Scrambler

Modifying the Green Eggs Kit into the 1969 Classic

A Classic Series Project

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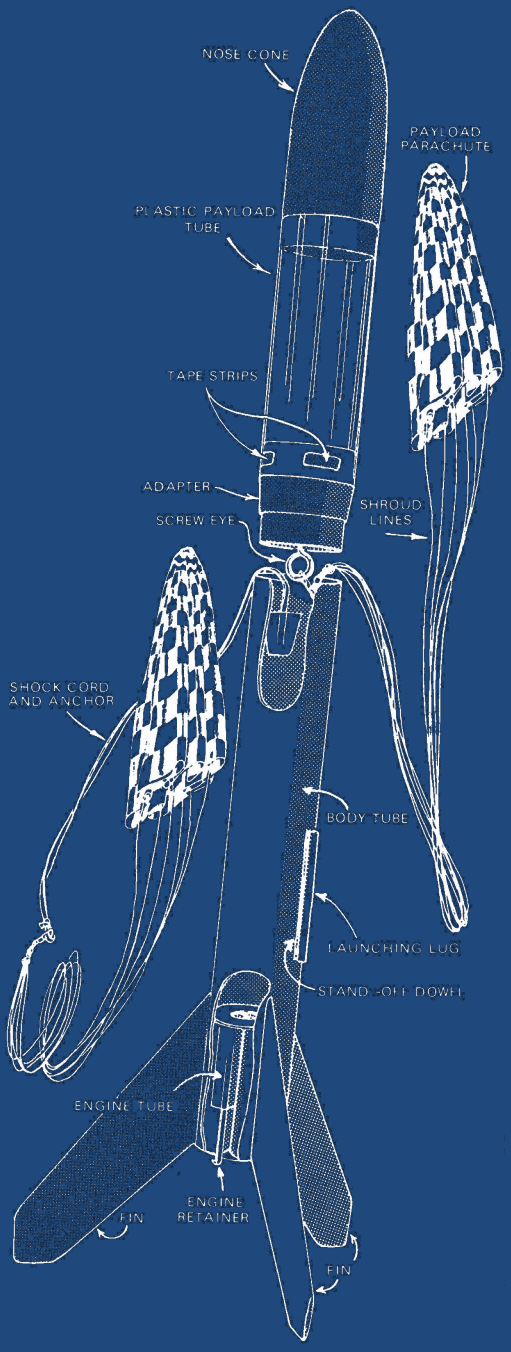
NAR 47533



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The cover drawing is from the original instructions for the Estes Scrambler, kit K-37 (Later Kit#1237 (1969-1977)

A Quick Note about the Products Mentioned

Any product that you see mentioned in this manual is listed because I bought it, use it, and found it did the job I asked of it. No person or company sent me anything. I do not receive any type of compensation if you buy anything I mention here.

A Quick Note about the Screenshots

Unless specified, all screenshots are from the Linux Q4OS distribution with the KDE Plasma Desktop.

Disclaimer/Terms of Use

The *Green Eggs/Scrambler* model rocket conversion is something you build, use and interpret entirely at your own risk. It has been designed in good faith to help educate the rocketeer about rocketry. However, this is a pilot project. Consequently, I cannot be held responsible for any losses or damages caused by reading or misreading the project instructions or constructing any components of this project. Please do not build this project if you are not comfortable with these terms of use.

AAEN gives no warranty and accepts no responsibility or liability for the accuracy or the completeness of the information and materials contained in this project manual. Under no circumstances will the AAEN be held responsible or liable in any way for any claims, damages, losses, expenses, costs or liabilities whatsoever (including, without limitation, any direct or indirect damages for loss of profits, business interruption or loss of information) resulting or arising directly or indirectly from your use of or inability to use this project manual or any websites linked to it, or from your reliance on the information and material on this website, even if the AAEN has been advised of the possibility of such damages in advance. Please do not build this project if you are not comfortable with these terms of use.



The Austin Aerospace Educational Network

The Austin Aerospace Educational Network (AAEN) is a network of projects, documents, manuals, files and more that is designed to provide you with the resources you need to perform a wide variety of projects using model rocketry. Model rocketry is a wonderful hobby, a great educational tool and just a world of fun. Model rocketry can provide a window that allows you to look towards the future, be active in present day events and peer back into history and learn from those who have gone before us.

If you like working with technology, model rocketry and computers are made for each other. You can use software to design your own model rocket and make sure it is stable so it will fly straight and true. You can create simulations of how your model rocket will perform using different motor or fin configurations. You can conduct real research projects.

How about electronics? Thanks to small micro-controllers like the Arduino and ESP 32 as well as single board computers like the Raspberry Pi, anyone can add real electronics and avionics to their rocketry projects.

You can incorporate 3D printing to create parts that currently don't exist or to bring old designs long since removed from store shelves back to life. This offers the rocketeer a way to create components for their rockets and support systems that couldn't have been imagined even 10 years ago.

But perhaps the best news is that we have only begun to scratch the surface of the hobby, as there is so much more that you can do with model rocketry. Our intention is to provide you with a full array of information on the wide and wonderful world of model rocketry, what I consider the most fascinating hobby on the planet!

The Rocketry Research Journal

Our main web site is the *Rocketry Research Journal*. This blog and web site can be found at https://rocketryjournal.wordpress.com. Below is a list what you can expect to find on our site. There is no charge for any of the information or software you find on the site. Please feel free to download and share our reports, software, technical manuals, etc.

Some of the Resources on the Journal

The web site provides a portal to a number of the resources we have available. They include:

- The *Rocketry Research Journal* blog features articles on recent projects, news from the world of rocketry (both full size and miniature) and more. Check back frequently for the latest updates.

- View our *Tech Reports*. At the time of this report there a total of twelve reports available. They cover the basics of model rocketry, an introduction to doing research, single station altitude tracking, two station altitude tracking, how to adjust your electronic altimeter to account for temperature changes, how to use a spreadsheet to calculate altitude and tips on getting started using an Arduino micro-controller, plus a while lot more.
- We have a section that focuses on the Arduino micro-controller and how it can be used in model rocketry.
- We have a section set aside for 3D printing. This includes an article on using 3D printing to build the Dyna-Soar Titan II model rocket.
- We have published several Model Plans. There are three plans currently available, but more are under development.

Our Sister Sites

We have a number of other sites that you can visit for specific rocketry projects or activities.

Source Forge Open Source Software Repository

- A Listing of All of Our Software
  https://sourceforge.net/u/austinaerospace

3D Printing File Repositories

- Thingiverse
  https://www.thingiverse.com/austin_aerospace_education/designs

CAD Files

- TinkerCAD
  https://www.tinkercad.com/users/kGt9Dmmc88b

Project Instruction/Tutorials

- Instructables
  https://www.instructables.com/member/Austin_Aerospace_Education

YouTube

- Rocketry Research Journal Video Channel
  https://www.youtube.com/@AustinAerospace

Project Manuals Available from AAEN

The Arduino Launch Control System



Our very first Project Manual is on our Arduino Launch Control System. This manual offers an introduction to the Arduino micro-controller and electronics. The manual takes you step-by-step through the process of design, breadboard, code creation and making the physical system. In addition to the instructional component the appendix contains drawings and schematics of the system, the Nano pin assignments, the complete source code listing and a listing of the parts needed to create the project.

164 pages. Adobe Acrobat (pdf) format.

https://rocketryjournal.wordpress.com/wp-content/uploads/2022/12/arduino-launch-control-system-v1.0.1.pdf

Arduino-Primary Avionics Module



The A-PAM is designed as a foundational component of an overall avionics system. As such, the A-PAM by itself really doesn't do much. It needs to be connected to another payload module or sensor array to have data to collect.
What the A-PAM does is supply power for your payload system, provide a micro-controller to conduct sensor readings and other task, utilizes a MicroSD card to record the data, and incorporates a RGB LED lamp that can be used to provide status messages in the field, when not connected to a computer. With the foundation provided for an electronic avionics system, the rest is left to your imagination.

66 pages. Adobe Acrobat (pdf) format.

https://rocketryjournal.wordpress.com/wp-content/uploads/2022/12/arduino-primary-avionics-module-v1.0.1-1.pdf

Project: Icarus



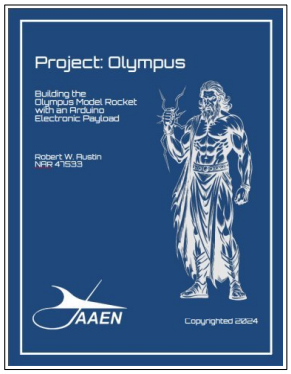
Project: Icarus is a proof of concept that brings several projects together into a single model rocketry research launch vehicle. This specific project includes the A-PAM avionics payload (listed above), temperature sensors along the body, and a video camera.

The sensors record the heat inside the body tube as the solid rocket motor burns and fires the ejection charge. They provide data on the temperature outside the motor mount, the temperature above the motor mount but below the flameproof recovery wadding and the area where the parachute is housed, just above the wadding.

112 pages. Adobe Acrobat (pdf) format.

https://rocketryjournal.wordpress.com/wp-content/uploads/2022/12/project-icarus-v1.0.0.pdf

Project: Olympus



This is a multipart engineering project that is designed to introduce the concept of building a payload model rocket kit, creating a custom designed electronic payload, and tracking your progress using the Rocketry Research Assistant software. We want to show that anyone can create an interesting rocketry science/engineering project using off the shelf rocketry kits and electronic components that are readily available.

The goal is to develop a system that can be used by high school students. It involves proven rocket designs that can be flown on school yards. It needs to be small, much smaller than the high power rockets that you typically see. It meant fitting everything into a body tube with a diameter of about 42mm (1.65 inches). This allows the use of "D" or "E" powered black powder motors. No special HPR certification is required to purchase or use these motors. No large dry lake bed required to fly these rockets.

132 pages. Adobe Acrobat (pdf) format.

https://rocketryjournal.wordpress.com/wp-content/uploads/2023/12/olympus-payload-v1.0.pdf

Project: Vulcan



Project: Vulcan is a model rocket motor test stand. Which means at its core it is a measuring device. It measures how much thrust a motor produces. We measure this thrust through the use of a load cell – the same type of electronic device that is in your weight scale. With this test stand the motor is placed in a downward position (with the motor exhaust coming out of the top). When the motor is ignited it presses down on the load-cell. That creates a small change in the electrical current and that change is measured and recorded.

The project uses an Arduino Mega2560 microcontroller (I used an Elegoo clone board) as the brain of the project. Sensors provide environmental data on temperature, humidity and barometric pressure just prior to the ignition of the motor. The system not only stores the data from the motor firing, it also keeps a log of the testing information as well as a system status log. All of this is conveniently stored on a MicroSD card so that you can easily transfer the data to any computer.

182 pages. Adobe Acrobat (pdf) format.

https://rocketryjournal.wordpress.com/wp-content/uploads/2024/10/model-rocket-test-stand-v1.0.pdf

Rocketry Research Assistant-Part 1



The *Rocketry Research Assistant* Database Project is designed to get you started in understanding, designing and creating databases. To make you aware of how databases work, to help you understand how they can be helpful in your research projects and to let you know that you can develop basic database programs and skills that can be immensely beneficial to you and your team.

With this release you will see the start of building the foundation for this database. It includes three basic forms (Projects, Team Members and Tasks) and the initial foundational tables. Our SourceForge download includes a copy of our Tech Report TR-11 “Introduction to Database Design” along with the accompanying Project Manual, “Creating the Rocketry Research Assistant-Part 1”. The Project Manual takes you step-by-step through the design and creation of the database. The Project Manual has a number of screen shots and a detailed appendix. If you have an interest in database development this is a great introductory package.

79 pages. Adobe Acrobat (pdf) format.

https://rocketryjournal.wordpress.com/wp-content/uploads/2023/06/creating-rradb-version-0.1.0.pdf

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01 Introduction

Egg lofters are a unique aspect of the hobby of model rocketry. As far as we can tell, model rocketry is the only hobby that attempts to fly and recover raw hen's eggs, unharmed. The raw hen's egg is said to represent the fragile body of an astronaut, and like their full scale astronauts, the rocketeer must exercise caution in order to secure a safe and crack-free flight.

Scrambler (Kit K-37)

The Scrambler is a historical model rocket. Released in 1969 by Estes, it was the first commercially produced egg lofter kit. The original Scrambler kit utilized a 3-engine cluster arrangement. This allowed the rocket to use a wide variety of motors, from an A8-3 when no payload was used, up to the C6-5 for getting payloads up to 1,000 feet.



The main body of the Scrambler used a BT-60 body tube, while the payload area was the slightly larger diameter BT-65 tubing.

The model also utilized a 2-parachute recovery system. The main body returned on an 18-inch diameter chute, while the payload bay returned to the ground via a different 18-inch diameter chute.

The overall length of the model was 23½ inches, and weighed in a 2.8 ounces. It's last appearance in the Estes catalog was 1977, a very long 9-year run for the model.

Scrambler 2 (Kit 1908)



Over the years several other Estes kits have flashed the Scrambler name. The next kit to wear it was the Scrambler 2.

This version replaced the 3 engine cluster with a single 24mm engine mount. The only engine recommended for this kit was the D12-5.

It did maintain the 2-parachute recovery option, however it was modified with a 12-inch parachute for the payload bay. It kept the 18-inch chute for the main body.

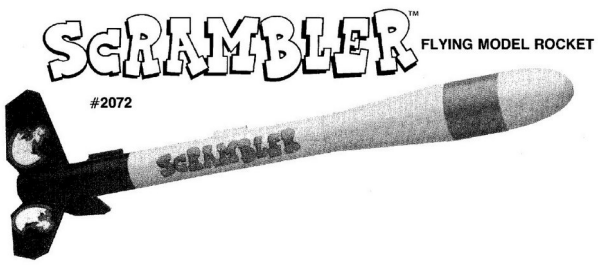
This model was slightly smaller in diameter than the original Scrambler. It utilized the BT-60 tubing for the payload and BT-55 for the body. The smaller diameter payload bay made it difficult, if not impossible, to load a standard size hen's egg in the payload bay.

Despite the smaller diameter, the model ended up being slightly taller at 25.4 inches in length. It is the heaviest Scrambler at 3.2 ounces This kit was only shown in the 1983 and 1984 catalogs.

Scrambler (Kit 2072)

The last Scrambler kit to appear in the Estes catalog occurred in 1992. This model changed up engine configuration again, sporting a single 18mm engine mount. The minimum recommended engine was the B4-2, and the only engine recommended for an egg payload was the C5-3.

This model used some odd sized tubes during construction. The main body tube was BT-56, coming in at 1.304 inches in diameter. The payload transition and nose cone were both made of injection molded plastic, with the payload bay tube being the 2-inch diameter ST-20. This increased diameter payload bay meant you could now have room to launch a standard size hen's egg.



This version of the Scrambler did away with the dual parachute design and instead resorted to the standard single 18-inch diameter parachute recovery system.

This was also the shortest Scrambler rocket produced by Estes, coming in at 21.5-inches in length and weighing in a 2.51 ounces. This version of the Scrambler was a regular in the Estes catalog through 1996.

The Green Eggs (Kit 7301) Conversion

In this project we are going to be converting a Green Eggs rocket to look like the original Scrambler model. The Green Eggs kit (Kit 7301) was first released in the 2020 catalog. It has a 24mm engine mount and uses the C11 or D12 engines. The model has an overall length of 23.6 inches and uses BT-65 tubing for the main body and the payload bay. It also uses a single 18-inch parachute.



The model's fin are very reminiscent of the original Scrambler, however these fins feature 'through-the-wall' or TTW fin mounting. We will be making a couple of modifications to the kit to get it looking more like the original Scrambler. This should be a fun build!

Project Manual Layout

While you can read the manual from cover to cover, you don't have to. By looking at the various chapters in the manual you can go directly to the area you are interested in.

02 Researching the Project

In this build we are going for the 'look' of the original Scrambler and not trying to make an exact replica. This makes the build a bit easier as we don't need to worry about clustering engines or transitions between the main body and the payload bay. However, we do need to do a few things to the model to bring it more in line with the original Scrambler.

Documentation

Before we can begin modifying our Green Eggs model into the Scrambler we need to know how the original model looked. Fortunately there are a number of pictures and plans available for this model on the web. It has always been a very popular modeling subject.

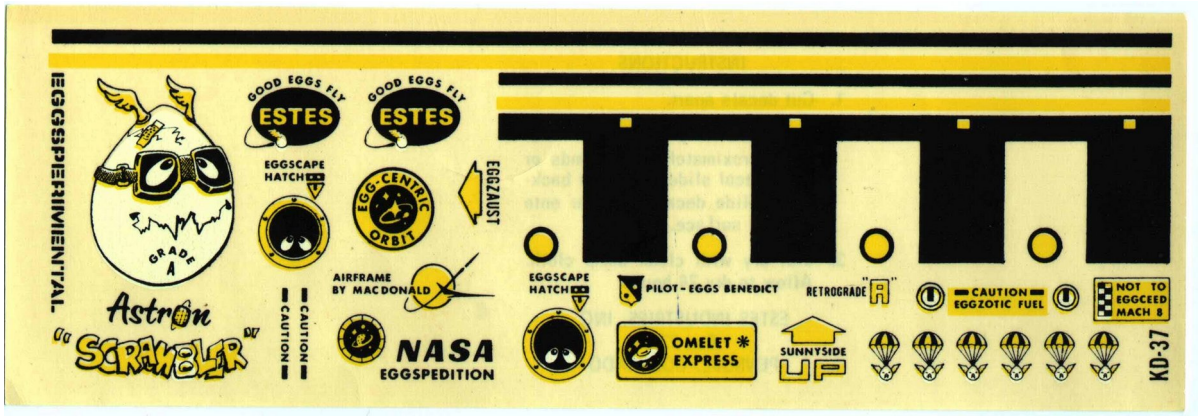
The biggest issue for us is the decals that came on the original Scrambler. While you can purchase decals from a couple of dealers, I decided to create my own based on the original decals. To find scans of the original decals there are two web sites that I will always check first. They are:

- JimZ Rocket Plans
- Ye Olde Rocket Plans

Between these two sites, you will probably find the plans, instructions and decals that have been scanned in for most any kits you want to recreate.

Decal Sheet

Once again we found the decals we were looking for on JimZ's site (https://www.spacemodeling.org/jimz/estes/k-37f.jpg). There are a lot of decals on this sheet,and the decals are just one of the things that make the Scrambler so much fun to build.



There are a couple of the things that we should notice about this scan of the decal sheet. The first is the yellow coloring. If we try to print the decals as they appear in the scan, the decals will print with the yellow tint on all of the decals. That is something we will need to try and correct.

The second issue is that there is no size reference. This is why we highly recommend that when scanning items such as decal sheets, fin sheets, etc., that a ruler be placed alongside the item. This will help getting the items right sized.

Nose Cone

The other item that we will be tackling in this build is the difference in the nose cones between the two rockets. The Scrambler uses an elliptical nose cone that has a much more rounded and blunt nose cone compared to the parabolic nose cone in the Green Eggs kit that is longer and has a more pointed shape. While it is not necessary to change out the nose cones, we will be looking at how we can create the Scrambler nose cone, and get our model to look that much closer to the original.





Overall, not a lot of changes being made to the Green Eggs kit. The bulk of the changes are simply aesthetic, but as a result they do capture the look and feel of the original Scrambler.

03 Construction

The construction of the Green Eggs rocket is typical of an Estes kit. Because of that most of the construction of the rocket will be according to the instructions. We'll highlight what changes we made as we go through the building of the rocket.

The Fins



The fins are laser cut and almost pop-out of the balsa sheet on their own. There were a couple of spots where we needed to cut the balsa tab. Use a sharp knife when making these cuts.

Because of the laser cutting process, the edges of the balsa wood are burnt and brown. They also have a slight angle caused by the laser cutter. Use a sanding block to straighten up the edges and remove the burned areas.

The leading edge of the fins should be sanded round. This is done with the sanding block as well, making sure all three fins are identical. When they are complete, set them aside.

The Engine Mount

The basic construction of the engine mount is what you expect to see in an Estes rocket. It has two centering rings, an engine hook, engine block and engine hook retainer. What you do need to be careful about is measuring the distance between:

- the two centering rings
- the engine tube aft end and the rear centering



The fin tabs will go between the two centering rings. If they are too close or too far apart, the fins will not fit properly. The aft end of the engine tube is mounted even with the body tube. If the bottom centering ring is too far aft or too far forward, the fin tabs will not fit into the slots on the body tube properly.

As I was making my engine mount I would regularly check that the fin tabs fit between the centering rings. I also double checked the distance from the engine tube to the bottom centering ring, checking alignment with the fin tab slots. Once you are sure everything is aligned properly, allow the engine mount to completely dry before moving to the next step.

Take your time with this step of the construction process. Doing so will save you headaches down the road.

Inserting the Engine Mount



Once the engine mount is completely dry, it is time to test fit it inside the body tube. Gently insert the mount into the tube. If it is too tight, lightly sand the centering rings until it glides smoothly into the body tube.

With the engine mount in place, test fit the fins. Place the fin tabs through the slots in the body tube. Check for any misalignment and make adjustments to the fins and/or fin slots. The fin tabs should fit snugly through the slots and between the two centering rings. You may need lightly sand the fin tabs to get them to fit.

The root edge of the fins should fit flat against the body tube. The bottom trailing edge fin corner should be even with the bottom of the body tube. The fin tabs should touch the engine mount tube.

Once you have everything in place with the test fit, identify each fin and its placement on the body tube. The engine hook aligns with the launch lug line. This way when you remove each fin that has been fit into place, you know that same fin will go back in properly when it comes time to glue the fins in place. Once everything is marked, remove the fins and the engine mount from the body tube.



When you are ready to glue the engine mount in place, follow the instructions. Begin by running a line of glue inside the body tube and near the top of the fin slots. Now begin to slide in the engine mount, but only partially. Do not insert it fully into the body tube. With the engine mount hanging out of the body tube, apply a line of glue around the inside of the body tube near the bottom. Then insert the engine mount in one non-stop smooth motion until the end of the engine tube is even with the end of the body tube.

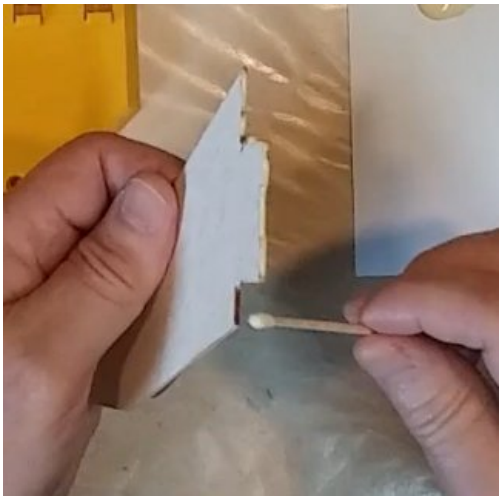
As you inserted the motor mount, the excess glue formed a fillet along the top of the centering rings. To allow this fillet to be even around the body tube and centering ring, stand the body tube straight up, with the engine mount at the bottom. Keep the body tube in this position and allow the engine mount to dry completely.



Once the engine mount has dried, turn the body tube upside down and run a glue fillet around the bottom centering ring. Do not get glue into the slot above the engine hook. Let this dry completely.

Attaching the Fins

With the engine mount completely dry, it is time to glue the fins in place. Apply glue to root edge of the fin and the fin tab. Insert the proper fin (identified from above) into the proper fin slot. Once all three fins are in place, align the fins. If you have a fin alignment guide, you can use it to keep the fins properly aligned. If you don't have anything, use the alignment guide on the instruction sheet to align the fins. Let the fins dry completely.



Once the fins are dry, you can apply fillets to the fins to strengthen the joint. You may also need to fill openings in the fin slots. If the openings are too big to fill with glue, you might consider using modeling putty to fill the gap. If you use modeling putty, let it dry and sand it smooth before applying the fillets.

The Body Tube

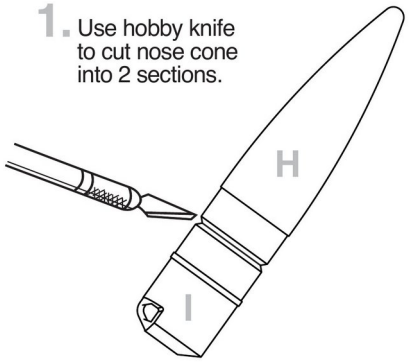
There are two things we need to do to the body tube. The first is to glue the launch lug in place. Make sure it is straight. Once it is dry, apply fillets to each side of the lug. You may need to use toothpicks or cotton swabs to get into the small area between the launch lug and the body tube.

The second item is the shock cord mount. Here we replace the rubber band shock cord with an elastic band shock cord. I also make a copy of the instruction sheet with the shock cord mount and cut the mount from the copy, leaving the instruction sheet intact.

Glue the elastic band in place according to the instructions, creating a slight curve in the mount and letting it dry. Once it is dry, glue it inside the body tube according to the instructions.

Nose Cone & Payload

The nose cone and payload adapter come as a single injection molded plastic component. There is a grove that identifies separation point between the two items. This is where you will cut the nose cone into two items as shown on the instruction sheet. While the instruction sheet shows using a hobby knife to make the cut, I prefer to use a razor saw. I find it gives me a straighter and smoother cut. However, if you don't have a razor saw, a hobby knife with a fresh blade will work just fine.



Once the two pieces are separated there is a small amount of plastic located in the eyelet of the payload adapter (Part I). Use your knife to remove this plastic, taking care not to damage the eyelet. This is where our recovery system will attach.

Creating the Scrambler Nose Cone

As we noted in the introduction, there is a difference in the type of nose cone used by the Green Eggs rocket versus the nose cone used in the original Scrambler. To get our model to appear more like the original Scrambler, we can recreate a nose cone that more closely matches the original using our 3D printer, OpenRocket, and Tinkercad.

Our recreation of the Scrambler will fly just fine with either nose cone. The creation of the elliptical cone is simply to provide a greater resemblance to the original Scrambler.

Original Nose Cone

The first step in recreating the original Scrambler nose cone is to determine the part number of the nose cone. Fortunately, that information is provided on the first page of the instruction sheet.

SCRAMBLER PARTS

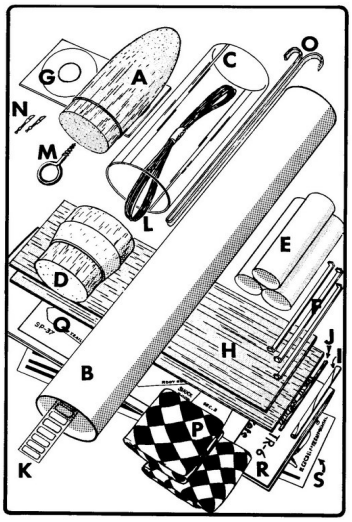
Your Astron Scrambler model rocket kit consists of the following parts as illustrated in the drawing at right:

A 1 nose cone--Part #BNC-65AF
B 1 body tube--Part #BT-60D
C 1 clear payload tube--Part #PST-65R
D 1 balsa adapter--Part #TA-6065
E 3 engine mount tubes--Part #BT-20J
F 3 engine retainer hooks--Part #EH-2
G 1 ring set--Part #RA-2060
H 2 sheets balsa fin stock--Part #BFS-40
I 1 launching lug--Part #LL-2B
J 1 launching lug stand-off--Part #WD-2B
K 16 tape strips--Part #TD-2P
L 2 108" shroud line cords--Part #SLT-18
M 1 screw eye--Part #SE-1
N 2 snap swivels--Part #SV-12
O 1 shock cord--Part #SC-2
P 2 parachutes--Part #PK-18A
Q 1 pattern sheet--Part #SP-37
R 1 technical report--Part #TR-6
S 1 decal--Part #KD-37

In addition to the materials included with your kit you will also need the following tools and supplies:

1) Modeling knife or single edge razor blade
2) Scissors
3) Extra strong white glue
4) Ball point pen or pencil
5) Fine and extra fine grit sandpaper
6) Paint or dope

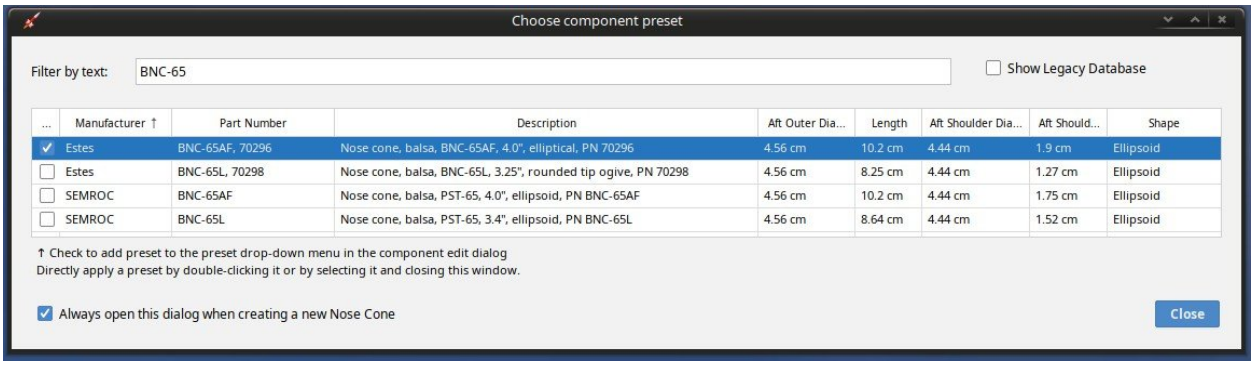
Read the entire assembly instructions carefully before beginning work on your rocket. Then start construction, following each step in order, checking off each step as it is completed.



The illustration identifies the nose cone as Part A. The listing to the left identifies part A as nose cone BNC-65AF. The BNC indicates that the original nose cone was made from balsa wood (BNC = Balsa Nose Cone). We will not be making our reproduction nose cone from balsa, but instead will turn to our 3D printer to create proper looking cone.

OpenRocket

With the part number in hand, we now turn to OpenRocket to see if it is included in its rather large database of rocketry parts. After opening OpenRocket, click on the "Nose Cone" in the "Add Components" section. The "Choose component preset" dialog box will appear. In the "Filter by text" box, enter "BNC-65". Four entries should appear (based on Version 23.09). Click on the entry for "BNC-65AF, 70296" and then click the "Close" button.



The nose cone should now be displayed in OpenRocket, along with the Nose cone configuration dialog box. Since the original nose cone was made from solid balsa, we need to make some adjustments to the nose cone for 3D printing.

The first thing we need to change is the wall thickness. We are looking at using a two wall setting for printing the nose cone. Here we set the thickness to 1mm. The next item is to remove the check from the "Filled" box. Next we click on the "Shoulder" tab and we set the length of the shoulder to 0. Once these changes have been made, click on the OK button.

Next we need to export the nose cone as an OBJ file. Right click on the nose cone and then select "Export as OBJ (.obj)" from the pop-up menu. Save the file.

Cura Slicer

The nose cone OBJ file is imported into Cura and sliced at 0.12mm quality setting. Wall thickness was set to 2. Due to the thin walls of the nose cone at these settings, a brim was added to keep the nose cone firmly attached to the printer bed.



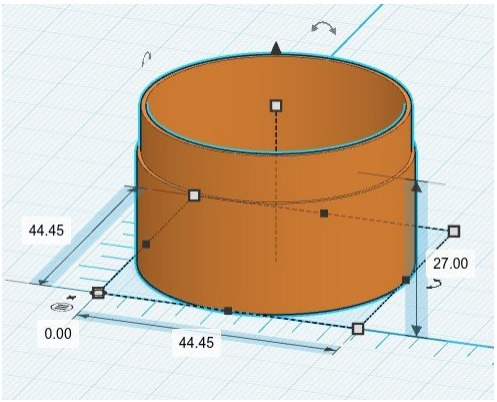
Another thing that you can do to keep the nose cone from coming loose on the print bed is to apply a layer of glue using a glue stick to the bed. When combined with the brim, this combination will almost assuredly not move or be knocked off the print bed.

We used white PLA+ filament for this print. At these settings it took about 2 hours and 45 minutes to print the nose cone on my Ender 3 V2 printer.

When the print was complete, it was noticed that there is a slight opening at the top of the nose cone where the print layers don't exactly overlap. This was addressed by adding some model putty to the inside of the nose cone. This will also help strengthen the top nose area. A small bit of putty was added to the exterior to smooth out the rough opening.

As with any FDM printer, you will have layer lines visible. I sanded down the nose cone to a fairly smooth finish using 220 grit sandpaper. This was followed by a coat of Rustoleum Primer-Sandable filler. This was sanded smooth with 320 grit sandpaper, followed by wet sanding with 800 grit sandpaper. The nose cone was now ready for paint.

Nose Cone Shoulder



The next item was to create an open ended shoulder for the nose cone. This was done in Tinkercad.

The shoulder was created using three cylinders:

- Base at 44.45 mm in diameter, 19 mm tall
- Inner shoulder at 43.25 mm in diameter, 27 mm tall
- Center hole at 42 mm in diameter, 30 mm tall

Create all three cylinders, center align them, then group all three pieces. Export the shoulder as an STL file.
The shoulder was imported into Cura and sliced using a standard 0.20 mm quality setting. Again the use of a brim was added to the settings due to the thinness of the shoulder. After slicing Cura indicated an approximate print time of 40 minutes.

The shoulder was printed on an Ender 3 V2 printer and we did add the glue stick adhesive to the build plate as we did with the nose cone. The shoulder was printed using black PLA+ and once printing was complete the fit to the inside of the nose cone was checked. Due to the fact that this would only be holding the inside of the clear payload bay, no other sanding or finishing was performed. We would not attach the shoulder until the nose cone had been painted.

Construction Completed

This completes the construction of our rocket. You could fly the rocket now if you wish. However, we plan on finishing the model in the original Scrambler livery. The next chapter will look at how we are going to prep the model for paint and finish the model.

04 Finishing

To obtain a quality finish on our rocket there are several things we need to do before the first coat of paint is ever applied. To make our rocket look like the Scrambler we will also need to create the decals that we will be using.

Prepping the Rocket

Before we do anything to the model we need to prep it. This is the process of going over the model and looking for any defects that can be corrected. If there is a gouge in a balsa fin we want to fill it and correct it before we start the finishing process.

Once all of the defects are corrected it is time to lightly sand the model using 220 grit sandpaper. This should remove any bumps or fuzz on the model. These types of imperfections will be magnified once paint is applied. Run your fingers over the model feeling for any defects. Once you are satisfied, it is time to move on to the next step – filling the fins and body tube spirals

Filling Fins and Body Tube Spirals

Next I want to fill the balsa grain in the fins. This will help me obtain a smooth surface for the primer and paint to stick to. By filling the grain in the wood we reduce the drag caused by the wood grain.

The same is true of the spirals that go along the entire length of the body tube. By filling these we create a smoother body tube and reduce the amount of drag. Both of these processes result in a much nicer looking finish.

There are any number of methods that you can use to fill the fins and spirals. A simple Google search will bring up hundreds of articles dealing with the subject. The process I will describe here is the one I use and have had very good results. It involves the use of wood filler thinned down with water.



Creating the Filler

I create my filler using either MinWax or Plastic Wood water based wood filler and water. You may find others around the web who use other types of wood filler. I have been able to obtain good results with this so I keep using it.

Mix the filler in a small container with a little bit of water. It doesn't take much water to get the filler to

the consistency of a thick paint. Make sure you stir the filler and water well as you want a nice smooth liquid without any lumps.

Filling the Fins

To start filling the fins simply brush the filler on the fins. If the filler doesn't go on smooth you may need to thin it with a bit more water. The smoother you can brush on the filler the less sanding you will need to do when the filler dries.



As you work on the fins you may find that the filler in your brush starts to get thick and harden. If this happens simply clean the brush off with a rag and some water. If the filler in the container starts to get too thick, just add a few drops of water and stir it in to get the filler back to the consistency you need.

Pay attention to the fins that you are working on. Make sure that you cover all of the bare wood with filler. This includes the leading and training edges as well as the fin tips. After the filler is dry if you find you missed a spot, simply go back and apply some filler to the area.

Filling the Spirals



If you look at the body tube you will see that there is a spiral gap that runs up the entire length of the tube. Like our fins this can be filled using the wood filler as well. You don't need a lot of filler here. I typically use a brush edge or a toothpick. Others may use an old knife blade to help get the filler into the seams. I find that if the filler is a bit thicker it fills the spirals better. While you are filling the spirals on the body tube, don't forget to fill in the spirals on the launch lug. It is made just like a body tube and has the same spirals. Filling in these spirals will help you get a nice smooth overall finish.

Sanding the Fins and Body Tube

Before you start sanding, make sure the filler is completely dry. Trying to sand the fins before the filler has completely dried will result in a gummed up piece of sandpaper and gouges in the fin and other parts.

I start with 220 grit sandpaper. This should help get the fins down to a fairly smooth finish. Don't forget to sand the leading and trailing edges. You want to sand down any filler that is on the body tube where the fin meets the body tube. Check your work and make sure that the fin is smooth and doesn't have bumps or ridges.

You want to sand down the body tube spirals the same way you did the fins. Take your time as you only need to sand down the excess filler, not the entire body tube. Don't forget to sand the launch lug as well. When you are done, everything should feel smooth to the touch.

Once you have everything feeling good and smooth with the 220 grit paper, go ahead and sand down the entire rocket with 320 grit paper. This will help get rid of the small gouges in the fins and body tube caused by the 220 grit sandpaper. It doesn't take a lot of sanding with the 320 grit paper to get a smooth surface.

Primer

With all of the prep sanding completed it is time to apply primer to the model. First I need to protect a couple areas from paint and primer before I start spraying the parts.

The primer I use is the Rustoleum "2-in-1 Filler and Sandable Primer" in gray. This is something you likely won't find in the paint aisle with all of the other colors and brands of spray paint. Instead, you will need to look in the automotive body care section. This is a primer that is used on cars to help fill in small scratches – the exact same thing we want to do here.

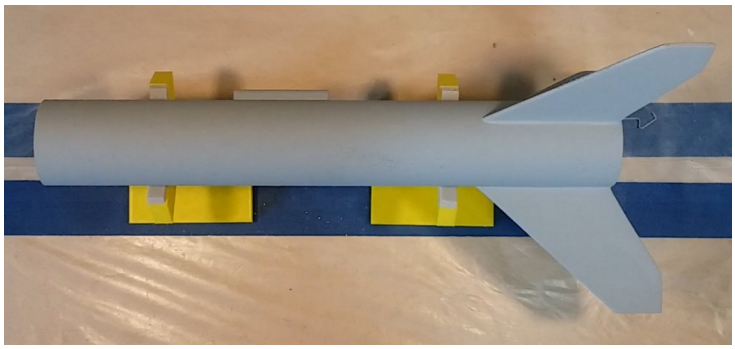
Applying the Primer

As before I used a dowel to hold the rocket while I applied the primer/paint. The dowel allows you to move the rocket around while applying primer or paint. It is a great way to maneuver the rocket to ensure you cover the entire model.



This time I used a 7/16-inch diameter dowel and a set of 3D printed adapters created just for this activity (Model Rocket Motor Mount Paint Wand Adapters by McSinned on Thingiverse: https://www.thingiverse.com/thing:4778644). Start with the 13mm adapter that attaches to the dowel. Next slide on the 18mm adapter over the 13mm adapter, and then slide the 24mm adapter over the 18mm adapter. This can now be inserted into the engine tube and you are ready to start applying primer.

Apply the primer in even coats. The primer should cover the entire model. Do not apply the primer as a single thick coat, but rather applying two thinner coats with sanding in between applications.



You want to make sure that the primer is completely dry before moving on to sanding, otherwise it will gum up on the sandpaper. It will also cause small scratches or even gouges in the primer – something we are trying very hard to avoid.

Sanding the Primer

With the primer coat completely dry, it is time to start sanding. I typically use just the 320 grit sandpaper to dry sand between the first and second coat of primer. During this part of the process I am just knocking down the roughness of the primer, as well as looking for any issues with the model. This may include incomplete fillets, areas of grain showing through, body tube spirals not completely filled, etc. After correcting any issues and sanding everything smooth, I spray a second coat of primer on the rocket.

Once the primer has completely cured, we again look for any areas that need to be addressed and take the proper corrective action. With the body tube looking smooth, it is time to sand this second coat of primer. However, unlike our previous sanding efforts that used dry sanding techniques only, this time we are going to be adding wet sanding. We want to provide a very smooth surface for the color coat to lay on. The smoother the primer surface, the better the color surface will appear.

I start with 320-grit sandpaper for this part of the process. First I dry sand to get most of the rough areas smoothed down. Once that is complete I move to wet sanding. I stick with the 320 grit, but get a fresh piece of sandpaper. I dip the paper in water and then sand then entire rocket. You will both see and feel the difference in the finish as you wet sand. Using just the 320-grit paper, you can begin a slight shine on our flat gray primer. I wipe down the rocket so that it is dry. Next I switch to 800 grit. Again, this is dipped into water and I sand the entire rocket. I am not trying to remove all of the primer. I am simply trying to get a smooth surface. I dry the rocket off with a paper towel and let it sit to finish air drying.

Because you are using water to assist with the sanding, make sure you wipe it off occasionally as you work. Our rockets are made of paper and balsa and we don't want the water to seep into either of those materials. Light sanding and wiping down the excess water will provide you with that smooth surface you desire without messing up the materials under the primer. Once you have a nice smooth surface it is time to transition to adding the color paint to the rocket.

Painting the Rocket

The overall color of the original Scrambler is white with an orange nose cone, along with one orange fin and one black fin. There is also black bands on each end of the payload bay. We'll paint our look-alike version the same way.

Painting Order

As a general rule, when painting anything you want to start with the lightest color and work your way progressively to the darkest color.



The general exceptions to this are the colors silver and gold. Here you often want a base color of black to help bring out the vibrancy in the gold and silver.

As the rocket body is to be painted white, orange and black, it meant starting with a white base coat and then overlaying the orange and then the black. As the nose cone was separate from the shoulder, the nose cone will be painted orange and then glue in the black printed shoulder. The payload adapter will be sprayed black without any primer being applied.



The bulk of the model is painted using Rustoleum 2X Gloss White rattle can paint. The orange is Rustoleum Gloss Orange and the black is Ace Premium Gloss Black.

Painting the Base Coats

Using the same dowel assembly as before to hold the rocket, I began by laying down a thin coat of gloss white on the rocket. This gave the rocket an overall white appearance, but I wanted a slightly glossier look. This first color coat took almost a week to completely cure. Once the paint was completely cured, we did a light sanding to even out the areas where the pain had bubbled and crazed. Afterwards I was able to apply a nice even coat over the entire rocket. This gave me the gloss look I was hoping for. This took about four days to completely cure.

Next came the nose cone. Since I had used white filament and sanded everything smooth I didn't need to use any primer. Instead of a dowel this time I used a paper towel tube to hold the nose cone while I painted on the orange. Again a light first coat was applied and allowed to dry for 15 minutes and then a second coat was applied to give it a smooth even finish. Both the body tube and the nose cone were set aside to dry.



Before moving on to the masking and the black and orange color coats on the fins, I let the white cure for several more days. The humidity is high where I live and as we have already experienced with the white base coat this can slow down the cure time of the paint. This is a time for patience if you really want the model to come out looking nice. Start handling the model too soon and you will find your finger prints are permanently embedded in the finish.

Masking the Fins



With the white base coat thoroughly dry it was time to move on to masking the fins for the orange and black finish. I started off by using the ¼-inch wide yellow modeling tape available at Hobby Lobby to mask off the area where the fin meets the body tube. This narrow tape makes it easier to work the tape up to the root edge of the fin and around the leading edge. Once the thin tape was in place, I laid down a strip of the wide painters tape, slightly overlapping the narrow tape. The remainder of the rocket was covered with plastic bags. You can see the bag ends pushed inside the body tube to protect it from the spray paint.

Before you spray that first coat of color you want to smooth down the edges of the tape. Take your fingernail (or other smooth object) and 'burnish' the tape edges. This will help seal the edge of the tape and prevent the colors from seeping under it. First I sprayed the orange fin. Once it cures I remove all of the tape and masking. Next I repeat the process for the black fin.

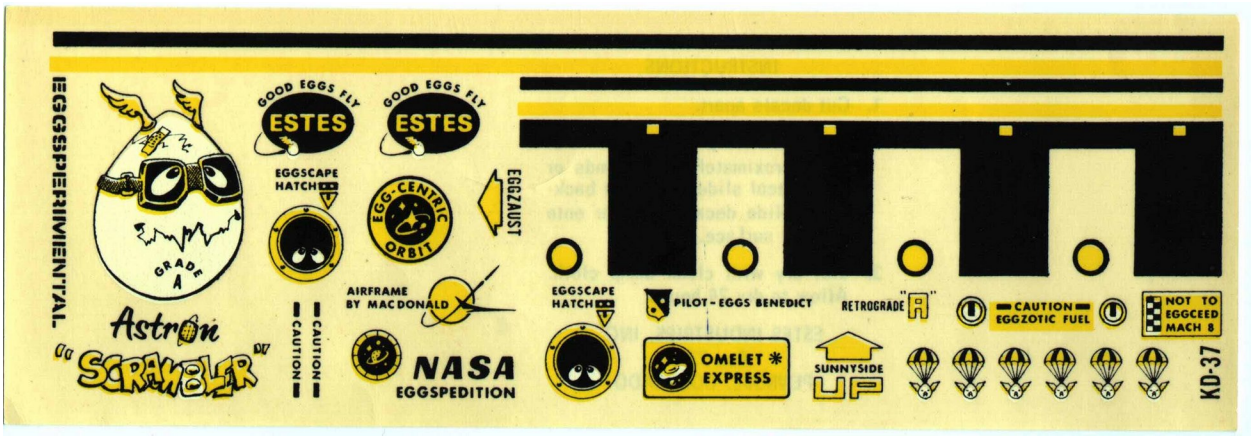
With all of the various parts painted in their final colors, it is time to set the entire rocket aside and allow the paint to completely cure. As we have already seen, depending on the paint and the conditions where you live, this can take a while. While we wait on the paint, we can move on to creating the decals.

Creating the Decals

There are a couple of routes we can take when it comes to getting decals for our Scrambler build. You can order new decals from a company like Stickershock23.com (https://stickershock23.com/product/astron-scrambler/) or you can look on sites like eBay for new old stock decals or recreations. Sometimes, however, you may not be able to find new decals but you may have a scan of the original decal sheet available. For this project we are going to go through the process of taking the original decal sheet scan, cleaning it up, and then printing a new set of decals using our inkjet printer.

Updating the Original Scan

For our project, we are going to be using the scan we found on JimZ's web site. It is included with the kit instructions and fin pattern documentation. The decal sheet is shown below.

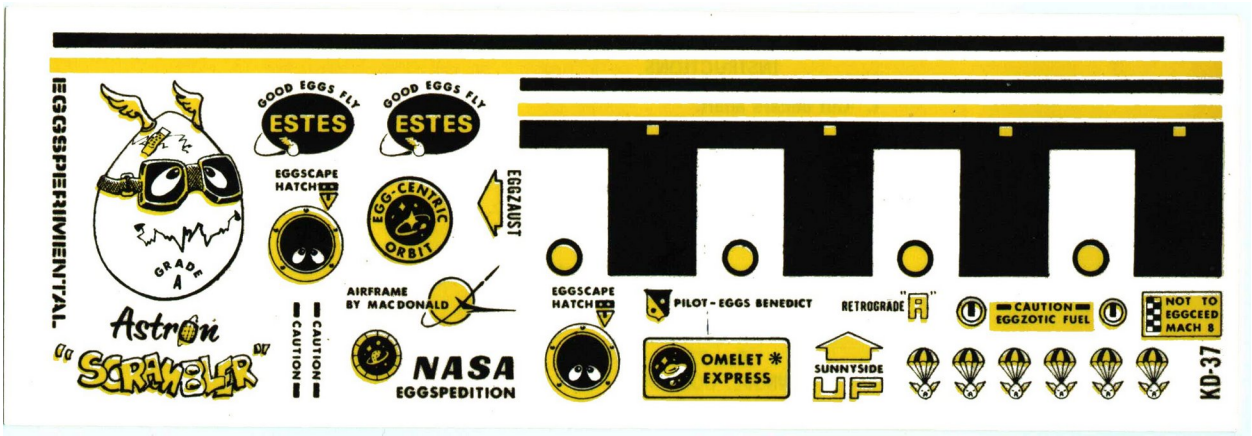


One of the first things you will notice is the yellow coloring of the sheet. This will need to be corrected or all of our decals will have that yellow tint.

The second thing to notice is that there is no size reference for the sheet. The individual who scanned the sheet didn't lay a ruler next to it so that we would know the size of the decals. For most of these decals the size is of little importance. The exception is the two yellow and black stripes and roll pattern.

Initial Cleanup

To begin to cleaning up this decal sheet the first thing I will do is import it into the Pinta graphic program (https://www.pinta-project.com). I am going to select the "Paint Bucket" option with the primary color as white. Next I set the "Tolerance" level to 36. I am now ready to apply a white fill to the entire sheet, while leaving the other other items untouched. This one action makes a big change in the decal sheet.



While this setting works in my graphics program 'Pinta' running under Linux KDE Plasma, the same settings may not provide the same results in a different graphics program or on a different operating system. You may need to test several settings to get the desired results.

Selecting Decals

This decal sheet has a lot of decals on it. In this build we won't be using all of these decals, just a few. The ones we will be using include:

- The large "Grade A" egg
- The "Astron Scrambler" under the egg
- The black and yellow roll pattern

One thing you will notice is that the scan of the decal sheet is not square. For the Grade A egg and the Astron Scrambler name, that is not an issue. However, it may be an issue for our roll pattern.

Cleaning the Roll Pattern

The roll pattern scan is a bit rough. We'll want to correct that. In order to make things a bit easier, we'll first want to straighten the scan. For this I'll import the roll pattern into a different graphics program called Krita (https://krita.org). This graphics programs has a lot more options available, and one of the options is the ability to rotate a graphic any number of degrees that you specify. In this case, we rotated the roll pattern 359.75 degrees. That gets us very close to being straight. I then save the roll pattern graphic under a different name.

Now it is time to clean up the edges and give the roll pattern a sharp look. I started with the top black stripe. I simply created a black filled rectangle and extended it slightly beyond the ragged edges. I did the same thing with the yellow, pulling out the yellow color of the original decal using the color picker option.

The next item to tackle is the black roll pattern. There are four yellow boxes at the top of the roll pattern. Before we tackle these boxes, we are going to add a layer and create four new boxes in that layer. Using the same color as the yellow strip, use the rectangle tool to create a single box that overlays one of the yellow boxes boxes on the roll pattern. Make sure that you are creating the box on the new layer. Once you have adjusted the box to the proper size, copy it and paste three additional copies over the three remaining yellow boxes. Save your work.

Now click on the base layer that contains the original decal graphic. Change your rectangle tool back to black, and draw the top part of the roll pattern. You will notice that the yellow boxes stay on top of the black rectangle. That is the beauty of layers.



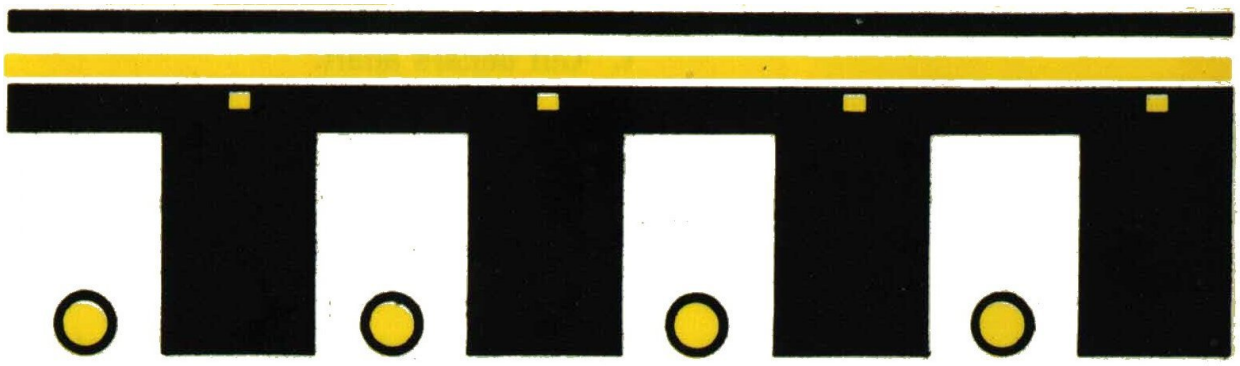
If the black bar goes over top of the yellow boxes, then the yellow box layer is below the graphic decal layer. In your graphics program, look for a screen that shows the layers in the drawing. Make sure that the yellow box layer is above the graphic decal layer.

Complete the roll pattern by drawing rectangles over the vertical boxes.

The next step is to clean up the yellow and black circles at the bottom of the roll pattern. Begin by creating a new layer for the yellow circles. Using the same yellow as the top stripe and boxes, create four new yellow circles.

Now create a new layer for the black circles. Make sure that this is under the yellow circle layer. Create the black circles and center them under the yellow circles.

The last thing I did is save the roll pattern as a JPG file. Below are two graphics of the roll pattern. The top one is the original scan from the JimZ's web site, while the bottom one is the cleaned up version of the graphic.



Original



Cleaned Up

Cleaning the Scrambler Logo and Egg Graphics

The "Astron Scrambler" logo and large egg graphic were also cleaned up. We referred to numerous pictures and catalog entries during the cleanup process. This was the most time consuming part of the project. Cleaning up these graphics involves using a paint brush or pencil tool and slowing cleaning up pixels and placing color where it needs to be. This took a couple of hours to get both graphics clean, but it does appear to be worth the effort.

The graphics below show the original scan and the cleaned up graphic.



Original Scan



Cleaned Up



Original Scan



Cleaned Up

Printing the Decal Sheet

With the graphics completed, the next step is to create the decal sheet. We will start with a blank sheet in our writing program, LibreOffice Write. The three decals were laid out as shown in Appendix A1.

Size Testing

Before we started printing the decals on decal paper, we first wanted to make sure the decals are about the right size. There was no ruler on the original scan of the decal sheet, so we have to work out the sizes we need. Another issue is that the original roll pattern decal was for a BT-60 body tube, while our 'Green Eggs' conversion body tube is a BT-65 – slightly larger in diameter.

Given the diameter of the body tube, we determined that the length of the roll pattern should be about 5.8 inches, with a height of 1.65 inches. The egg and Scrambler name decal were sized using my very own 'Mark 1' eye ball. These were laid out in a LibreOffice Writer document and then printed out on plain paper.

The paper mock up decals were cut out and placed on the rocket. The most critical item was the roll pattern. When placed on the rocket the two edges just came together. This was taped in placed using painters tape. This is what we were looking for. The actual decal will be significantly thinner than the paper and will likely overlap slightly.

Next the egg and Scrambler decals were cut out and also taped into place. With these two decals were are looking to see if they 'look right' and their approximate position. These were also held in place with painters tape.



The mock up of the decals gave us what we needed – confirmation that the roll pattern was the correct size and the overall look of the remaining decals. It was now time to move from design and testing to actual creation.

Printing the Decals

The decals were printed on an ink let printer. I used the following settings (look for similar settings for your specific printer)

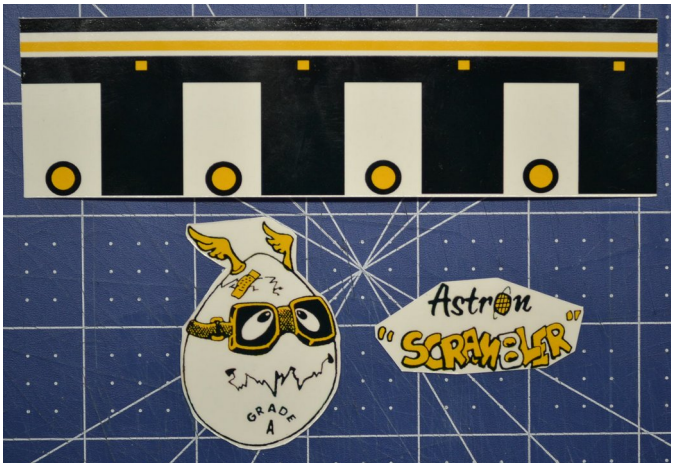
- Media Type = Glossy Photo Paper
- Print Color Mode = Deep Color (Wide Color Gamut, AdobeRGB)
- Print Quality = High
- Print Optimization = Graphics



These are very similar to the settings I would use if I was printing a photograph on glossy photo paper.

Once the decals are printed, I cut off the excess decal paper and set it aside for my next project. Next I pulled out a can of decal bonder spray. Unfortunately the Testor's spray is no longer available. I have used a clear acrylic spray with mixed success. I have been told that the Krylon Workable Fixative works well, but I haven't tried it yet.

I lightly spray two fine coats over the decal sheet. Don't use a heavy or soaking spray. This can cause the ink to run and ruin the decal sheet. Also, heavy coats will make the decal thick and noticeable once it is attached to the model. Let the spray dry between each coat. I use two coats to simply make sure all of the decal sheet is covered and thus protected.



Once the decal sheet is dry, it is time to cut out the individual decals. You want to cut as close to the graphic as possible so that as little of the decal paper itself is visible. You can use a pair of scissors to cut them out, but you will probably get better results using a sharp hobby knife.

Applying the Decals

When you apply the decals you need to take your time. The decal paper I am using is rather thin, and if you try and rush things you will find that the decal will either rip, flip, or fold back on itself, rendering the decal useless.

I started with the roll pattern. This is not only the largest decal we will be applying, but the remaining decals are placed about halfway between the bottom of the roll pattern and the top of the fins.

Prior to placing the decal on the rocket I wet the area down where the decal is to be placed. This will make it easier to move the decal around on the rocket. Once the decal moves freely from the paper, align the seam with the launch lug then slowly slip the paper away from the decal as you wrap it around the body tube. Once the decal is completely on the body tube you can begin to move it into place. Use a wet towel to help push the water out from underneath the decal once the decal is in the proper position. You can also use the towel to smooth out any wrinkles. Again, take your time and work around the decal. When you are done you should see just a slight overlap where the two ends meet.





Depending on your printer and print settings, you may find that your 'black' comes out looking gray when applied to a white background, such as our body tube color. One way to get the black color instead of the gray is to create two sets of decals. Apply the first set and let dry completely. Then apply a second decal directly over top of the first decal. The dual layers of the decal should result in a much darker black

With the roll pattern in place, you can place the egg decal, along with the "Scrambler" decal on the rocket. These should be located about midway between the bottom of the roll pattern and the top of the fins.



While nether of these are as large as the roll pattern, they are still good size decals. Care should be taken when placing them on the model, especially if the deal film is thin. Make sure to smooth out the decals with a wet rag.

Clear Coat

Once the decals have fully dried, you can determine if you want to add a clear coat. Some folks will spray a coat of gloss clear spray paint over the entire model. Others will use something like floor wax to coat the model. The purpose of the coating is to protect the paint and decals. Sometimes the model is painted in gloss colors to help with

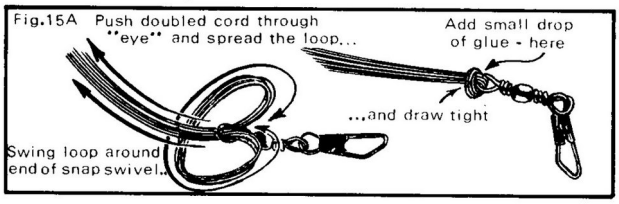
decal adhesion, and once completed is sprayed with a flat clear to mimic a military vehicle. Still others never add anything to the rocket. In the end, the choice is yours.

Recovery System

To original Scrambler used a two-parachute recovery system – one for the main body and one for the payload section. Both parachutes are 18-inches in diameter. The original Scrambler kit also came with snap swivels for both parachutes. We are going to mimic that same setup in our build.

Attaching the Snap Swivels

We are going to attach one snap swivel to the parachute for the payload section. The original instructions show the proper method for attaching the shroud lines to the open end of the snap swivel. I usually use a small drop of Fabri-Tac glue on the knot to hold it in place. I would not use CA or superglue here.

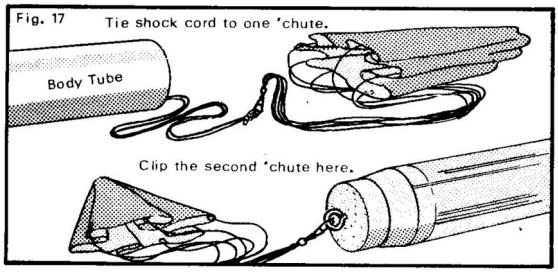


The second snap swivel will be attached to the shock cord. Insert the shock cord through the open end of the swivel and then tie it off in a knot. Again, a little bit of Fabri-Tac glue will help keep the knot secure.



For the parachute that will be attached to the body and shock cord, we are going to use a different type of swivel called a ring swivel. It doesn't have the snap connector on the end but instead it has two rings. We will attach the parachute to one of the rings using the same method we used on the snap swivel.

The parachute with the snap swivel is attached to the payload section. The parachute with the ring swivel will connect to the snap swivel on the shock cord. The original instructions show the set up in the graphic on the right.





As noted in the original instructions, if there is nothing in the payload section you will want to go to a single parachute configuration. In this case, remove the parachute that is attached to the shock cord. Then attach the snap swivel on the shock cord to the payload section.

The Completed Model

The picture on the right shows our completed model. While it is not an exact replica of the original Scrambler, it definitely gives off the look of the original. The 3D printed nose cone adds to the look of the original rocket. In the end, the rocket bears a greater resemblance to the original Scrambler than it does the Green Eggs kit that composed the foundation of this model.



We decided to go with a minimum decal set for this version. This also matches the catalog pictures. There are a number of additional decals on the original sheet that can be cleaned up and added to the rocket if desired. As with most projects, it is up to you what you want the finished rocket to look like.

We would encourage you to create your own version of the Scrambler. The Green Eggs kit offers a great base to work from. You can decide what modifications you want to do to the kit, to make it your very own Scrambler.

We are very pleased with our tribute to one of the early classics of model rocketry. We think you will like making one as well.

05
Tactics to Improve the Scrambler

Any time you build a project you should always go back and see how it might be improved. Such "lessons learned" will help you improve projects that you create later. It can also be beneficial to try some of the ideas on a current project where possible. Improvement through iteration is a valid engineering process. Companies like SpaceX have made great strides in rocket performance by trying new things, and being willing to break stuff to learn in the process. With that background, let's take a look at some of the changes, updates and improvements that can be made to this project.



Anytime you make a modification you should check the stability of the rocket before first flight. Some of these modifications may result in changes to the Center of Pressure (CP) and/or Center of Gravity (CG) which must be accounted for

Replace the Kit Body Tube with a BT-60 Tube

For those that may want to more closely follow the original shape of the Scrambler, you can replace the Green Eggs BT-65 tube with a section of BT-60. The BT-60 was the original body tube on the Scrambler. You will need to use an adapter to transition from the BT-60 body tube to the BT-65 payload section. You can check if anybody offers the transition. You can also 3D print a transition using the same method that we used for the nose cone.

Replace the Single Motor with Cluster Motors

The Green Eggs kit comes with a 24mm x 70mm engine mount. However the original Scrambler was powered by a 3 engine cluster of 18mm motors. When combined with a BT-60 main body tube (as outlined above) you get even closer to an accurate reproduction of the Scrambler. The cluster arrangement will add an increasing degree of difficulty to both the construction and the flight.

Increase 24mm Engine Mount Tube Length

If you decide to keep the single 24mm engine mount, you might consider extending the mount tube to accommodate a 95mm E12 engines. With the extended engine mount tube, you can add a third centering ring near the top of the extended tube.

This would also allow you to leave the bottom ring off, allowing access to the fin tabs during construction. This access would allow you to reinforce the fin tab glue areas, resulting in increased strength of the fin joints. Once these joints are dry you could then glue the bottom ring in place.

Appendix

A1
Decal Drawings

These drawings show the final setup of the decal sheet. This was printed onto clear ink jet decal paper using an ink jet printer. If you have a color laser printer, be sure to use laser decal paper.



If You Enjoy Rocketry, Consider Joining the NAR

If you enjoy model rocketry and projects such as the Arduino Launch Control System, Project:Icarus, Project: Olympus, the Dyna-Soar and others, then consider joining the National Association of Rocketry (NAR). The NAR is all about having fun and learning more with and about model rockets. It is the oldest and largest sport rocketry organization in the world. Since 1957, over 80,000 serious sport rocket modelers have joined the NAR to take advantage of the fun and excitement of organized rocketry.



The NAR is your gateway to rocket launches, clubs, contests, and more. Members receive the bi-monthly magazine "*Sport Rocketry*" and the digital NAR Member Guidebook—a 290 page how-to book on all aspects of rocketry. Members are granted access to the "Member Resources" website which includes NAR technical reports, high-power certification, and more. Finally each member of the NAR is cover by $5 million rocket flight liability insurance.

For more information, visit their web site at https://www.nar.org/