

Hubble Space Telescope Expert Model — Interior



HUBBLESITE

Directions

Downloads, patterns, and other information at: www.hubblesite.org/go/model

Materials:

- The patterns and instructions, which can be downloaded at www.hubblesite.org/go/model. The pattern pieces should be printed onto 32-lb paper. (You may want to have extra printouts handy in case you need them.)
- Cardboard (the weight of a cereal box is good)
- Glues: White or clear craft glue, gluestick (permanent), and superglue
- Good scissors
- A sharp craft knife with extra blades
- A metal straightedge and/or ruler
- A cutting board or similar surface

Optional (but very helpful) materials:

- Tweezers for handling small pieces
- A small paintbrush for applying glue
- Flat-edged toothpicks for applying glue and superglue
- Thin dowels and/or tapestry needles to help roll up thin tubes
- Clear spray-on sealant to protect the finished model

Before beginning construction:

1. Read all instructions carefully!
2. Have all of your materials ready.
3. Make sure a responsible adult is nearby to help out if necessary.
4. Glue all the pages that require it onto cardboard and paper ahead of time, so they can dry. If they curl up when drying, press them under heavy books.

Construction tips:

- Read through all the directions first and make sure you know where all of your materials are and what you will need to do.
- Always follow safety precautions when using a sharp blade, like the one on a craft knife.
- Have extra blades available and safely stored until you need them. Change the blade whenever it starts to become dull; a sharp blade cuts more easily and is safer to use. Dispose of used blades safely.
- Don't cut out pieces until you need them, so you can keep track of them. You can also lightly pencil the piece numbers on the backs. Pieces are numbered and labeled in the recommended order of assembly.
- Score fold lines before cutting out the pieces. This will make it much easier to fold the flaps later. Draw the edge of a narrow but not sharp object — like a butter knife or a small flathead screwdriver — along the dotted lines to make an indentation. Use a ruler to make sure your lines are straight. Alternately, you can use the “dull” side of a craft knife, with a very light pressure so you don't cut through the paper. Fold lines that are on cardboard require heavy scoring: use the point of the scissors or a craft knife to lightly cut along the line, just enough to make a small groove, but not going more than halfway through the cardboard.
- Fold the pieces and try to fit them together at least once before applying the glue.
- Very small folds are easier to make with a pair of tweezers.
- Keep your hands and your workplace clean and clear of scraps to prevent accidents and errors.
- Protect your work surface with scrap paper, especially when gluing.
- Keep your hands clean, so you won't get glue or fingerprints on your model.

Construction tips continued:

- When using white glue, apply in a thin coat with a flat toothpick or a small paintbrush. If you wait a few seconds for it to become “tacky” it will stick more easily.
- When using superglue, follow all the safety precautions on the label. Be VERY careful not to get any on your hands or skin, and do not touch pieces that have had superglue applied for several minutes, to be sure it is dry.
- Only use as much glue as is needed to cover the surfaces you’re connecting with a thin layer. Too much glue may end up on your hands or on the surface of your model.
- Be careful using sharp scissors and blades. Have a responsible adult nearby to help you if you need assistance.
- When gluing two flat pieces of paper together, use as little glue as possible. The glue stick is very helpful for this.
- Unless otherwise indicated, allow the glue to dry before going on to the next step.
- Take your time and be patient!

About the designer

Ton Noteboom describes himself as a “space age kid.” Growing up in the Netherlands, he followed the progress of the space program, hearing about Sputnik on the radio, and watching Neil Armstrong take his first steps on the Moon. But what really fascinated him was the technology – the technology that got the astronauts to the Moon, the technology that brought the journey back to people around the world.

“The force of the rockets, the hardware part – that was what interested me,” he said. “It was amazing to see pictures on the television screen, especially in that time, that came all the way from the Moon.”

He got his first cardboard model of a boat when he was 11 years old, as a present from Sinterklaas, the Dutch version of Santa Claus. The model joined his already extensive collection of plastic models, but after a short time that phase gave way to a period of model-train building that he shared with his father. And that was it until the day about five years ago, surfing the Web, that he started finding plans for elaborate paper models online.

Lured by nostalgia, and with both training in silver-smithing and job experience in construction engineering under his belt, Noteboom thought he’d give the paper models another shot. “I said, ‘Well, let’s try it,’ and it stuck,” he said. When he couldn’t find a model of the Saturn V rocket, he decided to design his own. “I didn’t start with an easy one,” he noted wryly. “You just put your teeth together and go. It took a lot of patience, paper, ink and time. It’s fascinating to see a model taking shape.”

His love of technology and engineering is evident in both the level of detail and the painstaking attention

to structure and precise construction in the 35 paper models Noteboom has designed and shared online with the world. One of the greatest compliments he’s received, he says, is from a model builder that praised the way everything about his models “fit together.”

The allure lies in constructing something three-dimensional out of a flat piece of paper, Noteboom said. “It’s intriguing to make something very sturdy out of something that isn’t. I treat the piece of paper as a piece of metal, though metal is easier because you can shape it into intricate forms. With paper you can’t.”

In addition to designing paper models, Noteboom is a licensed radio amateur hobbyist specializing in television transmissions. He lives in the small village of Rozenburg, near Rotterdam, with three cats, and handles facility operations at a local school.

More of Ton’s models can be found at <http://jleslie48.com>

About Hubble Space Telescope

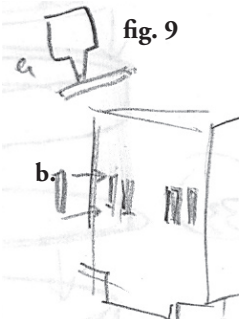
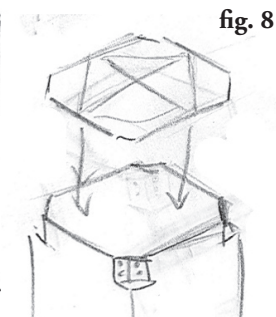
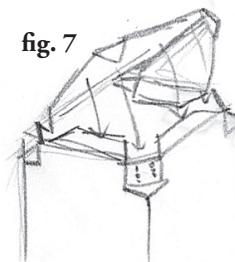
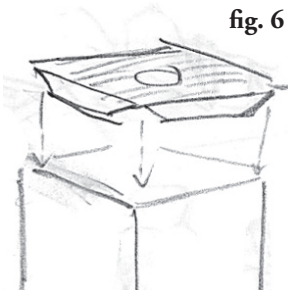
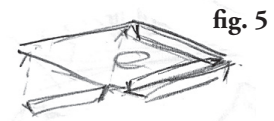
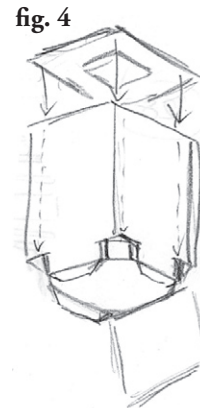
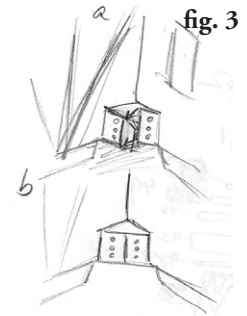
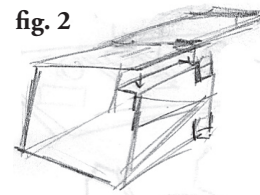
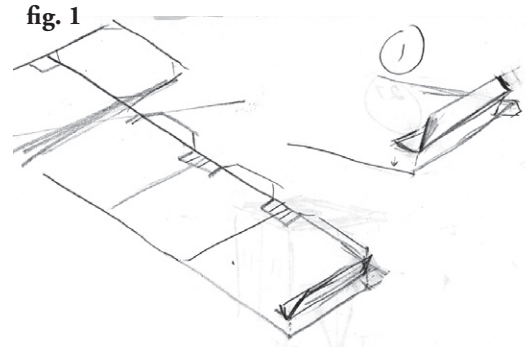
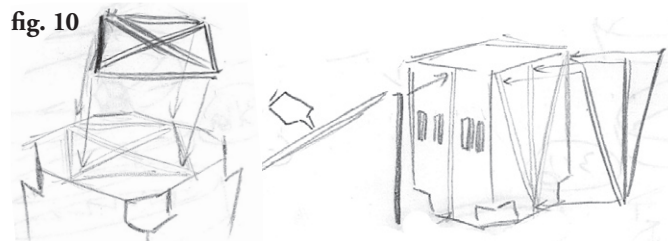
This highly-detailed model of the Hubble Space Telescope (HST) is intended for experienced model-builders. You may build only the exterior part of the model which shows all of the HST’s surface features, or you have the option of also making the removable internal structure which includes the mirrors and instruments. All of the files you need can be downloaded from www.hubblesite.org/go/model

The details of this model are based on the telescope’s configuration after Servicing Mission 3B in 2002.

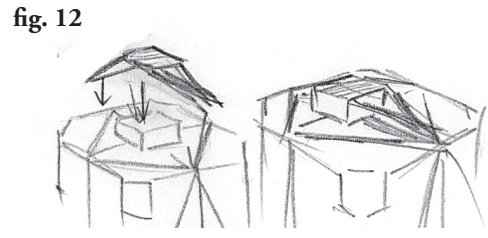
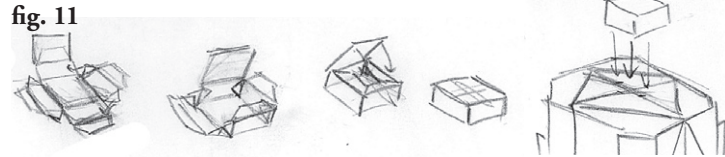
Assembly instructions

The axial science instrument housing

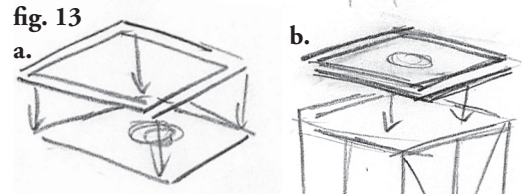
1. Score and fold glue tab 2 and glue one side of it to the back of piece 1, as shown. Be careful to line up the folded edge of the tab with the edge of the box, so that it doesn't stick out (fig. 1).
2. Fold piece 1 into a box, using glue tab 2 to close it (fig. 2).
3. Carefully glue tabs a-d behind their flaps (fig. 3); leave the end flap (marked 9) open for now.
4. Slide piece 3 inside of the box from the flap-free end until it rests against the folded flaps. Be sure the white side faces out through the triangular holes (fig. 4). Glue into place.
5. Fold tabs 5-8; glue one tab underneath each side of piece 4 on the unprinted side (fig. 5). Glue them so they are flush with the edge or a little behind it.
6. Use the free ends of the glue tabs to glue piece 4 inside the open end of the axial science instrument housing so it is flush with the edge (fig. 6). Use the opening in the bottom of the box to help you position it correctly and press down the flaps.
7. Close the box by glueing the lid onto the flaps. Be sure the folded corners go inside the box (fig. 7).
8. Glue piece 9 on top (fig. 8).
9. OPTIONAL Details: Carefully cut the yellow handrails (piece 10) and apply glue along the edges to help seal them. Glue them over the matching printed details on the sides of the box you've assembled with a drop of glue on either end. There are extra handrails in case you need them (fig. 9).
10. OPTIONAL: Glue piece 11 to the bottom of the box, over the matching pattern of grey lines. Cut the grey rails (piece 12) and seal them in the same manner as the handrails. Glue them over the grey rails on the sides of the box, trimming them to fit as you go along. There are extra rails in case you need them (fig. 10).



11. Assemble piece 13 (fig. 11). Glue it cross-side down where marked on the bottom of the box (or in that same spot on top of the grey bars, if you've used them).



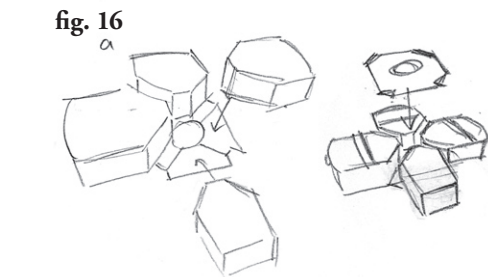
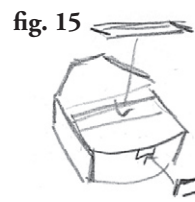
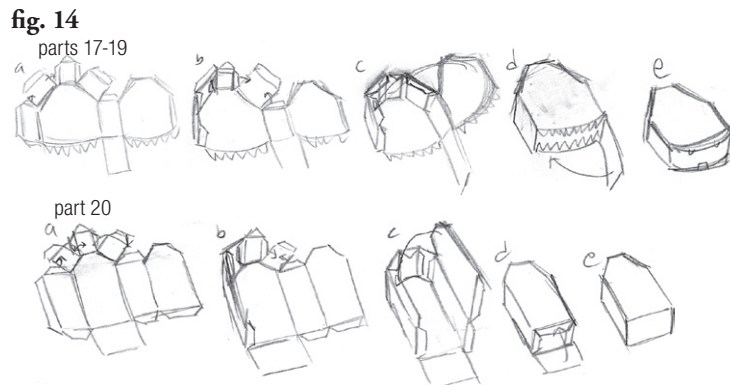
12. Deeply score and fold piece 14. Center the part on top of the small box and glue the free ends down on either side (fig. 12).



13. Cut out pieces 15 and 16 and glue them back-to-back. Glue to the top of the instrument housing box (fig. 13).

Radial Science Instruments

14. Assemble pieces 17-20 (fig. 14).

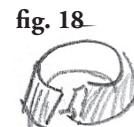


15. Glue details 21 and 22 onto pieces 17-19 where marked (fig 15).

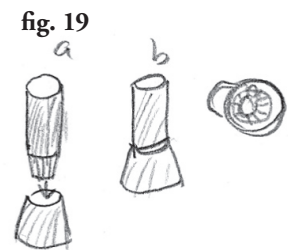
16. Glue pieces 17-20 onto piece 23, being careful to line them up with the markings. Glue piece 24 on top (fig. 16).

Fixed-head star trackers (FHST)

17. Roll piece 26 into a cylinder and glue the tab underneath. It will be easier to glue if you roll it around a thin dowel first to curl the paper, and test fit before adding glue (fig 17).

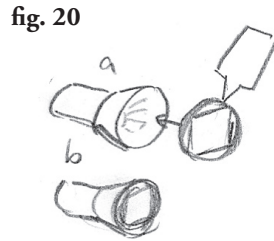


18. Roll piece 27 into an open-ended cone and glue the tab underneath. It will also help to curl and test-fit this piece before gluing (fig. 18).



19. Use the thin glue tabs on the cylinder to glue it to the cone, being sure it goes on straight (fig. 19). TIP: Apply the glue to the inside edge of the cone instead of to the glue tabs on the cylinder; bend the tabs inward to insert them inside of the cone; use a pencil to help press the glue tabs flat against the inside of the cone.

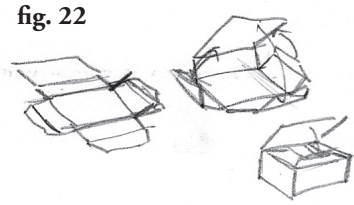
20. Glue around the edges of piece 28 and glue piece 28 inside the top of the cone to finish this camera (fig. 20). Set it aside.



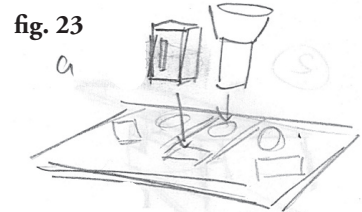
21. Repeat the last 3 steps to assemble the other two cameras from pieces 29-31 and 32-34 (fig. 21). Set them aside.



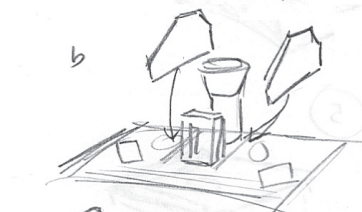
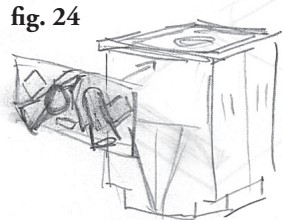
22. Score, cut and assemble the small boxes 35-37. (fig. 22). Set them aside.



23. Cut out pieces 38-40. Glue pieces 26 (the straight camera) and box 35 onto 40, making sure the yellow handle on the box faces out, away from the camera. Apply glue to the widest edge of 38 and 39 and glue them on either side, following the guidelines, so the flattened side is against the edge of 40. Glue pieces 29, 32, 36, and 37-40 where marked (fig. 23).

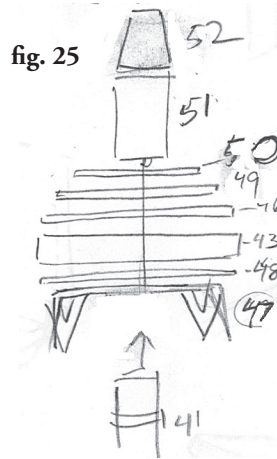


24. Glue the completed FHST assembly (piece 40) to the science instrument housing (piece 1) where marked, so that the slanted cameras are pointing down (fig. 24).

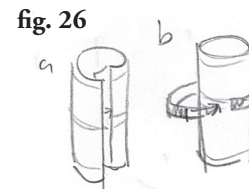


Primary mirror assembly

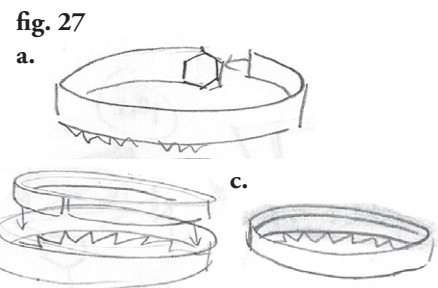
25. Reference the diagram in fig. 25 for the order of assembly.



26. Glue piece 41 into a cylinder, curling it first around a pencil. Glue piece 42 to the cylinder where marked (fig. 26).



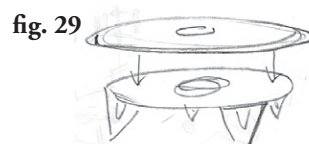
27. Using glue tab 44, score, cut and glue piece 43 into a ring (fig. 37a). Fold the triangular glue tabs toward the center of the ring, and glue piece 45 inside of the ring so that it lines up with the folded edge.



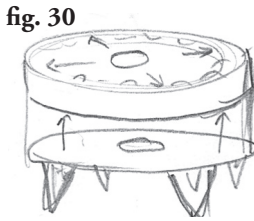
28. Lightly apply glue around the edges of piece 46 and glue it inside the top of the ring, like a lid (fig. 28).



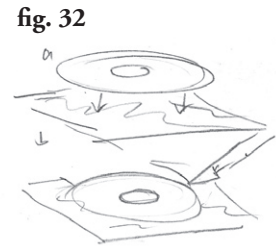
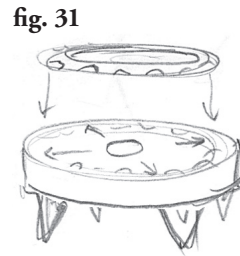
29. Deeply score the flaps on piece 47 and fold them down. Glue to piece 48 as indicated (fig. 29).



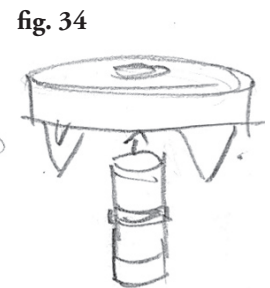
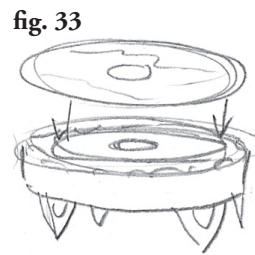
30. Glue the back of piece 48 to the ring (piece 43) using the glue tabs, being sure that the triangular flaps are pointing in the same directions as the arrows marked on the lid on the other side of the ring – piece 46 (fig. 30).



31. Glue piece 49 onto the assembled disc, using the markings on the disc to line it up (fig. 31).

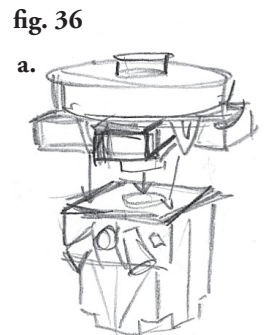
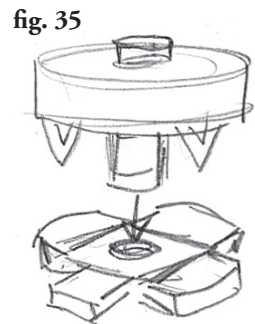


32. Piece 50 is the mirror template. Cut it out and glue your silvery reflective material to it, being careful not to get any glue on the shiny surface. Trim off any excess, including the opening in the center (fig. 32). TIP: If using aluminum foil, be sure to have the shinier side facing out. Silver Mylar also works well.



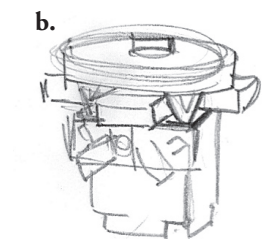
33. Glue your mirror shiny-side-up on top of piece 49 (fig. 33).

34. Test-fit all of your assembled pieces first before gluing them together. Slide the mirror assembly onto the connector cylinder (piece 41) above the black bar, with the mirror side facing out (fig. 34). A little glue will hold it in place.



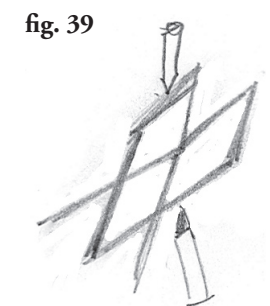
35. Slide the WF/PC-FGS module over the other end of the cylinder, so that the glued-on tabs of the FGS instruments are facing away from the mirror assembly and the triangular flaps from piece 31 are hanging down between each of the instruments (fig. 35). Again, a little glue will hold it in place.

36. Applying a little glue, slide the science instrument housing onto the cylinder. The FHST should be on the same side as the WF/PC instrument, and the points of the triangles from mirror assembly should lock INSIDE the corners of the square frame (fig. 36). They should lock into place, but if needed add a little glue to make them stay.



37. Color the backs of 51 and 52 black. Roll them into a cylinder and cone respectively, curling them around a pencil first and gluing them so that the printed side faces out. Use the glue tabs on the cylinder to glue the two pieces together (fig. 37).

38. Glue the assembly to the final end of the connector cylinder, being careful not to get any glue on the mirror (fig. 38).



Support structure

39. Carefully cut out pieces 53-59 and reinforce them with superglue for extra strength, as you did with the solar panel supports. Carefully apply a few drops of superglue along the back and/or cut edges of the trusses, using the glue applicator tip or a toothpick to spread it quickly and evenly. Be very careful not to touch the glued surfaces for several minutes, set

them aside in a safe, well-ventilated place to dry (fig. 39).

- 40. Bend trusses 53-56 carefully in the center (where they were scored). Starting with ring 57, wrap the trusses around the ring and snap them into the ring's notches where the Xs cross (fig. 40).
- 41. Insert ring 58 (which has wider notches) and do the same. The structure should be able to stand on its own, even without glue (fig. 41).
- 42. Ring 59 has marks on the top for placing the secondary mirror. Insert it into the top of the truss tube as with the other rings, with the marks facing outward. Make sure that the ends of the trusses are flush with the surface of the ring. If not, trim them a bit so they are, especially over the marks (fig. 42).
- 43. Once you're certain all the trusses are fitting properly, glue the joints together with a drop of glue. You should be able to do this without taking the trusses apart again (fig. 43).
- 44. Insert the free end of the trusses into the ring around the primary mirror, so that the marks on the top ring point in the same directions as the FGS-WF/PC instruments below. Glue with a drop of glue at each joint (fig. 44).

fig. 40

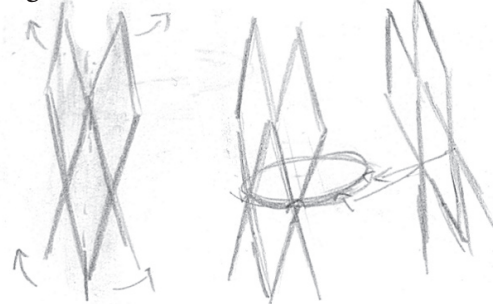


fig. 41

fig. 42

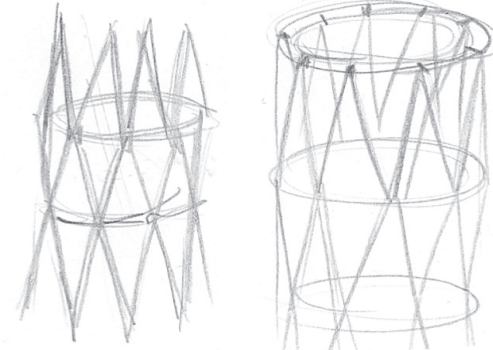
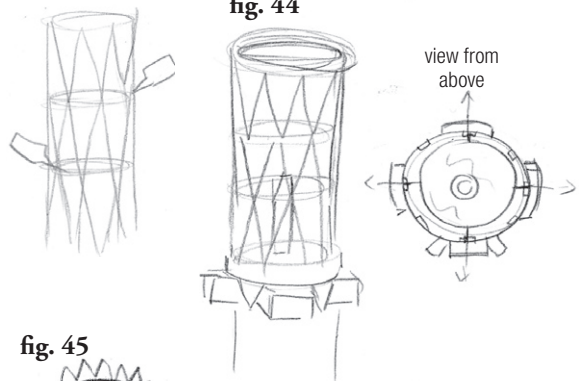


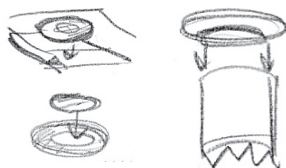
fig. 43

fig. 44



Secondary mirror assembly

- 45. Color the back of piece 61 black before cutting it out. Glue pieces 60 and 61 into cylinders, with the printed surface on the outside, after curling them around a pencil (fig. 45).
- 46. Color the back of piece 62 black before cutting it out. Glue the tab of piece 62 underneath its free end, making a loop with a slight angle to the sides (fig. 46).
- 47. Using the thin glue tabs on the larger cylinder (61) attach it to narrower side of the loop (62) as you did with the FHST cameras in step 15 (fig. 47).
- 48. Glue the backing piece (63a) to the back of piece 63 before cutting it out. Glue piece 64 to piece 63 where indicated (fig. 48). You may want to color the cut edge of 63 black.



49. Apply a little glue around the edge of the inner circle (piece 64) and glue it into the flat end of the smaller cylinder, like a plug (fig. 49).

fig. 45

fig. 46

fig. 47

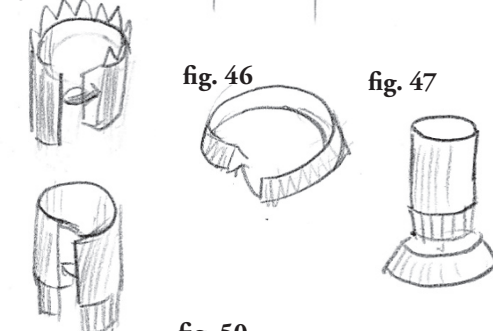
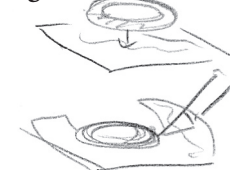


fig. 50



50. Glue a small piece of your reflective material to the back (unprinted side) of piece 65 to make the secondary mirror. Trim it to fit (fig. 54).
51. Apply a little glue around the edges of your mirror and insert it just inside the free end of the larger cylinder, like a lid (fig. 51).
52. Use the glue tabs on the smaller cylinder to glue the two cylinders together (fig. 52).
53. Mounting brackets: Fold pieces 66-69 in half along the fold and glue together. Carefully cut the triangular-shaped pieces out (fig. 53).
54. Apply glue along the short side of each of the triangles and glue them to the short cylinder of the secondary mirror assembly where the guidelines are. They should stick out at a 90° angle to the cylinder and to each other, and the longer “finger” at the pointy end of the triangle should be toward the top (the flat end) of the assembly (fig. 54).
55. When dry, glue the completed secondary mirror assembly to the support trusses where marked. The secondary mirror should be facing directly into the center light baffle on the primary mirror (fig. 55).

fig. 51



fig. 52

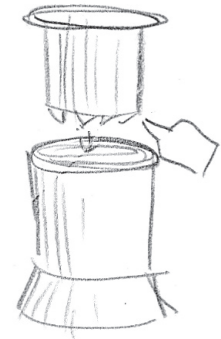
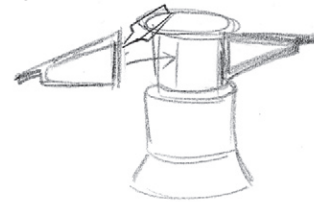


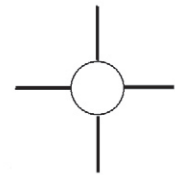
fig. 53



fig. 54



view from above



56. OPTIONAL: You may want to spray the completed structure with a clear matte aerosol varnish to protect the surface. If you do so, follow all safety precautions on the spray and use in a well-ventilated area. To avoid getting spray on the primary mirror, make a paper tube to wrap around the trusses and tape it closed. Stand the instruments upside-down on top of this makeshift structure and spray only the the instrument end (fig. 56).

fig. 56

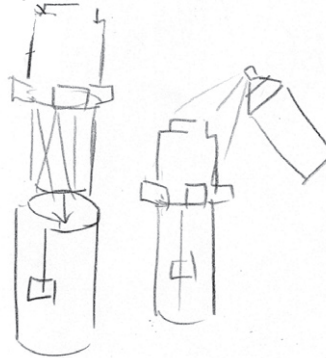


fig. 55

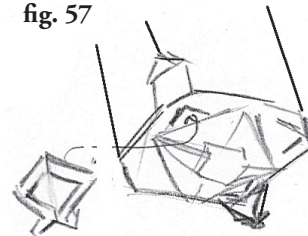


If you're making this structure to be a stand-alone item, you are now finished!

If you would like the instruments to go inside of the telescope exterior model, follow the next few steps:

57. Score and cut out pieces 70-73. Fold these brackets at a 90° angle. Position and glue them to the bottom of the instrument housing as illustrated (fig 57).

fig. 57



58. Set the telescope base on a flat surface face down; if seen from below, the two yellow “L” shapes on the bottom would be pointing toward you. Stand the instruments on the bracket legs in the center of the telescope base so that the FHST assembly is pointing toward you. Carefully lower the fully-assembled telescope body over the top so that the three circles on the aft shroud that represent the exterior openings for the FHST are pointing toward you. You may have to shift the position of the instrument assembly a bit to make sure everything goes in straight, but try to make sure everything is still pointing in the right direction.
59. Carefully remove the telescope body without moving the instruments inside. Mark where the feet of the connector brackets are resting on the telescope base.
60. Glue the connector brackets down where your markings are. Before the glue has time to dry, carefully slide the telescope body over it again to make sure it is lined up correctly. Let it sit for a few minutes until the glue is completely dry.

You are now finished with your own Hubble Space Telescope!

We want to hear from YOU!

If you've finished a model, why not share it with the world? Take a picture and send it in; we may post it on HubbleSite. Please visit the model gallery for details and to see what other people have made

www.hubblesite.org/go/model