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Projects in Model Rocketry

A Guide to Great Projects Utilizing Model Rocketry

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PREFACE

The publication was prepared to provide you with a number of ideas for great projects utilizing model rocketry. Some ideas are easy and can be handled by a beginner who uses reasonable care in doing the project. Other ideas offer exciting projects which can be successfully completed by the average rocketeer. Several ideas offer challenging projects involving real research.

Quite a few basic tips to help you make your project a real winner are included in the Foreword. The ideas presented are adaptable to any project.

Select the project you like best, plan carefully, keep accurate notes and have fun!

CREDITS

The project ideas presented in this book were gathered from many sources. Quite a few were winners in contests for favorite projects or ideas for projects. Several are old familiar favorites. Some require new research to advance the state of the art of model rocket technology.

Among the contributors of specific project ideas are: William C. Arrants, St. Petersburg, Florida; Jim Babb, Cleveland, Ohio; Steve Behrends, Highland Park, Illinois; Bob Bruce, Granada Hills, California; Gary Cole, Overland Park, Kansas; Charles Compton, Chesterfield, Virginia; Vince Draa, Frankfurt, Germany; Doug Fuller, Las Vegas, Nevada; Terry Gordon, Baltimore, Maryland; Bill Gowan, Ellenboro, North Carolina; William C. Griffiths, West Coxsackie, New York; John Langford, Atlanta, Georgia; Sid Martin, Suburn, Nebraska; Michael Pendley, Odenville, Alabama; Ed Reilly, Niagara Falls, New York; Martin Rubins, Spring Valley, New York; Williams R,. Tantlinger, Jr., New Florence, Pennsylvania; Craig Towmer, Columbia, Maryland; Frank Vaughan, Irving, Texas; Barry Wilhelm, Peninsula, Ohio; Karl Sliter, Colorado Springs, Colorado.

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FORWARD

Your project will be as good as you make it. Select a project that looks like fun and that you can handle. A project that is “over your head” is no fun, and your chance of successfully finishing it is small. It is better to pick a project with some challenge and lots of fun rather than an awe-inspiring task and failing to complete it.

The first step is to choose something that looks like fun and that appears possible for your present level of skill and financial resources. This booklet should give you ideas. Read through it to see what appeals to you. The topics are grouped into general areas. Above some paragraphs are topics for specific possible projects. The list of specific projects is not complete, but it should provide suggestions for you.

The grouping of topics in general areas is not entirely consistent because many projects can actually involve ideas from several areas. Look around in all areas for ideas which appeal to you.

Planning is half the secret of success for a good project. It is a lot easier and cheaper to think your way through your project BEFORE you do anything. So select your project, then think about it. Go through all of the steps several times in your mind. List on paper:

- What you want to accomplish
- What you plan to do
- How you plan to do it
- What supplies you need
- When you will start
- Where you will work
- When you should have a tentative result
- What you will use for references to read before you start
- Who you can go to for help
- When the final report and/or display must be started
- When it must be completed

Write everything down. Date all of your notes. It is extremely easy to forget to write down a critical fact or idea, then have to do a lot of extra work later to rediscover that fact or idea.

Measure all things which seem pertinent. Record times. Weight everything and record the weights carefully. Use English measurements or metric, but be consistent. Metric measurements are actually easier to use once you get the hang of them.

Make graphs as well as tables of data whenever possible. It is amazing how much information a graph can provide. Sometimes making a graph lets you see relationships which are not evident from the data. When making graphs always be sure to label each axis with what it is as well as with the appropriate numbers. Name the graph for what it tells. Plot each point on the graph carefully.

Photos can add a lot to your report and/or your display. Everyone likes pictures. Be sure the pictures are as sharp (focused) and as large as you can make them without spending too much money. A few, well-planned pictures can make the difference between a winning project and a nice effort.

Nearly every experiment should involve the use of “controls.” These are experiments done on an unmodified subject to see if the modification you are testing really does anything. For example, if you are testing the effect of boat-tailing on drag, you should conduct experiments on an identical rocket without the boat-tail to see what effect was produced by the boat-tail and how much was the change produced.

Make large, detailed drawings with everything labeled. So you are no great artist and you haven’t had mechanical drawing, you can still do your best! Use a ruler and a compass to make things neat-looking. Do the drawing neatly in pencil and erase all goofs before you ink in the drawing. Use a ball point pen or a marker, but ink it. A pencil drawing can be messed-up easily with handling. Put measurements on your drawings. It makes them look more impressive, and it also provides exact data which can make your report much more useful.

One format to use in writing up your experiment is the “classic” experiment report form or the scientific method form.

1. Purpose. State exactly what you want to find out or to produce.
2. Procedure. What you plan to do, step-by-step.
3. Background. Information on your subject which you determine by reading in suitable references.
4. Materials. The apparatus (equipment) which you used.
5. Data. The facts you gathered as you did your project. Give full details on what you did and the results. Provide full details on your control experiment.
6. Results. The facts you learned which answer your original question. If the data is sufficient, you may be able to state a major truth instead of just the answer to your problem.

Your project should have a purpose in easy-to-understand terms. It is fine if you are only after one specific fact. Knowledge is usually accumulated slowly as a result of the efforts of many people.

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PROJECTS IN MODEL ROCKETRY

<u>ACCELERATION</u> <u>STUDIES</u>

High acceleration at take-off means both rapid build-up of drag and maximum stress on the structures of the model rocket. The higher thrust levels available in some model rocket engines permit them to be used for launches of heavier payloads and other special uses.

Rate of Acceleration

Studies to determine actual acceleration (with an accelerometer you design), relative accelerations (as by effects such as distances a small, loose weight like a bb will dent a rigid but reasonably soft and dentable structure as soft styrofoam or one or more mounted facial tissues) or theoretical accelerations (through mathematical analysis of predicted rocket performances or analysis of actual data from flights) are possible and can be fun. The project may be a simple one to make comparisons or may be a thorough mathematical study.

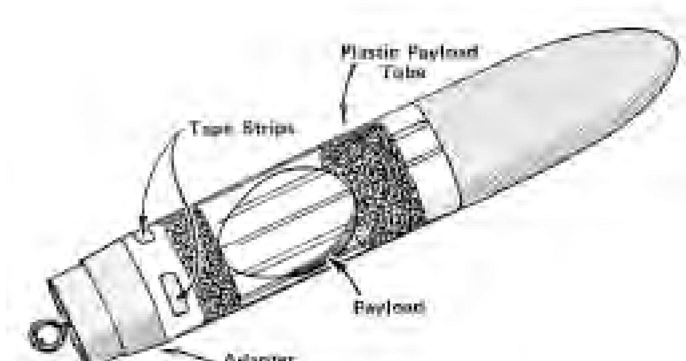
Launches of a rapidly blinking bulb at night or in twilight periods can permit the flight to be photographed by time exposure and actual velocities determined (if the bulb blinks rapidly and at a consistent rate).

<u>ACCELERATION</u> <u>EFFECTS</u> <u>ON</u> <u>LIVING</u> <u>ORGANISMS</u>

Do not launch an animal. Use only insects.

Effects of Acceleration on Chick Embryos

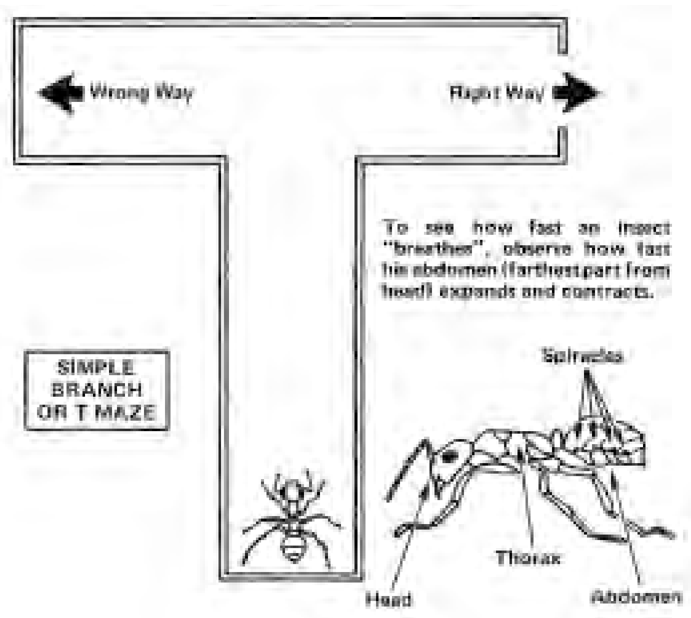
The launch and safe recovery of a raw chicken's egg is a good test of payload handling capability. Compare the embryo of the launched egg to the embryo of an egg that was not launched. Also compare the growth of both embryos.



If you feel the desire to launch a small biological payload, do so with care. Wasps and bees make compact passengers for all but the very smallest payload compartments.

Effects of Acceleration on Insects

Crickets, grasshoppers and flies may be launched. Even if you goof, these creatures stand an excellent chance of surviving an error on your part. But don't launch them and recover them and expect to learn much by just looking at them. Some rocketeers "train" their passengers to do a simple one branch maze or something similar, then test their reactions after flight. The results won't mean much if the specimen was damaged by poor handling or packaging in the payload compartment. Another problem can be that the effects you attribute to the g-forces experienced on the flight may be caused instead by a shortage of air in a too-small payload capsule.



The launch of living organisms should never be lightly undertaken. It appears from published reports and from our correspondence that at least nine out of ten launches of living organisms are successful. The few instances in which the "specimen" was lost were nearly always the result of an error on the part of the individuals who made the launches.

Experience indicates that most insects, given a minimum of protective packaging, can safely survive the forces developed during rocket launches. Remember that the comfort as well as the safety of the insects is important. Don't let the payload compartment become too hot or too cold. Be sure enough oxygen is supplied for the total time of the mission plus a safety reserve in case the payload compartment has to be recovered from a tree. An insect can use up a lot of oxygen just sitting in the payload compartment on the launch pad.

The primary purpose for the launch of a living creature must be carefully analyzed. If this project is to secure information that is useful, necessary and which cannot be secured in any other way, fine. Proceed with care. Plan every procedure carefully and rehearse before using the living insect. Do nothing to endanger the insect.

Acceleration Effects on Algae

Some projects have been carried out using plant material, usually algae in a water chamber, as payloads. Some researchers report that they have observed changes in the growth rate of algae subjected to the stress of acceleration. However, results reported do not agree. Also, no theory satisfactorily explaining the reported changes has been advanced.

Always do parallel experiments in which all conditions are identical except for the one condition being investigated. For example, observe one algae culture identical to the test culture except that it is not launched. These "control experiments" are extremely important in biology.

Effects of Acceleration on Maze-Learning Ability

One of the easiest effects to measure as a result of model rocket launches is the effect on growth and reproduction of such things as algae or uni-cellular organisms. The growth of fertile chick embryos can be observed to determine effects, if any, from the forces encountered during the flight. The easiest to observe phenomena for insects are disorientation effects (usually vanishing shortly after the flight), memory of previously learned "skills" and learning ability (as for mazes). Be careful to try to avoid the effects of "odor trails" on learning rates for solving mazes. Such phenomena as rate of heartbeat and respiration are sometimes hard to measure and generally are phenomena which change rapidly after flight. Additionally, the effects of handling, special restraints, new environments and similar things are hard to eliminate from test results.

RECOVERY SYSTEMS

Descent Rates for Parachute-Recovery Rockets

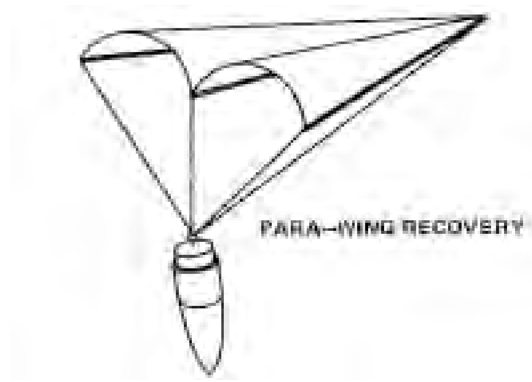
A number of possibilities exist for quite valid research involving recovery systems. Research could be conducted to establish standards for descent rates for a given rocket weight using a standard sized parachute. To "standardize" results, very careful measurements must be made. In addition to altitude at parachute ejection, time to touch down in seconds, horizontal wind drift, air temperature at the surface, air pressure at the surface, the exact size of the parachute and the exact weight of the rocket as it descends must be determined and recorded.

Parasitic Boost gliders

Designing, building and optimizing a parasitic boost glider is a very practical and challenging project.

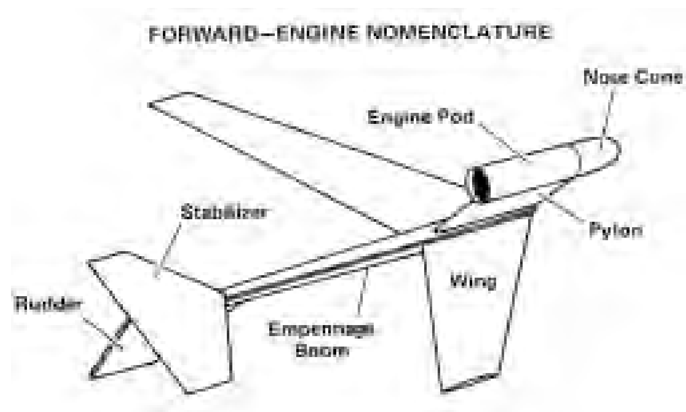
Designing the Most Efficient Parachute

Attempt to design a parachute for maximum efficiency. Triangular, square, pentagonal, hexagonal (our standard type), septagonal, octagonal, etc. types may be tried. Different ways of rigging a standard parachute may be tried. Different materials may be tried, as different thicknesses of plastic, cotton cloth, nylon cloth, mylar film, aluminum foil, etc. Elaborate new designs may be tested. Flight testing or hand-tossing with weights may be used. Rate of decent (distance fallen per second) is a good method of evaluation.

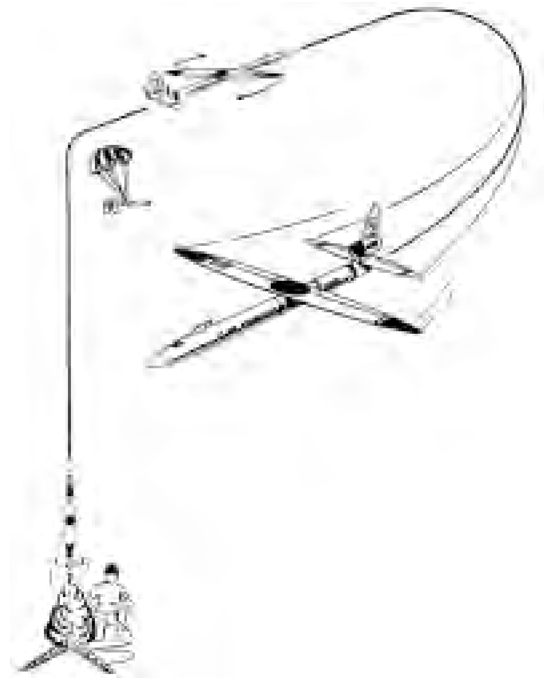


Glide Rates for Boost Gliders
Optimizing Boost Glider Design
Booster Stage Recovery by Gliding

Glide ratios for different types of boost gliders may be determined. Research on variations in design (changing shape of wings, changing aspect ratio of wings, changing dihedral of wings, changing angle of attack, etc.) for gliders provides unlimited opportunities for new discoveries. Designing booster states for recovery via gliding rather than tumbling offers research potential, both to develop such stages and to measure their performances.



The scissor-wing concept in boost gliders may be investigated. Drag produced by gliders of this design, glide ratios, etc. may be studied.



Parachute Modification Studies

The effects of spill holes in parachutes is worthy of further research. Allowing air to spill out of the parachute through one central hole or a series of smaller holes (as made by a paper punch) can affect the descent rate. However, there appears to be some question as to what the effect is and how pronounced is the effect.

"Reefing in" the parachute by taping the shroud lines together a specified distance down from their points of attachment can be a good topic. This technique is frequently employed to minimize lateral drift.

Recovery System Comparisons

Comparing the effectiveness of different recovery systems for the same rocket or different rockets of the same weight can be interesting.

Helicopter Recovery Systems

Is the helicopter recovery system really a practical, efficient recovery system for high performance rockets? If so, what is the best design?

Streamers for Rocket Recovery

Tests using a specified size of streamer, then doubling its surface area by an extra streamer, tripling its length, tripling its surface area by extra streamers, etc. can be an inexpensive yet valid research project to learn the effects on descent rates. Be sure to adjust the rocket's weight for each test to provide identical weights.

Effects on Descent Rate of Different Sized Parachutes

Varying parachute size for a rocket whose total lift-off weight is held constant could yield some valuable standards for descent rate as a function of parachute surface area and total weight during recovery.

Launch Angles, Wind Speeds and Rocket Recovery

Using the standards established by tests as suggested in the previous paragraph, estimation of the launch angle into the wind could be simplified to assure recovery of the models in the planned recovery area on windy days.

Techniques to Improve Durability of Model Rockets

Developing special techniques such as reinforcing the leading and tip edges of fins, heat-resistance treating of nose cone bottom surfaces, etc. are practical projects.

TELEMETRY

Radio-Homing Devices to Assist Rocket Recovery
Audio Devices to Assist Rocket Recovery

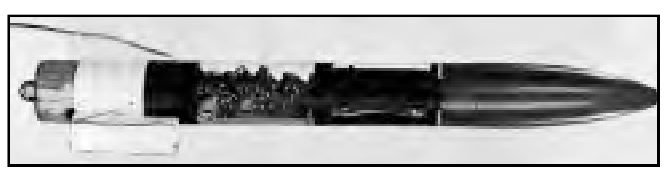
Use of a signal generating device as a payload for a rocket is one method for increasing the ease in which a rocket may be recovered, especially in bushy or uneven terrain. However, the use of such a device is not a good project unless the device itself is actually the product of the project. In this case, the development of a simple, inexpensive device with high reliability to continue emitting a tracking signal of sufficient strength can be a very valid and practical project. The device developed may use radio waves, sound waves, light waves or other means of making itself evident for tracking purposes.

Miniaturization of A Transmitter

True telemetry is the sending of information over a distance. The most commonly used form of telemetry in model rocketry is the small, light-weight radio transmitter (as the Estes Transroc II™). The project may be the development of a new transmitter. This project, however, requires some knowledge of electronics, miniaturization, radio building fundamentals, radio laws, access to the proper parts and a suitable receiver.

Air Temperature Profiles

Most telemetry projects are concerned with the collection of data, usually data which cannot be conveniently secured in any other way. Accurate data on air temperatures through a vertical segment of space from ground level to several thousand feet can be secured by using thermistors or similar temperature sensing devices as the input of suitable transmitters. Care must be taken to calibrate the device before the launch. Perhaps tape recording the signal from the receiver and then playing this signal through a suitable recorder to generate a graph is easiest. The recording can also generally be analyzed by carefully counting the number of "signals" recorded on a one second segment of the tape by slowly playing the proper length of tape. Most such systems use a frequency change to denote temperature changes. If your system uses instead an amplitude - modulated signal a more elaborate system is necessary. Perhaps playing the signal through an oscilloscope will permit data retrieval.



Causes and Cures for Spin

The performance of the rocket itself may be measured by use of a light-sensing element to determine spin rate for the rocket. Different fin configurations, fin attachment angles, fin shapes, wing angles, etc. can be compared using this system.

Audio Profile of A Rocket Flight
Rocket Flight Log from Viewpoint of A Passenger

Analysis of the sounds in and around the rocket is fun, but of questionable scientific value. Using a video camera and a transmitter in the microphone mode can produce a spectacular sound record of your flight. However, several mechanical problems such as proper insulation of the microphone from the sounds of the motor in the camera make this a difficult project.

Cloud Studies
Smog Studies

Determination of the thickness of cloud or smoke layers by use of telemetry apparatus can be a very valid project. Perhaps the light-sensing mode or the temperature-sensing mode for operation of the transmitter would be best for this. The "density" (optical) of the cloud, smoke or smog layer can also be determined. Be sure to conduct experiments of this nature in which the rocket goes into areas of the sky not visible to you very carefully and with FAA approval to be certain you do not come near any airplanes. Pollution studies can be very valuable as well as interesting projects. Use of the temperature-sensing mode of the transmitter in clear air can detect temperature inversions to enable you to predict pollution build-ups before they occur. Repeated launches to establish "norms" for the area under study are necessary to determine what are "normal" conditions for that area at different times of the day.

Micro-environmental Studies

A unique use of telemetry might be to study micro-environments by sending back temperature and/or light intensity information from such micro-habitats as under a bush, in a grassy area, up in the branches of a tree, under the bark of a dead tree, in a burrow, etc. Use of the microphone mode in such studies could produce interesting results on insect activity patterns, movements and sounds. In fact, such projects could be great biological studies as well as model rocketry projects.

AERIAL PHOTOGRAPHY

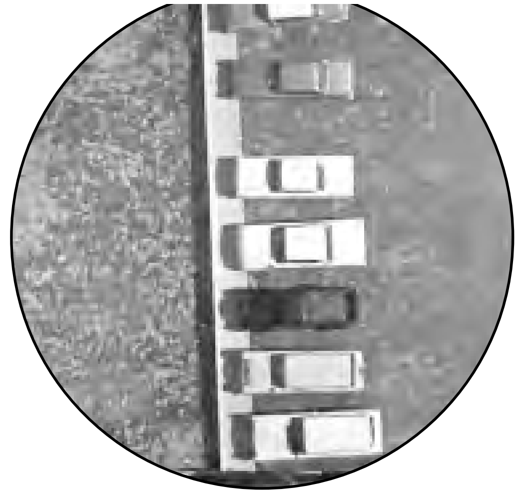
Taking pictures from high in the air is exciting! If you have your own plane or can rent one, great. If not, you are somewhat restricted in your opportunities for aerial photography. Unless you happen to have a skyscraper nearby, you are out of luck. Fortunately, there is one way to get good pictures from high in the air without having to rent a plane or have a handy, neighborhood skyscraper . Launch a camera as a payload on a model rocket.

ASTROCAM™ PHOTO

Aerial Photography

To get good color photos, use an Astrocam ™. This simple camera takes photos, one picture per flight. The film is fast and reasonably fine-grained, so good enlargements up to about eight inch diameter can be made. This is plenty for basic photo-interpretation work.

ASTROCAM™ PHOTO (ENLARGED)



Aerial Photo-Interpretation

Such basic features as houses, roads, trees, schools, etc. are easily identified through photo-analysis of the prints. Careful measurements can enable you to determine how high the rocket was at the instant the picture was taken and the actual sizes of objects shown in the photo. Careful control of the launch angle, the number of stages used in the launch vehicle and the choice of engines permit photos to be taken up to 1,000 feet or higher and permit selecting vertical or oblique photos. Taking exactly the area chosen can be somewhat of an art since winds hundreds of feet up in the air are often not the same as surface winds.

Habitat Analysis with Aerial Photos

Detailed analysis can permit some really interesting information to be secured from aerial photos. Counting the numbers of red ant colonies present in a given area can permit estimates of relative productivity for grass and weed seeds in different areas. Variations in available soil moisture or minerals often produce visible differences in vegetation.

Aerial Videos
Analysis of Stage Separation

Video pictures taken from on-board cameras really present unique views of model rocket flights. Watching the ground virtually drop away from your rocket is a thrill. Seeing the booster detach and tumble away is a not-soon-forgotten experience. The parachute deployment and recovery permit opportunities for study of the aerodynamics of parachutes (or streamers). Detailed photo-analysis of videos permit study of the sizes of objects on the ground, the height of the rocket at any given moment and the acceleration the rocket is undergoing. Did you know that you can even tell what season it is from many aerial photos? If you know the date your picture was taken, you can probably tell the time of day the picture was taken by studying the photo.

Survey of an Area by Aerial Photography

To get continuous videos of a large area from relatively low altitudes, why not design a large booster glider around a camcorder? The camcorder could even be flown in a model airplane to achieve long flights at relatively low altitudes. To save video tapes perhaps a timer could be used to activate the camcorder after the plane is at the desired altitude.

Photo-Mapping

Construct an accurate two-dimensional map showing roads, buildings, trees, etc. of a specific area from an Astrocam ™ photo. If several overlapping photos are used, a map may be made of an area larger than that shown in one photo. If enough overlap occurs, a contour map (topographic or 3-D map) showing relative elevations may be made.

A very challenging project would be a sound video flight. The problems to produce a good video with a quality sound track would provide interesting technical problems to solve.

WINDS

Winds are surprising. It is hard to appreciate the energy present in winds since we can't see them. The work they can do is fairly easy to study.

Wind Speeds at Different Altitudes

Measuring wind speeds with a small wind meter or anemometer is easy. The wind speed several hundred feet up in the air may not be the same as the surface wind. In fact, the wind several hundred feet up may not even be traveling in the same direction as the surface wind. Have you ever noticed cloud layers at different altitudes moving at different speeds or in different directions?

Relationship of Wind Speed to Drift Rate

Simple physical measurements for wind speed are probably easiest. One method to determine wind speed could be to determine the correlation between horizontal wind speed and rate of lateral drift of an object. Launching a rocket to a relatively low altitude (100 - 150 feet), measuring its apogee, then carefully determining its lateral movement from the point directly under its apogee (hopefully right over the launch pad) to touchdown will yield the vertical and horizontal movements of the model rocket. The time for descent from apogee should be accurately determined and recorded. Careful measurement of the wind speed at ground level and comparison of this with the horizontal drift speed of the rocket during descent will provide a guide for relationship between wind speed and the rocket's rate of drift, especially if the test is carefully repeated under different wind conditions. Repeating this experiment with rockets of significantly different weights or drags could yield interesting results.

Effect of Surface Area and Weight of Falling Object and Wind Speed on Rate of Drift

Rather than using the rocket under its recovery device as the test object, perhaps several objects of the same size (ping pong balls with something inside for different weights) or of the same weight but different sizes could be used to learn facts about drift due to wind.

Wind Patterns at Specific Altitudes

To get a better idea of drift due to winds high in the air, tracking the rocket during descent in three dimensions plus time and measuring only the part of the descent in the area of interest (as about 1000 feet to about 800 feet) can yield data to give the answers you seek.

Wind Dispersal
Air Turbulence

Interesting effects of air turbulence and wind speed can be observed by ejecting a "cargo" of talcum, tempera paint or some other highly visible, non-toxic, non-flammable powder at apogee. Watching the dispersal will prove interesting, but photographic records should be kept if serious research is to be conducted.

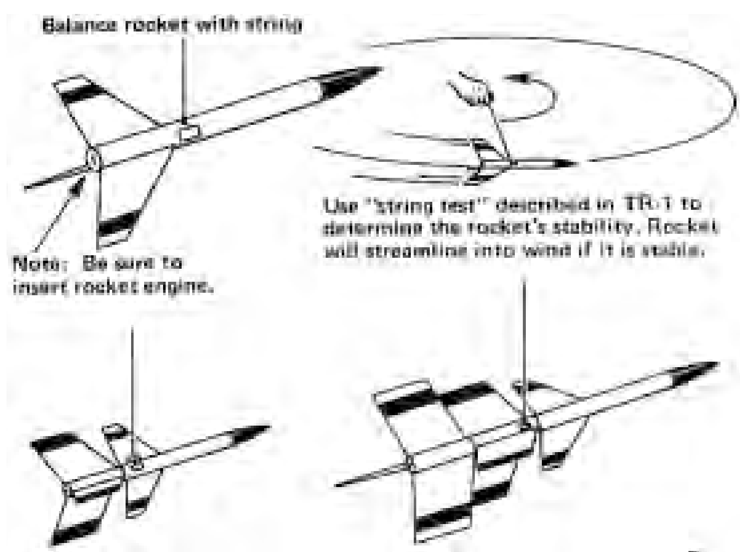
Message Dispersal by Wind

A really unique way to learn about the dispersal effects of winds on such common objects as some seeds, etc. would be to release a series of tiny slips of paper with your name and address on them as the cargo of a model rocket. When these are ejected at apogee, the wind can carry them away, sometimes for surprising distances. Each small slip of paper should contain in addition to your name, address and phone number, a sentence asking the finder to contact you (call or write a postcard) stating where and when the message was found. Use brightly colored paper for visibility. The paper should be an easily degradable type so that it will soon decompose and not be an "eye-sore" polluting the environment.

STAGING AND CLUSTERING

Effects of Streamlining

Staging is frequently used to reach maximum altitudes. Securing maximum altitudes requires minimizing drag. One method which can be used is streamlining fins while retaining stability.



Repeat the above procedure with each additional booster section. Be sure to insert a rocket engine in each stage.

Optimization of Ballistic Coefficient

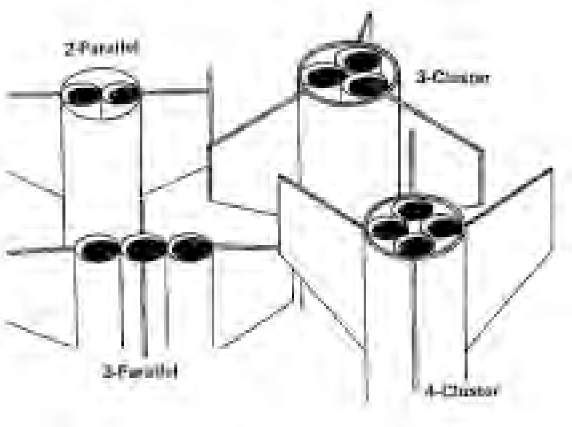
Another technique which deserves exploration is optimization of ballistic coefficient by careful control of the weight of each state and each configuration of stages.

Altitude Increase Through Staging

Construct a rocket employing two of three stages and make flight comparisons between it and a single-staged rocket. For accuracy both rockets should weigh approximately the same. Use combinations of engines in the staged rocket to equal the total impulse of the engine used in the single stage rocket. Each rocket should be flown and tracked at least three times before results are compared. Both rockets have the same thrust potential, but which one goes the highest, and why?

Effects of Using Clusters of Engines

Construct a rocket with a large body tube diameter and provide for changing engine holders (one engine, two engine cluster, three engine cluster, etc.). Comparisons of flights with one engine, two engines, etc. can be simplified by adding weights to the rocket's nose cone or removing them so that initial weights (with engines) before launch are equalized. At least three flights should be tracked and averaged in each specific flight configuration before results are compared to see effects of additional power on altitudes achieved. For simplicity, all tests should be made using the same type of engine unless more than one series of tests is to be conducted. Be certain that the rocket will be stable in all flight configurations.



Staging Versus Clustering

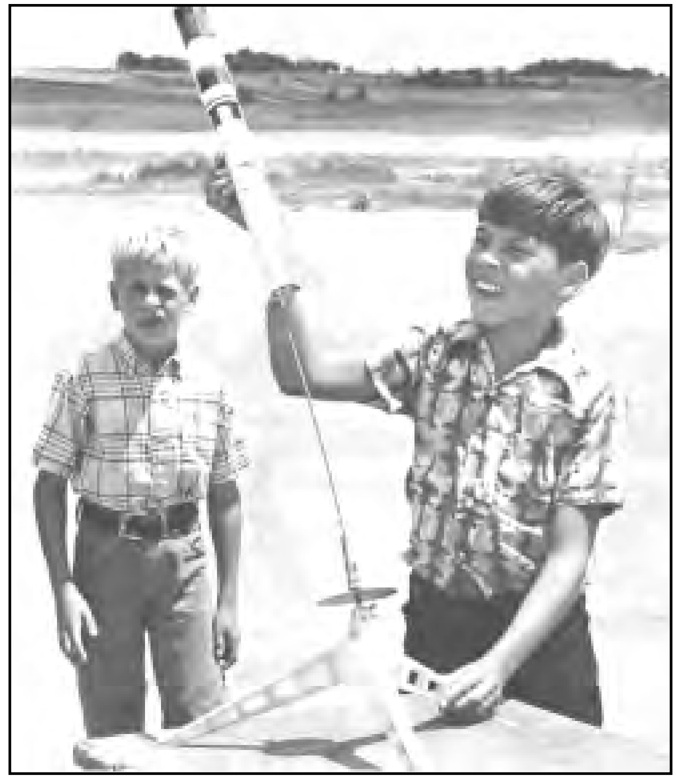
Studies of clusters of engines versus staging to cause a given payload to reach the maximum altitude are valid. Both theoretical studies and actual tracking of several launches each way should be made.

Improved Staging Techniques

Research to perfect a reliable new method of staging engines which are separated from each other is an area worthy of study. Using ignition channels between the booster and the sustainer engine is one possible method. Ignition of upper stage engines (or clusters of engines) by flashbulbs or other heat sources is an area of possible further research. Minimizing the weight while retaining 100% reliability for upper stage ignition by this method could prove a challenging undertaking.

A Booster as a Piston Launcher

A challenging project is the development of a simple, reliable and light-weight method of increasing altitude reached by making the booster serve, in effect, as the base for a piston launcher. The purpose of this project is to make more efficient use of the initial gas generation by the upper stage engine.



DRAG

Effect of Minimizing Drag on Altitude Performance

Determining the actual effects of different finishes on rocket altitude performance is a good project. Theory indicates that a rocket with a smooth finish should go higher with a specified engine than a similar rocket with a rough finish. Is this really true? Launch a rocket three times with a specific type of motor before sanding or sealing the fins or nose cones. Then carefully sand and seal the balsa, carefully paint and polish the rocket and launch it again three more times with the same type of engine. Track all six flights and compare averages for each set of three flights.

Drag Determination

Try to determine the actual drag of your model rocket. After estimating the drag on your rocket, use this estimate to predict the altitude which will be reached with a specific engine. Launch the rocket three or more times with this type of engine. Use the tracked altitude to determine the real drag on your rocket.

Drag Reduction Techniques and Their Effects

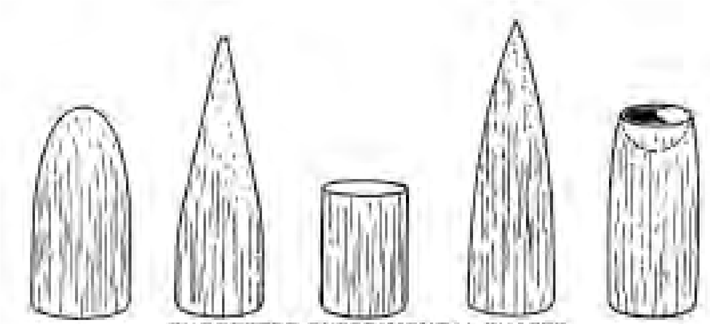
Drag is the nemesis of model rocketry. Of the efforts which go into maximizing performance, the greatest share seem to go into reducing drag. Streamlining the rocket's shape, airfoiling fins, using shrouds to taper transitions in body size, boat-tailing, etc. all help reduce drag. Learning more about both the theoretical and the real aspects of drag can really improve the performance of your rocket if the things learned are put into practice.

Fin Shape and Altitude Performance

Using fins of different shapes can affect rocket performance.

Nose Cone Shape and Drag

The effects of variations in nose cone shape on drag and hence on a rocket's altitude performance are a topic suitable for much theoretical work and extensive testing.



SUGGESTED EXPERIMENTAL SHAPES

Derivation of a Formula for Altitude Increase With Different Types of Engines

Launch one rocket (whose specific empty weight and frontal area you know) at least three times with each of the different engines recommended for that rocket (as 1/2A6-2, A8-3, B6-4, and C6-5 as one possible series of engines for a particular rocket). See if you can derive a mathematical relationship which shows the increase in altitude to be expected when using an engine of twice as great a total impulse as the one used in the previous flight. Possibly series relationships exist, and possibly no consistent relationships will be found.

Effects of Changes in Weight of a Rocket on Altitude

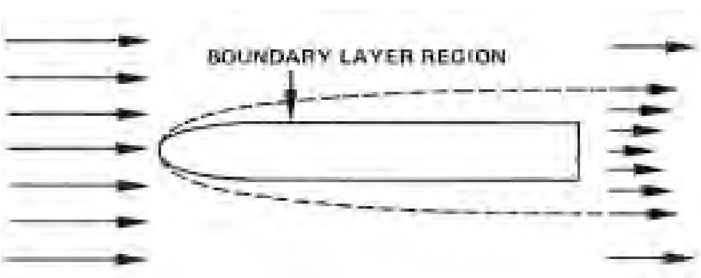
Repeated launches of one rocket, preferably lightweight, high-performance types, with one type of engine can be made if at least three flights are made and tracked with each weight increase. Steps of ten or twenty grams may be used. Some surprising results may be determined as the ballistic coefficient is changed by changes in weight.

Effect of Delay Smoke on Rocket Performance

Does the smoke generated by the delay and smoke tracking element as the rocket coasts actually cancel the effect of the potentially great base drag? Does this smoke really not contribute any thrust?

Boundary Layers

Is a laminar boundary layer really more desirable than a turbulent one for maximizing model rocket altitude performance? Proof for your hypothesis must be provided. At what point should the boundary layer convert from laminar to turbulent for maximum performance?



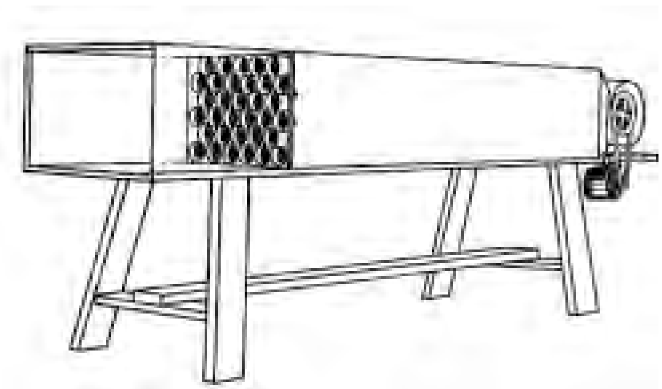
STABILITY STUDIES

Effect of Fin Shape on Performance

Effect of Fin Size on Performance and Stability

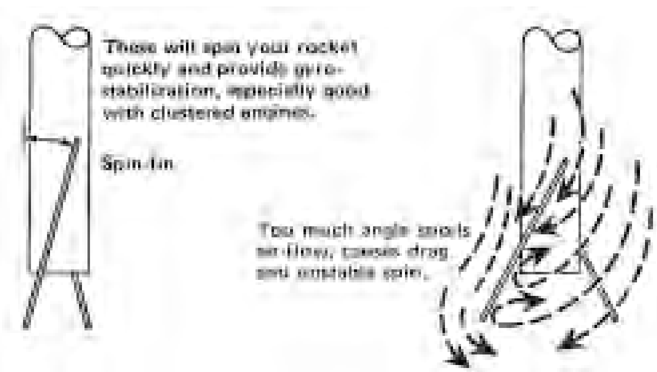
Wind Tunnel Tests

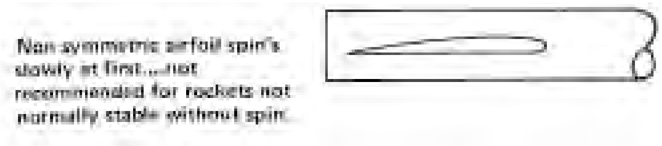
"Flying" model rockets in wind tunnels is both fun and educational. Repeatedly flying a model in a wind tunnel as the size and shape of the fins (and possibly the number of fins) are changed provides an interesting series of experiments. Without somewhat sophisticated instrumentation, quantitative results will probably best be achieved by measuring time for recovery to stable, non-oscillating flight after a given number of degrees of deflection from 'straight" flight path (no angle to attack). Effects of canard fins may be studied. Possibly a pendulum balance can be used in drag analysis.



Rotation for Stability

Mounting fins at angles, either by mistake or on purpose, to cause rotation to improve stability is a valid area for experimentation.



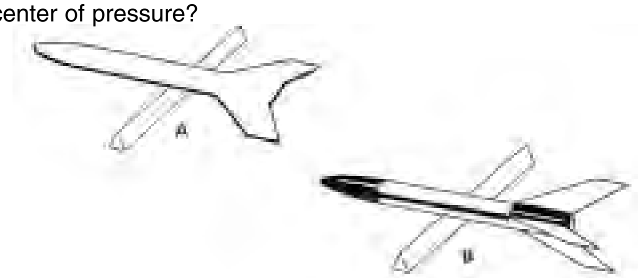


Conical Shrouds for Stability
Cylindrical Fins for Stability

Use of conical shrouds or cylindrical tube sections as fins can be checked for stability and for the effects on performance.

CLA Versus CP Determination

Does the classical cardboard cut-out system for determining center of lateral area (CLA) really give a reliable guide for finding center of pressure?



Determining the Center of Aerodynamic Pressure
Determining the Center of Gravity

Construct a rocket of your own design and perform the necessary pre-flight center of pressure and center of gravity calculations to assure its stability.

Roll Rate Study

Study the roll-rate effects of fins canted at different angles. A camcorder will provide excellent in-flight data for this experiment. The Estes Transroc II ™ may be used in this project.

Spinning Rockets As An Aid to Stability

Does spinning the rocket through using canted fins really increase its stability (gyroscopic stability)?

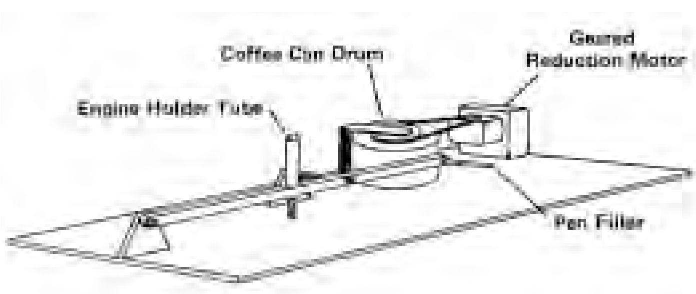
<u>MODEL</u> <u>ROCKET</u> <u>ENGINES</u>

Krushnik Effect

Conduct a series of experiments using a static thrust stand to determine the effects on thrust produced by recessing the rocket engine into the body tube by different amounts. Body tubes ("flame-proofed") from BT-20 on up can be used. A series of tests using one size of body tube and repeated firings of the same type of engine with different amounts of recession could be run. For greater accuracy, three readings should be made with each amount of recession. The amount of recession can be measured in centimeters, body tube diameter fractions or engine exit nozzle multiples. A multitude of different test series based on different sizes of body tubes could be run.

Static Tests

Construct a static test stand to secure time-thrust curve information for comparisons of the various types of model rocket engines.



Temperature Effects on Engine Performance

Determining the effects, if any, of differences in the pre-launch temperatures of engines on performance could be a good project. Finding out what effect the ambient air temperature has on the performance of a rocket when launched repeatedly with engines at the same initial temperature could yield interesting results.

Exhaust Plume Studies

What is the actual exhaust plume of a model rocket engine? Would adding an exhaust "bell" to a standard model rocket engine increase its performance? High speed photography could be very helpful on such studies.

<u>LAUNCH</u> <u>SYSTEMS</u>

Launch Towers

Developing more efficient launch systems can be a good area for research. Launch towers seem to increase rocket performance, but how, and how much? What is the best design for a launch tower?

Capacitative Discharge Ignition System
Flash Bulb Ignition System

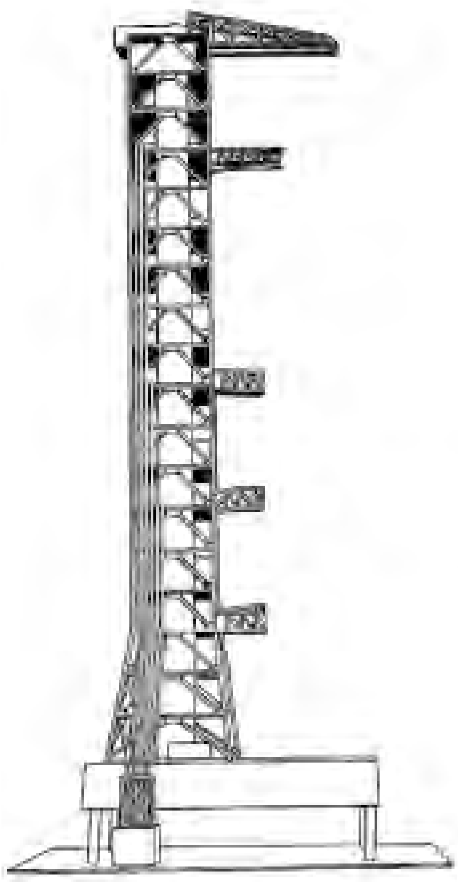
Ignition systems have received some attention, mainly in finding ways to insure ignition of clusters of engines and to minimize the weight of batteries which must be used. Research could lead to the development of a reliable capacitative discharge launch system. Such a system might be light and compact enough to use for ignition of upper state engines which are too far from the booster engine for normal staging systems to work. Use of miniature flash bulbs in ignition systems merits further research.

Closed Breech Launcher

Using a closed breech launcher appears to add altitude, even when compared to using a launch tower. How much performance, in per cent, is added by using a closed breech launcher? What is the best design for a closed breech launcher?

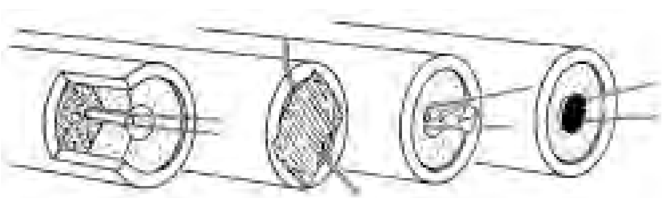
Gantries

If you have good modeling skill, you might undertake the design and construction of a launch gantry. You could scale down an existing gantry like one of the gantries used in the launch of a Saturn. Your gantry could be operational in having, in addition to providing initial guidance, such features as "navigation lights," movable sections which rotate out of the way just before lift-off, devices to do things such as switch on a camcorder just before lift-off, etc.



Effects of Igniter on Engine Thrust

Does the method you use to secure the igniter in the engine have a measurable effect on the thrust generated by the engine or the time needed for ignition to occur? Using a "plug" of tissue to hold the igniter in place, securing the igniter with a piece of masking tape or an Estes igniter plug could affect the initial pressure build-up as the engine starts thrusting. Does it make a difference which type of igniter you use? Can you design and build the "ideal" igniter?



Underwater Launch

Can you properly prepare a rocket and its launch system to perform a good underwater launch? While you may not need to do much research for theory, you will probably have to find the best solutions for a series of small practical problems.

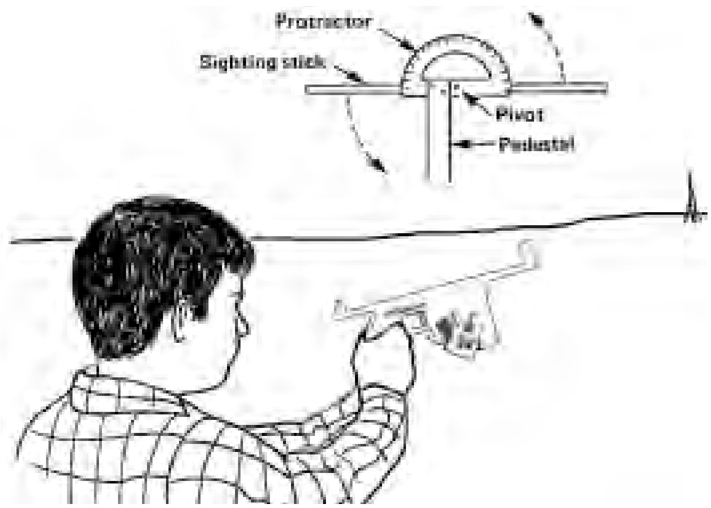
<u>ALTITUDE</u> <u>CALCULATIONS</u>

Three Dimensional Tracking

Many people are not satisfied with the currently available tracking systems. Even with good equipment and experienced trackers too many flights experience "lost track" or "track not closed." While there is not much research necessary to learn how to determine the heights reached by model rockets, designing a simple method for locating true apogee heights in three dimensions could be a very challenging undertaking.

Altitude Tracking Devices

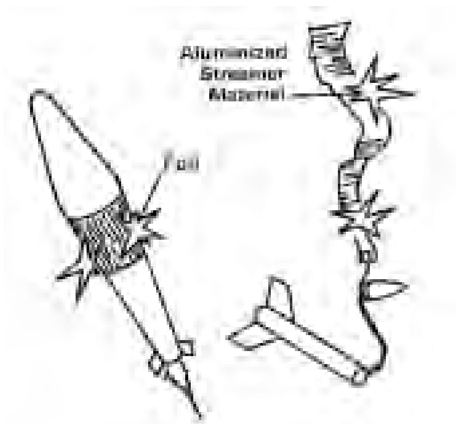
Making your own tracking device for one or two station tracking is not hard and produces a very useful device. The device should have a relatively wide field of view and still provide easy visibility for seeing the rocket clearly at great heights.

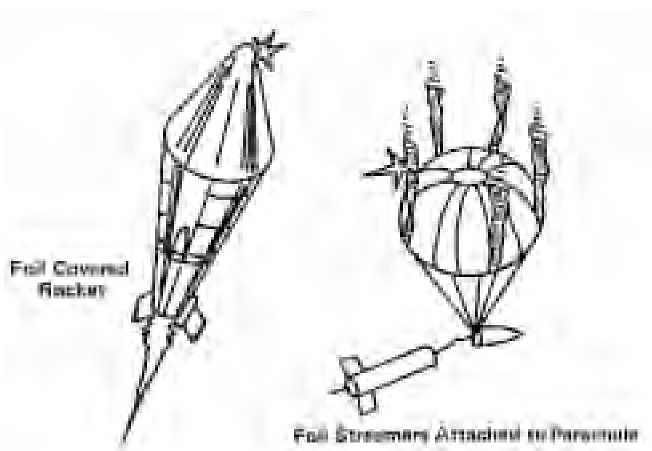


"Zoroing in" on the rocket with an AltiTrak™

Enhancing Visibility at Apogee

Developing systems to enhance rocket visibility could be a good project. Such techniques as reflective foil on the rocket body, powdered tempera paint or other highly visible, non-combustible powder above the parachute, etc. could be perfect to reduce lost tracks.





New System for Calculating Apogee

Development of an easier and still accurate way to determine apogee could be a worthwhile but demanding project.

OTHER IDEAS

The list of possible projects is not complete. Many additional good projects can be completed. Use your imagination in selecting the project that is best for you.

If you find new project ideas, why not let us know? Send your ideas to Estes Educator ™, Estes Industries, P.O. Box 227, Penrose, Co. 8l240