading and trailing edges (Fig. 4).

Cross Section

Fig. 3

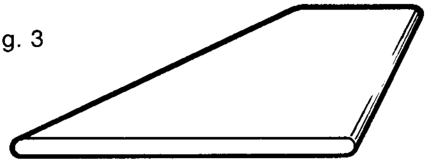
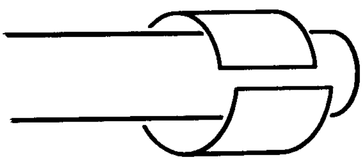


Fig. 4

When mounting fins onto the body, the following procedure will ensure that they are properly aligned. First, wrap a strip of paper around the tube, and mark the spot where the strip crosses itself. When unwrapped, the distance from the end of the strip to the mark will be the circumference of the tube. Cut the strip at the mark. Divide the circumference strip into as many sections as you have fins, and place an arrow at each section. (Fig. 5) When wrapped back around the rear of the tube, the arrows will give the location of each fin so that they will be equally spaced. Mark the tube at these arrows. Setting the tube on the inside ledge of a drawer, the mark may be extended by using the drawer as a straight-edge (Fig. 6).



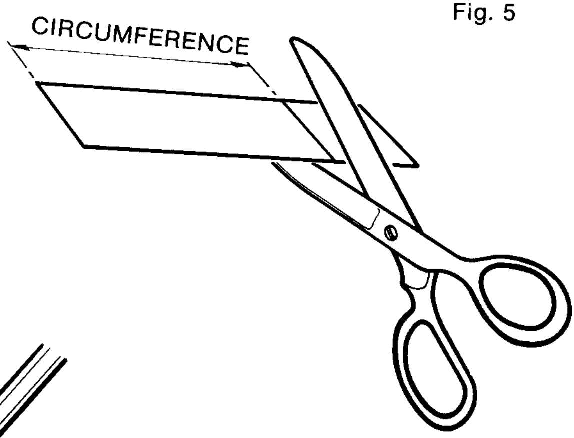
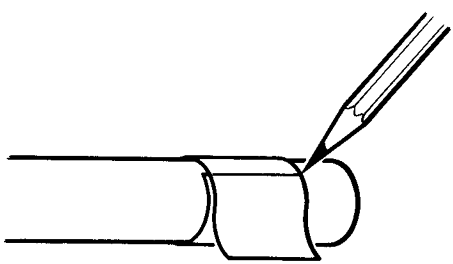
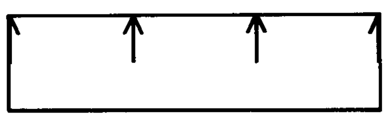


Fig. 5





Marking Guide for 3 Fins

When glued to the tube, the fins should line up on the marks. By looking down the fin from the rear of the tube, any mis-alignments should be noticed (Fig. 7).

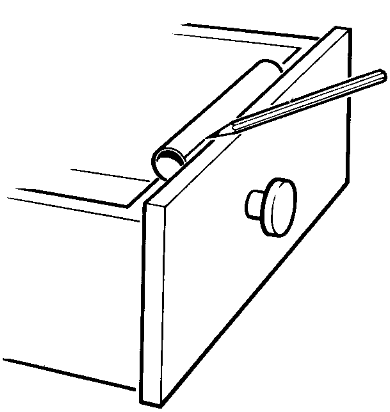


Fig. 6

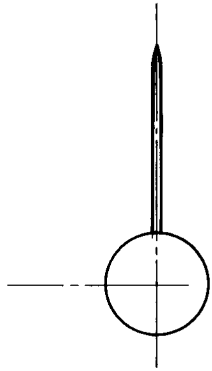


Fig. 7

Once all fins have thoroughly dried, it is best to 'fillet' the fin by spreading a thin line of glue along the fin joint, then running your finger along it to smooth it out (Fig. 8).

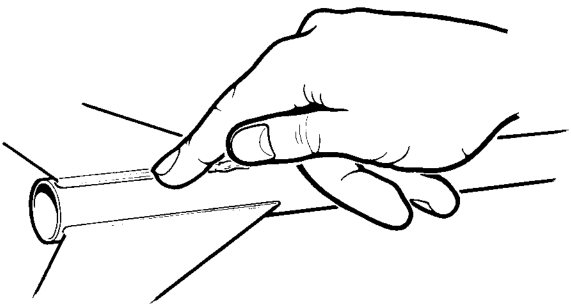


Fig. 8

LAUNCH LUGS

When glueing the launch lug to the tube, alignment may be checked by holding the tube at eye level, then rotating it until the lug begins to disappear over the horizon of the tube. If the lug is straight, then it will all disappear over the horizon at the same time. If it is crooked, one end will disappear before the other. (Fig. 9)

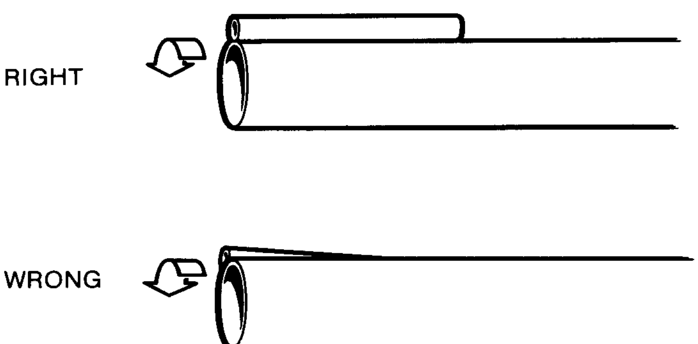


Fig. 9

FINISHING TIPS

DOPE

All balsa parts must be 'sealed' before painting for best appearance and performance. If the balsa wood grain is not filled, then the paint will be soaked up into the wood leaving a coarse, dull, grainy finish.

Filling is done by first rubbing corn starch, talc, or baby powder into the wood grain. Next, brush on a generous coat of clear butyrate dope or sanding sealer. Both are available from any hobby shop. When doping fins, always do both sides simultaneously as the fins will warp if this is not done. When the dope has **thoroughly** dried, sand the surface with fine sandpaper then apply another coat of dope. After the third coat, the grain should be filled. Firmly sand with fine, then extra-fine sandpaper till the surface is smooth and glossy.

RESIN

By far the best method is using Finishing Resin, available at most hobby shops that sell model aircraft supplies. The resin is similar to that used in fibre-glass work and gives a smooth hard surface. Balsa grain can be filled after only two applications.

The resin is used by pouring some into a mixing cup (¼ ounce is sufficient for most models) and adding the instructed amount of catalyst. After mixing vigorously for a minute, quickly brush it over the entire model. Let the resin cure for about an hour, until it is hard and glossy. Sand the entire model with a medium grit sandpaper until all the shiny spots on the model have dulled. Apply another coat of resin, brushing it out smoothly. Repeat the sanding with fine sandpaper, then polish with extra-fine, after curing.

PAINTING

ENAMELS

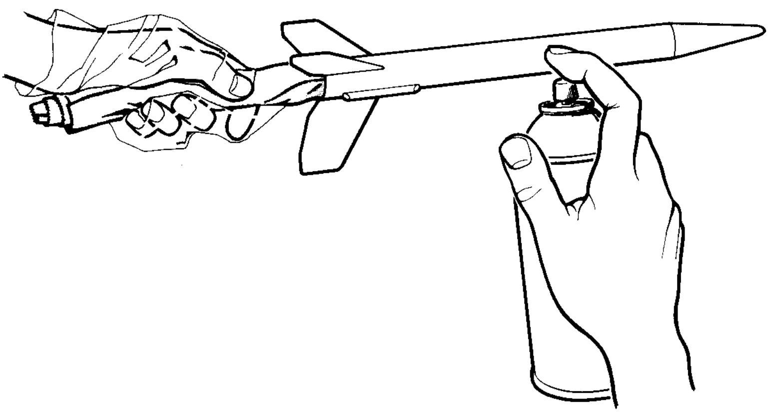
May be applied by brushing, from bottles, by spraying with an airbrush, or from a can. Enamel is easily available, but requires a long drying time and may "run" or "sag."

SPRAY PAINTING

The best finish is obtained by spray painting, rather than brushing. Of the available sprays, KRYLON yields the most superior finish. This is laquer enamel that dries quickly, and gives a smooth glossy finish. By far it is the best paint for model rocket applications. It is sometimes difficult to find, but is available from most art or drafting supply stores, some department stores, and some paint stores.

When painting, an initial undercoat of white will always yield the best results. When spraying hold the can about 200 mm to 300 mm away from the object so as not to apply the paint too thickly. Paint that is applied too thick will "run" before it has a chance to dry and ruin the finish. If the can is held too far, then the paint will be too thin, spattered, and have a dull appearance. When spraying do so in long, even strokes so as to give even distribution.

When spray painting, hold the model with a dead engine casing or rolled up newspaper. Placing a plastic bag over your hand, when holding the model, will prevent paint from getting on it.



MASKING

Stripes and paint separations can be achieved by painting everything the lightest of the colors to be used. When this has dried for a good length of time (24 hours for KRYLON; several days for Enamels), cover the areas to be left that color with masking tape. When large areas are involved, it is best to cover all but the edges with a plastic film (such as sandwich wrap or dry cleaning bag), rather than tape. If too much tape is used, then the previous layer of paint may be peeled when the tape is removed. When all the tape has been applied, run your thumb nail along all the edges to be sure that they are sealed and no paint can run under them.

Allow the final coat to dry completely before attempting to remove the tape. Run the blade of a knife lightly along all the tape edges so as to cut through only the previous coat of paint. Gently peel off the tape by pulling it back, flat against itself. Do this very slowly and carefully so as not to lift the original paint.

FLYING

The selection of a proper launch site is important. It should be free of power lines and trees. The size of the launching area should be large enough to allow for the recovery of your models. A rule for determining the correct size is to have the shortest side of the launch site at least one quarter the maximum altitude you expect the model to reach.

Once a launch site has been selected, set up the launch pad and controller, following their instructions. Be sure to strategically place the launch pad on the site to provide for wind drift.

Prepare your model for launching:

— Install the engine by sliding it into the engine tube and locking it into place with the engine retainer. If your rocket does not have an engine retainer, you must test fit the engine to make sure it is snug. If the engine is loose, wrap tape around the casing until a tight fit is achieved. If the engine is not tight, the ejection charge will kick the engine out of the model instead of the recovery system.

— Push a piece of recovery wadding into the top of the tube. The wadding protects the recovery device from being melted by the hot gases of the ejection charge. There should be about a 20 mm thickness of wadding to create a good piston between the recovery device and the engine.

— Attach the recovery device (parachute or streamer) to the screw eye in the base of the nose cone.

— If a parachute is being used, fold it in the following manner.

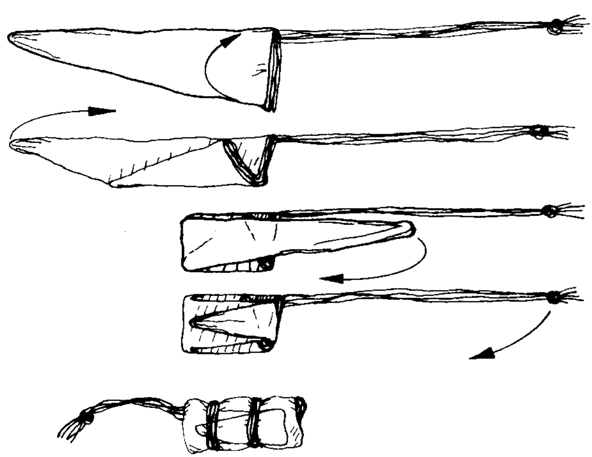
hold the tip of the parachute with one hand and the shroud lines with the other.

— gather together all of the free corners so that the parachute forms a triangle.

— fold over the corners.

— fold over the parachute into thirds.

— wrap shroud lines around the bundle.



BEYOND BASICS

PERFORMANCE OF SPACE MODELS

The performance of a space model is affected by gravity, the thrust of the engine, and **aerodynamic drag**.

Aerodynamic drag is the result of air resistance on the model; the greater the drag on a model, the lower its altitude will be.

Although the factors affecting the performance of space models involve complicated mathematics and aerodynamics, the basis can be understood quite simply.

Aerodynamic drag may be determined by the following equation:

$$D = \frac{1}{2} Cd\ P\ A\ V^2$$

where:

Cd = Drag Coefficient

P = Air density

A = Cross-sectional area of the model

V = Velocity of model

From this we can see the following:

The Drag Coefficient is strictly a "reference" number that relates such factors as surface finish, nose and fin shapes to the drag of the model. Its value is generally between .5 and 1.0 for space models and the lower the value of Cd, the better the design is.

The air density is a factor the modeller has little control over, and simply states that the less air there is, the lower the drag will be. It implies that a model launched from a mountain will have less drag and consequently go higher than a model launched from sea level.

The cross-sectional area of the model is the area of the model seen head-on. Thus, the smaller the diameter of the tube the lower the drag.

The most significant factor in the drag on a model is the velocity, since the drag, D, increases as **the square** of the velocity; that is V^2. Thus by doubling the models velocity, the drag is **increased by four**. Tripling the velocity **increases the drag by nine**.

This is important because it means that the **slower** the velocity of the model, the higher it will go.

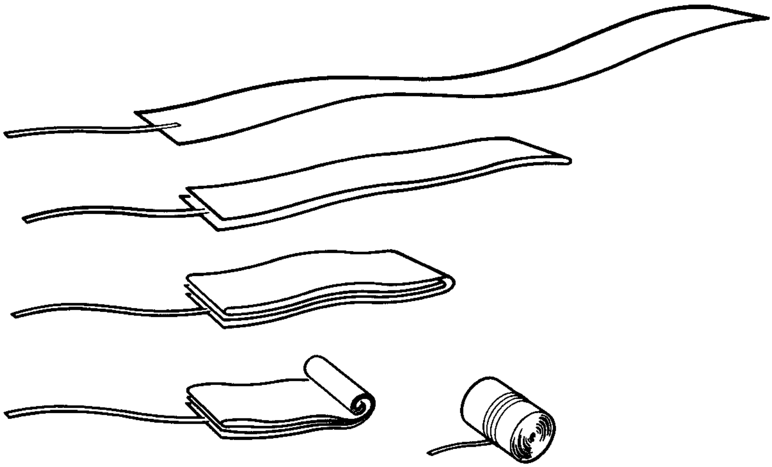
This means that a low-thrust, long burning engine will go higher than a high-thrust, short burning engine.

— A streamer is prepared in the following manner.

— fold the streamer in half twice.

— holding one end of the streamer tight start rolling it up from the other end.

— wrap the shroud lines around the streamer to keep it snug.



— The recovery device can now be inserted into the body tube. Push the shock cord and remaining shroud line into the tube and slide on the nose cone.

— Install the ignitor according to the instructions supplied with the engines. Once the ignitor has been installed, make sure the two leads are not touching each other, otherwise they will short circuit and the electricity will not get to the part of the ignitor against the propellant.

— Make sure the safety key is **not** in the launch controller.

— Load the model onto the launch pad by sliding the launch lug over the launch rod and lowering the model to the blast deflector.

Test the model to make sure it will slide freely on the launch rod. If it catches or does not slide smoothly, sand the rod lightly with sandpaper.

— Before the microclips are attached, inspect them to make sure they are clean. If they are dirty, lightly sand them with sandpaper. Dirty clips will prevent good electrical contact with the ignitor leads, and result in a misfire. With the model sitting on the pad, attach the clips to the ignitor leads. To prevent the circuit from short circuiting, the two microclips must not touch each other or the launch rod.

— If the continuity light comes on, you have a complete circuit and are ready to launch.

— Clear everyone at least 5 meters away from the launch pad. Give a short countdown then press the launch button to launch the model.

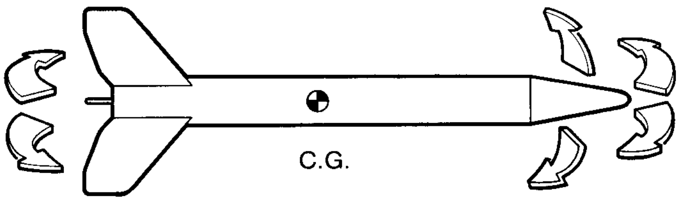
— In the event of a misfire, let a safe period elapse, before you approach the model. First check to see if the clips or ignitor wires were shorting. If not, check the ignitor and replace it with a new one if necessary.

STABILITY OF SPACE MODELS

Having seen that space model performance is determined by gravity, engine thrust, and aerodynamic drag, it is now important to know that a space model will not fly at all unless it is **aerodynamically stable**.

When examining a space model we see that it has a balance point called the Center of Gravity, or C.G. (Fig. 1).

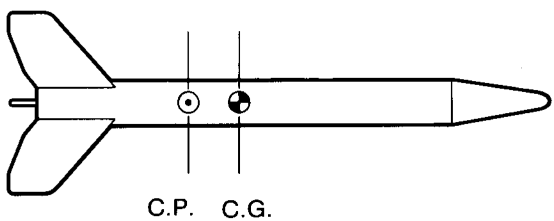
Fig. 1



The C.G. is the center of all mass of the model, and is similar to the pivot point of a weathervane.

If there is a center for all the mass of the model, which can be considered the point at which gravity acts, it follows that there will be a center for the air pressure forces on the model. This point is called the Center of Pressure, or C.P. (Fig. 2).

Fig. 2



If a space model is to have **static stability**, then the Center of Pressure, or C.P., must always be behind the Center of Gravity, C.G.

As a result, any rotation of the model will be around the Center of Gravity.

The location of the C.P. is dependent on size and shape of nose cone; size, number and shape of fins, and body length. These factors determine the distribution of air pressure force on the model.

Consider the weathervane pointing into the wind. (Fig. 3).

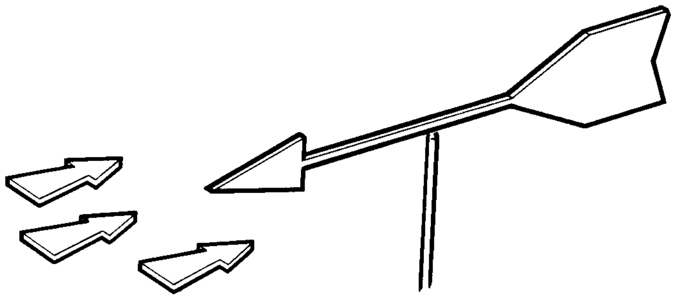


Fig. 3

The wind is flowing past the weathervane in such a way that there is no force causing the weathervane to rotate.

Let the wind direction change; and now there is a force on the weathervane that causes it to rotate so that it is again pointing into the wind. (Fig. 4).

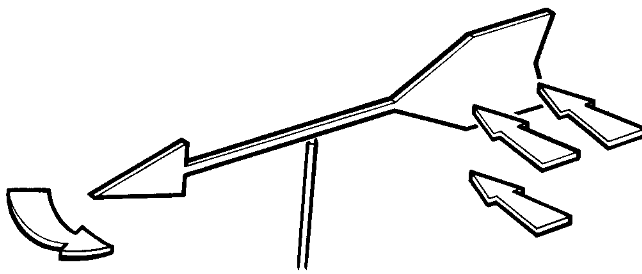


Fig. 4

Exactly the same holds true with a model. If a wind disturbance causes the model to fly at an "angle of attack", a force occurs that acts at the C.P. The model will rotate around the C.G. until the force disappears. (Fig. 5).

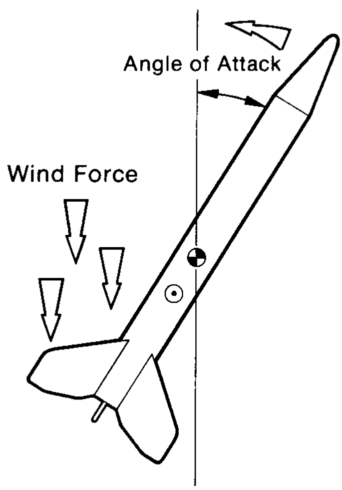


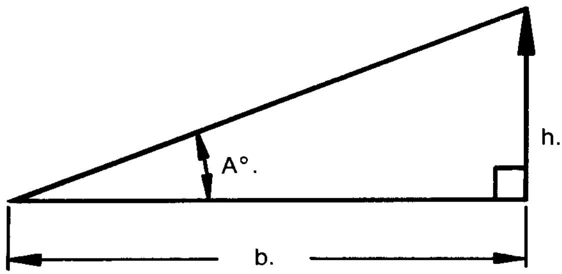
Fig. :

If the fins are too small and the C.P. is **ahead** of the C.G., the model will rotate until the C.P. is behind the C.G. In effect the model is attempting to fly backwards. This will result in the model looping end over end, creating a safety hazard.

ALTITUDE TRACKING

Altitude tracking of space models may be performed using the Canaroc Altitude Finder and simple trigonometry. (Fig. 1)

Fig. 1



The following relation may be taken from trigonometry:

b (Tan A) = h
where b = baseline
h = altitude.

Angle A is found using a tracking device such as the Canaroc Altitude Finder. The tangent of that angle (tan) is found from a trigonometric table of tangents:

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

The baseline is, of course, measured out or paced out. The length of the baseline should be approximately the same altitude you expect the model to reach.

Sample Problem

h = b (Tan A)

b = 300 meters

A° = 40°

h = 300 (Tan 40°)

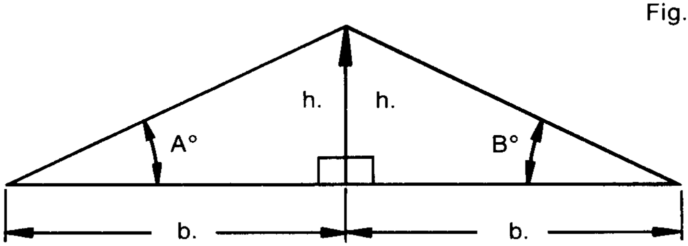
h = 300 (.8390)

h = 252 meters

In order to increase the accuracy of the track, the tracker should be at right angles to the wind. When the model leaves the launcher, it is likely to "weathercock" and fly into the wind, travelling at right angles to the baseline of the tracker. If this is not done, then the model may fly towards or away from the tracker and distort the baseline from what was actually measured.

A two station tracking arrangement may be set up and the results averaged to give a more accurate result. (Fig. 2)

Fig. 2



CLUSTERING

In some cases engines may be arranged so that two or more are ignited upon launching. Clustering engines in this fashion provides a higher lift-off thrust and acceleration, which is useful in launching heavy payloads. However, this practice is limited by the difficulty in getting all the engines to ignite simultaneously. It is usually more efficient and less expensive to use a larger motor rather than clustering several small ones. Cluster ignition is usually done by using 'Clip-Whips' that enable an electrical connection to more than one ignitor (Fig. 1).

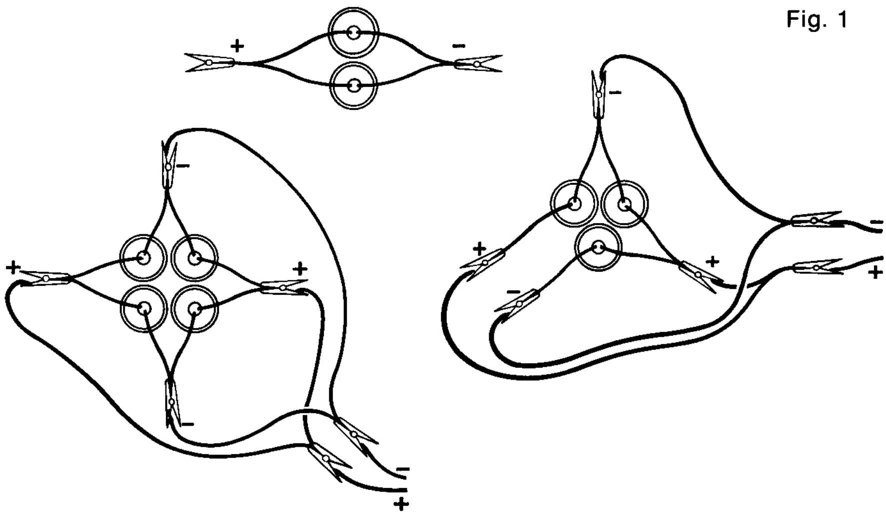


Fig. 1

MULTI-STAGING

A more common method of increasing the performance of models is to 'stack' engines, one on top of another. This is known as multi-staging and is similar to the way large space vehicles stage engines in order to increase performance by discarding dead weight.

The booster is a special motor that does not have any delay and ejection change; thus the booster burns until only a thin disk of propellant is left. The large internal pressure of the motor ruptures the propellant disk, pushing hot gas and burning propellant particles forward into the nozzle of the upper stage engine, thereby igniting it. (Fig. 1). The engines are connected with cellophane tape to ensure that the pressure of the propellant disk rupture does not separate the stages before upper stage ignition is attained. When the upper engine does ignite, it kicks away the lower stage and continues until burnout. The upper stage engine generally has a longer time delay, since the added velocity of the second engine will require that the upper stage coast longer.

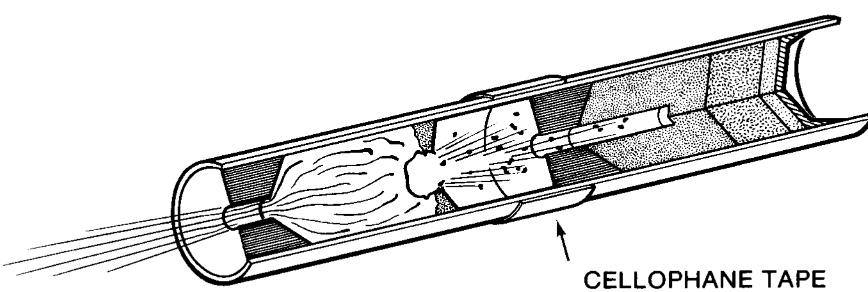


Fig. 1

PAYLOAD MODELS

These are models equipped with a section of the body that is separated from the parachute compartment. The payload compartment is used to carry such flight payloads as electronic transmitters, cameras, standard size lead weights in competition, or even raw eggs.

Electronic transmitters are available for space models or may be designed by anyone with some electronic background. Typical applications for electronic payloads are: homing device; spin-rate sensor; temperature measurement; humidity measurement; telemetry from biological payloads; inversion layer measurement.

Also available for space models are single frame cameras and movie cameras. The single frame camera releases the shutter after the model arcs over at the top of the flight. This device allows the space modeller to engage in aerial photography and remote sensinq.

The excitement of watching a movie film taken from a space model must be seen to believe. The camera is started just before ignition, with the lens pointing toward the ground. The camera remains on during the entire flight, taking motion pictures of the take-off, the ground receding as the model accelerates skyward, apogee pitch-over, ejection and recovery.

BOOST GLIDERS

One of the most popular areas of space modelling is the building and flying of Boost-Gliders (B/G's).

The B.G. originally was a model that descended in a gliding mode by the use of large fin areas and flip up elevators. (Fig. 1)

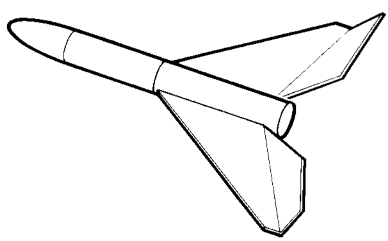


Fig. 1

Boost-Gliders advanced until they became quite similar to hand-launch gliders. (Fig. 2)

Known as a Front-Engine B/G, these can have fixed engine pods where the glide mode is actuated by the ejection of the engine; thus changing the 'trim' of the glider from boost to glide.

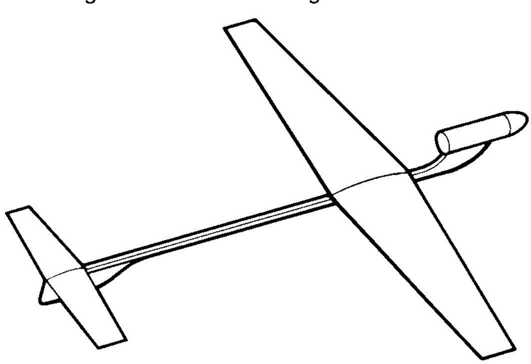


Fig. 2

More common is the 'Pop-pod' Front-Engine B/G where the entire engine unit pops off the glider and returns by parachute or streamer. The glider then makes the transition to the glide phase. (Fig. 3).

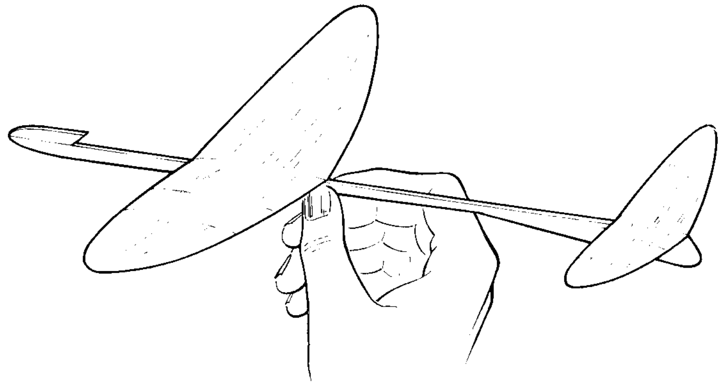


Fig. 3

Another type, the Rocket Glider (R.G), is similar but requires that the entire model remain in one piece throughout the entire flight. Figure 4 shows how the engine shifts backwards at ejection to change the model from boost to glide trim, and how the ejection gases are released through a hole in the pod.

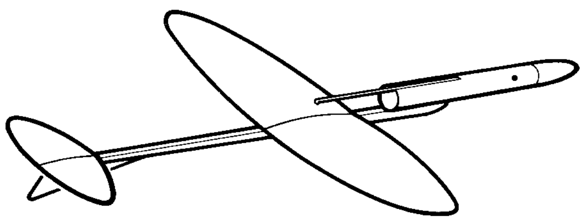


Fig. 4

Another type of B/G is the 'Parasite' glider, which rides piggy-back on a carrier vehicle. The glider is released upon ejection while the model returns by parachute. (Fig. 5).

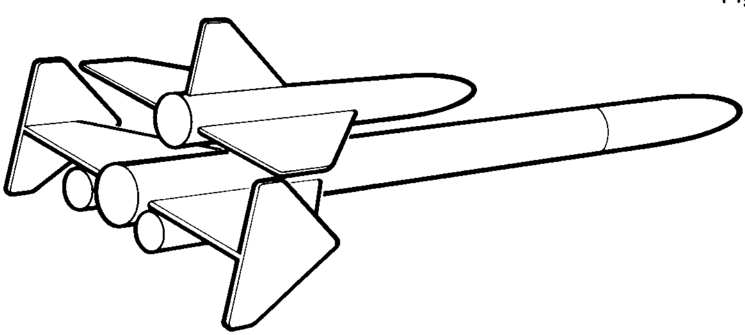


Fig. 5

COMPETITION FLYING

Competition events loosely divide into Duration events; Altitude events, and Scale events. Each event is divided into classes determined by the engine category. For example, a B engine altitude event would allow the use of **any** B engine, or combination of engines in cluster or stage, where the total power was not in excess of a B engine.

PARACHUTE DURATION: The model must be recovered by parachute and is timed from instant of lift-off to touch down, or when it goes out of sight. Greatest time wins, and the model must be returned to qualify.

STREAMER DURATION: Same as parachute duration, but a single streamer must be used.

BOOST-GLIDE DURATION: Any type of boost glider may be used, but boost must be straight up and the model must return in a stable glide.

ROCKET-GLIDE DURATION: Same as boost-glide duration except the entire model must remain **in one piece** throughout the entire flight. Pop-pods or ejecting engine casings are not allowed.

ALTITUDE: The highest tracked altitude with a specified category of engine wins.

PAYLOAD: Model must carry a "standard payload" to the highest tracked altitude. "Standard payload" is a lead cylinder weighing 28 grams and is 19 mm in diameter. Either one or two payloads may be specified.

EGG-LOFT: Model must carry a Grade A hen's egg weighing between 55 and 65 gms to highest tracked altitude and recover it completely undamaged. One or two eggs may be specified.

SCALE: A scale model of an actual rocket or space vehicle is built and flown. Judging based on Quality of Scale Data, Accuracy of Scale, Workmanship, Degree of Difficulty, and Flight Characteristics, according to a specified formula. Model must fly successfully to qualify.

SCALE ALTITUDE: The scale model is tracked, and the altitude achieved is added to the scale points for a total score.

SUPER SCALE: The scale model must be launched from its scale launcher or launch complex. The launcher is judged at the same time as the model.

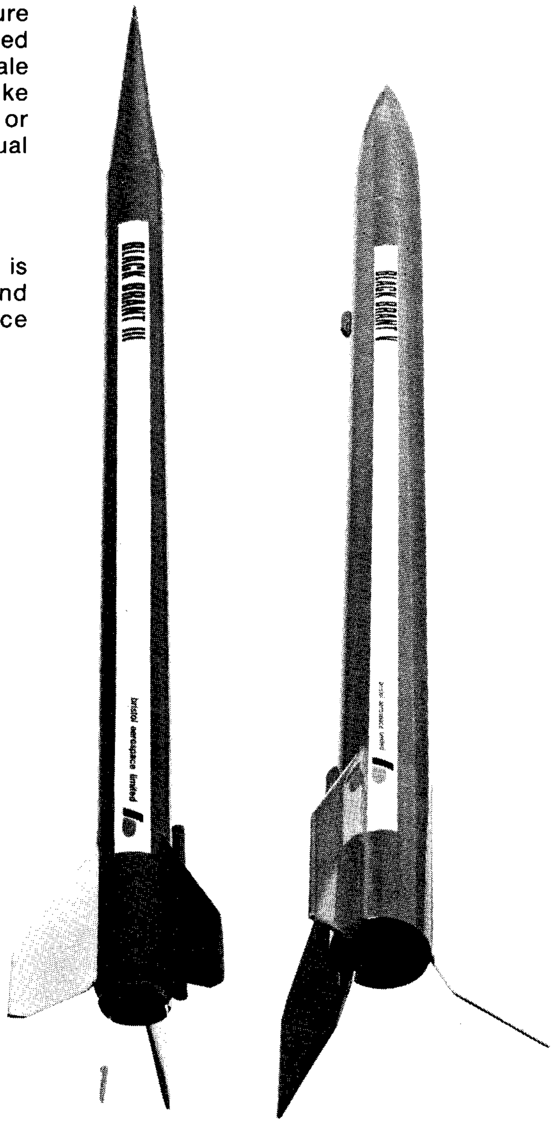
SPOT LANDING: A target is placed somewhere in the launch field and the models must be aimed so as to **safely** land as close as possible to it. Events are categorized into Parachute, Streamer, or Open (anything) as the recovery devices.

SCALE MODELLING

Scale modelling is the domain of the experienced and expert modeller. It takes time, patience, and expertise to build a proper scale model.

A scale model is a miniature flying replica of a full sized rocket or space vehicle. A scale model can be built from kits like Canaroc's Black Brant Series, or built from scratch using actual blueprints of the original.

Scratch built scale modelling is one of the most challenging and exciting aspects of space modelling.



MODEL ROCKET SAFETY CODE

CANADIAN ASSOCIATION OF ROCKETRY

1. **CONSTRUCTION**
I will always build my model rockets using only light-weight materials such as paper, wood, plastics and rubber without any metal structural parts. I will always construct my model with aero-dynamics surfaces, or a mechanism to assure a safe, stable flight.

2. **ENGINES**
I will use only pre-loaded, commercially available model rocket engines approved safe by the Department of Energy, Mines and Resources. I will never subject these engines to excessive shock, or extremes of temperatures, nor will I ever attempt their reloading, or alteration in any way.

3. **RECOVERY**
My model rocket will always have a recovery system to return it safely to the ground, so that my model rocket may be reflown. I will always prepare the recovery system with extra care so that it will always deploy properly.

4. **WEIGHT LIMITS**
My model rocket will not weigh more than 500 grams at liftoff, and the model rocket engines will contain no more than 125 grams of propellant.

5. **FIRING SYSTEM**
I will always use a remote, electrical system to ignite the model rocket engine(s). My system will include an ignition switch that will return to "off" when released, and a safety interlock switch to prevent accidental ignition.

6. **LAUNCH SYSTEM**
My model rocket will always be launched from a stable platform having a device to initially guide my rocket. This device will never be pointed below 30 degrees from the vertical. My system will have a jet deflector to prevent the engine exhaust from directly striking the ground, or easy to burn launcher materials. To protect myself and others from eye injury, I will position my launch rod or rail so that it is above eye level, or else I will place a large guard on the end between launchings. I will never place my body or hand directly over my loaded model rocket positioned on the launch system.

7. **LAUNCH SITE**
I will never launch my model rockets near buildings, power lines, or within nine (9) kilometres of an airport. The area around the launch system will be cleared of any easy to burn materials. I will always obtain the permission of the launch site owner(s) before I launch my model rocket.

8. **LAUNCH CONDITIONS**
I will never launch my model rockets in high winds, or under those conditions of low visibility which may prevent the complete observation of my model rocket in flight.

9. **LAUNCH SAFETY**
I will never leave the safety interlock key in my Firing System when I am not launching my models. I will remain at least five (5) meters away from any model rocket about to be launched. I will always announce to persons present that I am about to launch my model, and I shall give a loud countdown of at least five (5) seconds long.

10. **ANIMAL PAYLOADS**
I will never endanger live animals by launching them in my rockets.

11. **TARGET**
I will never launch my model rocket so that it will fall or strike ground or air targets, nor will I attach any explosive warhead or incendiary payload.

12. **HAZARDOUS RECOVERY**
I will never attempt to recover my model rocket from a power line, a high place in a tree, or any other dangerous place.

13. **PRE-FLIGHT TESTS**
Whenever possible, I will always test the stability, operation and/or reliability of my designs or methods previous to flight. I will launch unproven designs in complete isolation from other persons.

14. **PERSONAL CONDUCT**
I will always conduct myself in a responsible manner, conscious that the maintenance of safety for myself and others rests with my ability to design and construct sound, working models, and to enthusiastically abide by the above code.

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