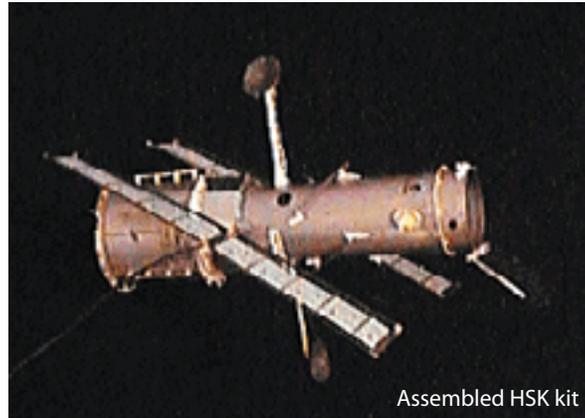


Hubble Space Telescope



Space Craft SCIENCE KIT

Assembly Instructions

Web Version 3.2

The photo shows an assembled HST Space Craft (tm) SCIENCE KIT.
These instructions are for use with the "Online Kit" laser-cut Parts Sheets.

1. ASSEMBLE THE AFT SHROUD.

HST's AFT SHROUD is a cylinder which surrounds the spacecraft's optical instruments and some other equipment. It has doors and handrails for servicing on orbit by astronauts.

Select the small rectangular Parts Sheet C from the kit. Find the words AFT SHROUD at one end of the silver side. Smear a small amount of low-moisture glue, using a glue stick, along the whole end, covering the words AFT SHROUD, and making the glue-smear exactly 1/2 inch (13mm) wide (measure first, and mark with pencil). Make sure the glue extends all the way to the edge of the paper which is below the words AFT SHROUD. Use of low moisture glue is intended to prevent making the seam soggy, which would cause an uneven bend in the resulting cylinder.

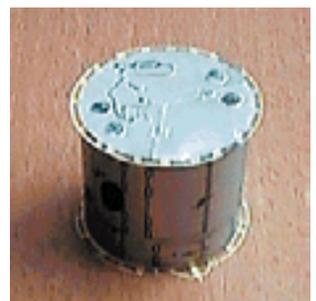
Bring the opposite edge around, forming a cylinder with the silver side out. Overlap exactly the measured and marked 1/2 inch (13mm) onto the glue, covering a little of the printed detail. Adjust so that the overlap is straight. Press and hold the surfaces together tightly until the glue sets. It helps to insert a ruler into the cylinder and press the seam. Avoid creasing the tube, so it remains round.

From parts sheet A release the circular AFT BULKHEAD (labelled on the back). Place it silver-side down on your work surface. Look for the letter K near the edge at one point (K will mark the direction to the Keel fitting, later).

Set the cylindrical AFT SHROUD down on top of the AFT BULKHEAD so that the seam, as viewed from outside, is aligned with the K. SCI's address inside should be down toward the AFT BULKHEAD. Apply glue to hold them together, and let dry.

From parts sheet A release the circular PRIMARY MIRROR ASSEMBLY. Place it silver-side down on your work surface. The protrusion near the letter K is the Keel fitting.

Turn the AFT SHROUD over, and set its open end down on top of the PRIMARY MIRROR ASSEMBLY so that the middle of the 1/2-inch glued seam is aligned with the K. Apply glue to hold them together, and let dry with a flat object, like a coaster, balanced on top to press down.



2. ASSEMBLE THE TELESCOPE TUBE.

HST's Telescope Tube is actually two parts: the Optical Telescope Assembly is a precision-engineered truss which holds the secondary mirror in exactly the right position. Forward of this is a shade called the Forward Light Shield which protects the optics from stray light.

Select Parts Sheet D from the kit. Find the words OPTICAL TELESCOPE ASSEMBLY and FORWARD LIGHT SHIELD along one end of the silver side. Smear a small amount of glue, using a glue stick, along the whole end, covering the wording, and making the glue-smear exactly 1/2 (13mm) inch wide (measure first, and mark with pencil). The glue must cover all the way out to the edge.

Bring the opposite edge around, forming a tube with the silver side out. Overlap exactly the measured and marked 1/2 inch (13mm) onto the glue. (If it overlaps less than 1/2 inch, other parts will not fit.) Adjust so that the overlap is straight. Press and hold the surfaces together until the glue sets. Insert a wooden ruler through the tube to press the seam against. Impart a curve to the seam to match the tube's curve. Be careful not to crease the tube anywhere, keeping it as evenly round as possible.

Set your previously assembled AFT SHROUD down with the PRIMARY MIRROR ASSEMBLY facing up.

Set the TELESCOPE TUBE down, centered on the PRIMARY MIRROR ASSEMBLY so that the seam is on the side across from the keel fitting. SCI's address should be at the bottom. Adjust the tube so that the Keel fitting, marked with an arrow, is centered below and between the two black circles on the tube. To be precise, the printed arrow should align midway between the letters P.O in SCI's address at the base of the tube.

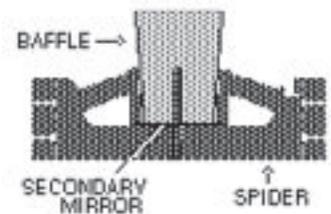
(The silver circle representing HST's Primary Mirror may not be exactly centered... sorry, this was due to a manufacturing error, which you can read more about if you want.) Apply glue to hold them together, and let dry.

Anyway, make sure the TELESCOPE TUBE is centered atop the AFT SHROUD, even if the silver circle is not.



3. INSTALL THE SECONDARY MIRROR.

HST's Secondary Mirror is held in exact position (within 0.0025mm) by graphite-epoxy trusses in HST's Optical Telescope Assembly. In HST's Cassegrain optical system, the Secondary receives light gathered and reflected from the hyperbolic Primary Mirror. The Secondary's own precise curvature reflects and focuses the light down through the hole in the Primary, into the cameras and other scientific instruments in the Aft Shroud.



From parts sheet B release the two halves of the SPIDER. Place them together slot into slot as shown, but turned at right angles to each other, to form a + when viewed from above. Secure with glue and let dry.

From sheet A, release the small, circular, silver SECONDARY mirror. Place it silver side up onto the cross beams below the arrow in the illustration above. The edge of the mirror will snap into four small notches as it comes in contact with the crossbeam. It will be a tight fit, causing the SPIDER to deform slightly. Secure with a droplet of glue at each notch.

From sheet A, release the BAFFLE. Wrap it around a pencil, curling it so its hashmarked end will be overlapped. Smear some glue over the hashmarked end. Wrap the other end around and overlap it so that the hashmarks are covered. This will create a cone-shape. Press the surfaces together, using a pencil inside, till the glue sets.

Set the completed BAFFLE narrow end down, onto the silver SECONDARY MIRROR inside the SPIDER, as shown below. Secure with glue.

Out at the ends of each of the four SPIDER legs there are 3 prongs. Bend the middle prong slightly one way, and the other two slightly the other way, on all 4 legs.

Place the SPIDER inside the TELESCOPE TUBE with the silver SECONDARY MIRROR pointing aft toward the PRIMARY MIRROR. Adjust the bends in the SPIDER's prongs so that they brush against the inside of the tube enough to hold it in place.

Work the SPIDER into the TELESCOPE TUBE with long-nose pliers, so that its top is 2-1/2 inches (65mm) down from the end of the tube. It will meet the truss printed inside. Turn the SPIDER so that one leg points in the same direction as the keel fitting. Secure with glue.



4. INSTALL THE EQUIPMENT MODULES.

The Support Systems Module and Optical Telescope Assembly Equipment Section house electronics and computers for attitude control, command processing, flight science data processing, etc. They also house components such as radios, batteries, and other support systems.

IMPORTANT CORRECTION: Refer to the back side of HST Parts Sheet A:

- o On the part labelled OTA EQUIPMENT SECTION:
Change OTA to read SSM.
- o On the smaller part labelled SSM EQUIPMENT SECTION:
Change SSM to read OTA.

From sheet A, release the large, silver SSM (Support Systems Module) EQUIPMENT SECTION. Bend so it becomes roughly circular, with the silver outside. Pinch a crease into each of the 9 hinges between the bays. Glue the tab at one end over the other end, connecting the ends together.

Bend up the 10 bottom (non-silver) hinged sections toward center, forming a bottom shelf at right angles

Bend the 10 top (silver) hinged sections toward center, forming a top shelf at right angles.

Apply glue to the bottom shelf and slip the SSM EQUIPMENT SECTION down over the TELESCOPE TUBE until it rests on the PRIMARY MIRROR ASSEMBLY. Rotate so the corner with the tab seam points to the keel fitting. Apply more glue if necessary, and let it dry.

From sheet A release the SOLAR ARRAY SUPPORT. Holding the side with silver toward you, bend each hinged section down away from you to form triangular struts. Place the tabs into the slots, twist, and secure with glue.

Apply glue to the crosshatched area. Stand the telescope in front of you, tube up, keel fitting pointed away from you. Set the SOLAR ARRAY SUPPORT down on top of the SSM EQUIPMENT SECTION, the open portion of the U-shaped loop pointing away from you. Position it so the struts are perpendicular to the keel fitting.

Apply glue where the triangular struts touch the TELESCOPE TUBE. Support the struts so that they extend straight out from the tube, and wait for the glue to dry thoroughly. If you're comfortable using a hot glue gun, this is a good place to use it.

From sheet A release the silver & yellow OTA (Optical Telescope Assembly) EQUIPMENT SECTION. With silver facing you, crease 10 vertical hinges, folding the panels away from you.

On the back of the OTA EQUIPMENT SECTION, you'll see 22 black panels. Fold each one back 90 degrees, away from the silver side. Don't bend or break the yellow handrails.

Three black dots identify the bottom side of the OTA EQUIPMENT SECTION. Apply glue all along the 9 bottom segments, and set it onto the surface identified by three black dots on the SOLAR ARRAY SUPPORT. Wrap it against the tube, from strut to strut. Its yellow handrails face up along the tube. Apply additional glue if necessary and let dry.

5. INSTALL THE FORWARD HANDRAIL.

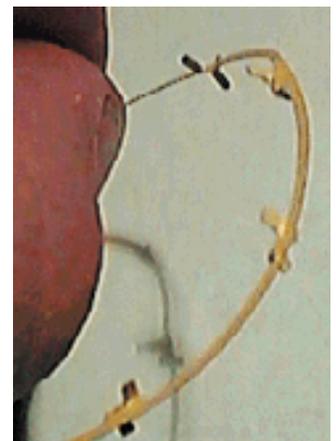
This is one of several handrails which help make it convenient for astronauts to handle and service the HST on orbit.

Working the handrail prongs From sheet B release the circular FORWARD HANDRAIL. There are eight pairs of prongs facing inward. Bend each prong of one of the pairs in opposite directions, one up and one down, and fold them all the way back. Repeat with the remaining seven pairs. Try not to distort the yellow ring, and be very careful not to tear it. (If you do tear the ring, it can easily be glued back together; just let it dry thoroughly before proceeding.)



Slip the FORWARD HANDRAIL over the front of the tube. It should not be too tight a fit. Slide it about halfway down to the word NASA. Pinch the yellow ring near each of the pairs of prongs so that the prongs fold down against the tube. This should cause the ring to tighten against the tube.

Slide the FORWARD HANDRAIL up until the yellow ring is 1/2 inch (13mm) below the black line near the end of the tube. Rotate it until one pair of prongs is over the seam in the tube. Adjust parallel with the black line. Secure with a droplet of glue at each prong.

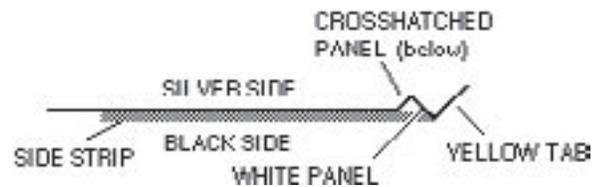


6. INSTALL THE APERTURE DOOR.

Normally wide open during scientific observations, the aperture door closes automatically if the HST reverts to its "safe" mode, and prevents bright sunlight, moonlight, or earthlight from inadvertently flooding the instruments through the telescope.

From sheet A, release the large APERTURE DOOR. With the silver side up, crease the two narrow side strips down 90 degrees. Turn it over, black side toward you, and fold the crosshatched panel down away from you. Fold the white panel back toward you. Fold the yellow tab back away from you.

Hook the ends of the white panel into the ends of the folded side strips. Apply glue and let dry. Viewed from the side, the result should look like this:



Bend the two halves of the yellow tab slightly toward each other, rounding the tab where it will glue to the TELESCOPE TUBE.

Smear some glue on the yellow tab. Position it at the end of the TELESCOPE TUBE with the silver side up, right about on the seam, and the aperture door protruding out past the end of the tube. The joint between the yellow tab and the white panel should be right at the end of the TELESCOPE TUBE. Adjust the APERTURE DOOR slightly so that its center stands straight out from the tube, and the small tab at the bottom of the door is directly in line with the keel fitting. Press and hold until the glue sets.

If you would like the door to remain open, bend it about 45 degrees up from the tube, and apply extra glue to the hinge to stiffen it there.

From sheet A release the small DOOR LATCH. Holding it silver side up, bend the two side panels down 90 degrees. Apply glue to the crosshatched area, and press it onto the end of the TELESCOPE TUBE across from the APERTURE DOOR hinge. The slot in the DOOR LATCH should just protrude past the end of the tube. Let the glue dry.

If you would like to close the door, bend it down and work its tab into the DOOR LATCH.

7. INSTALL THE HIGH-GAIN ANTENNAS.

HST has two steerable High-Gain Antennas. These are used for communications: receiving commands and sending science data and spacecraft health data. They maintain point on TDRSS satellites (Tracking and Rata Relay Satellite System) which in turn communicate with Earth — the people at the Space Telescope Science Institute.

HGA assembly from sheet B, release one black HIGH-GAIN ANTENNA. (HGA) Identify the two wedge cuts. Apply glue beside one wedge cut, and overlap the adjacent section onto the glue 1/8 inch (2mm) at most, so the flat circle begins to bend into a shallow cone. Hold until dry. It helps to squeeze the seam with long-nose pliers. Repeat for the remaining wedge cut. You should end up with a shallow cone shape.

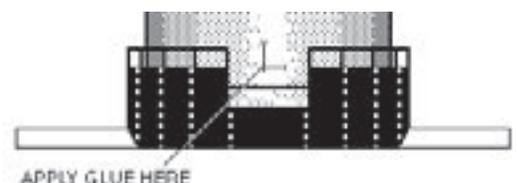


From sheet B, release an HGA BOOM. Fold the crosshatched panel, together with its attached runner, 90 degrees toward the white surface (either direction), forming an L-shaped beam. Bend the entire black end-part over 90 degrees to the boom (either direction).

Insert the white protrusion at the end of the HGA BOOM into the slot on the HGA, bringing the crescent-shaped part up to the slot. The white protrusion ends up inside the HGA bowl. Center it up and secure with glue.

Repeat the above three steps with the other HIGH-GAIN ANTENNA and HGA BOOM.

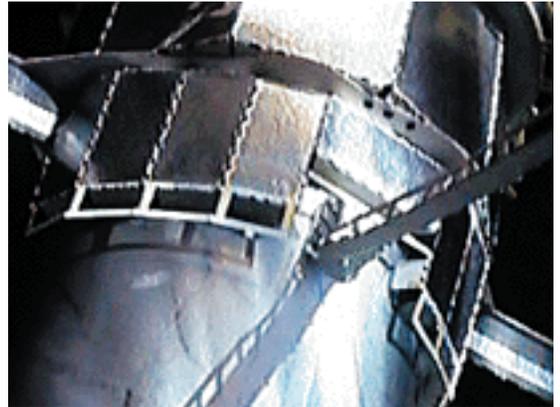
Set the telescope down lengthwise, with the keel fitting resting on your work surface, and immobilize it. Apply some glue to the tube in an L shape in the location shown here, even with the top of the equipment bays. This is a good place to use a hot-glue gun if you are comfortable using one.



Apply glue to the L-shaped base of the HGA boom. Allow it, and the L-shaped glue application on the TELESCOPE TUBE, to set until they are about half-dry.

Place the glue-covered, L-shaped base of the HGA boom down onto the L-shaped glue patch on the TELESCOPE TUBE. Hold it until thoroughly dry, with the HGA boom standing straight out from the TELESCOPE TUBE. It does not matter which way the HGA dish faces, since it is free to articulate on the actual spacecraft, but the HGA BOOM must come out perpendicular to the SOLAR ARRAY SUPPORTS.

In a similar manner, glue the other HGA BOOM to stand straight out from the other side of the TELESCOPE TUBE. The two HGA BOOMS should be exactly in line with each other. When you look down the telescope tube, you should see the SOLAR ARRAY SUPPORTS and the HGA BOOMS exactly perpendicular, and aligned with the SPIDER inside.



8. INSTALL THE SCUFF PLATES.

The scuff plates provided structural protection and some support during the HST's trip to orbit in the Space Shuttle's cargo bay. The Keel fitting and the Trunnions provided the main structural connections between the HST and the Shuttle.



From sheet A release one yellow AFT TRUNNION SCUFF PLATE. Place its I-shaped slot over one yellow trunnion which protrudes from the PRIMARY MIRROR ASSEMBLY, 90 degrees on either side of the keel fitting. Fit it at right angles to the trunnion, with the curved side facing in the direction of the keel fitting. Secure with glue.

Repeat with the other AFT TRUNNION SCUFF PLATE, on the opposite side.

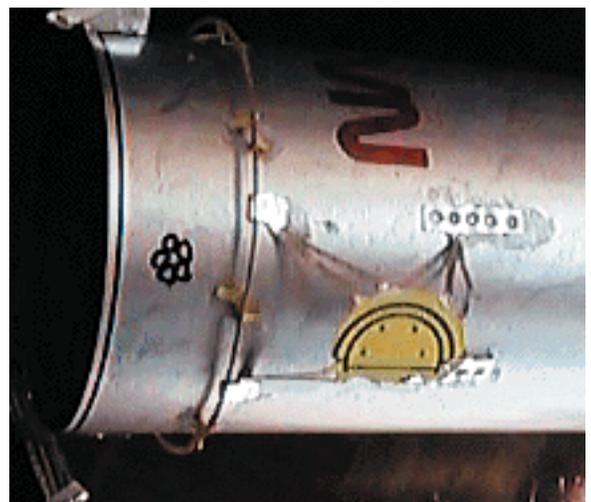
From sheet A release one yellow and silver FWD SCUFF PLATES. Hold it with the yellow and silver side towards you. Bend its four silver legs down away from you, making a crease where the silver legs meet the edge of the yellow plate.

Bend the four silver foot-pads up towards you, and adjust all the bends so the piece will sit like a table on a flat surface.

Release the other FWD SCUFF PLATE from Sheet A, and prepare as above. Apply glue to the bottoms of the foot-pads on both pieces.



These SCUFF PLATES will be placed on opposite sides of the forward TELESCOPE TUBE, even with the word NASA. Each piece is different, and can only go on one side, as follows: The long foot-pads with holes will face aft, and the curved edges of the yellow plates will face in the direction of the word NASA. They go at 3 and 9 o'clock, if the aperture door were at 12. Secure with glue in the locations described above. The yellow plates should be in the same plane as the AFT TRUNNION SCUFF PLATES. Adjust and reposition as necessary, before the glue dries, so they will be symmetrical.

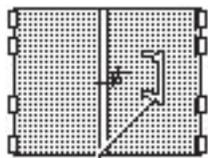


9. INSTALL THE REMAINING HANDRAILS.

From sheet B release the three yellow LONG HANDRAILS. Fold the prongs of each pair in opposite directions. Apply glue to the prongs of one HANDRAIL, and mount it standing up off the seam of the AFT SHROUD, aft of the printed doors.

Apply glue to the prongs, and mount another handrail, also running fore and aft on the AFT SHROUD, in the open spaces beside the black printed ovals as shown:

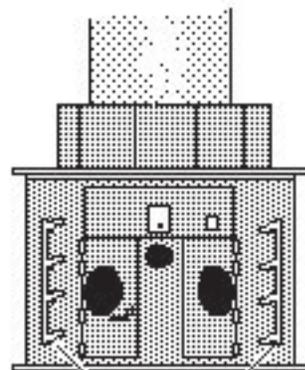
From sheet A release the two yellow SHORT HANDRAILS. Fold the prongs of each pair in opposite directions.



HANDRAIL

On the AFT SHROUD locate the printed door latch aft of the AFT TRUNNION SCUFF PLATE:

Apply glue to the prongs of one HANDRAIL, and mount it standing up off the AFT SHROUD, beside the latch as shown above. Repeat with the one remaining short handrail on the other side of the telescope.

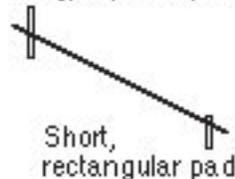


HANDRAILS

10. INSTALL THE MAGNETIC TORQUERS.

HST does not use rocket thrusters for controlling its attitude, as many other spacecraft do. The thruster exhaust would eventually condense on the optics and contaminate the instruments, deteriorating performance. Instead, when torque is needed (for desaturating, or changing speeds of the internal reaction wheels), an electric current is switched into the appropriate set of Magnetic Torquers — long electromagnets — which interact with the Earth's own magnetic field, applying the desired torque to the HST spacecraft (For more information, see the HST Fact Sheet and select the large illustration).

Long, tapered pad



Short, rectangular pad

From sheet B release one of the four MAGNETIC TORQUERS. Fold it in half along the hinge down the middle; start by creasing it over the edge of a metal ruler. Apply glue to hold each pair of pads together at the ends.

Hold the black rail part of the torquer, and twist the pad at one end about 45 degrees to the rail. Twist the pad at the other end so it parallels the first one. It should be able to stand on a flat surface now. Orient them as shown (viewed from above).

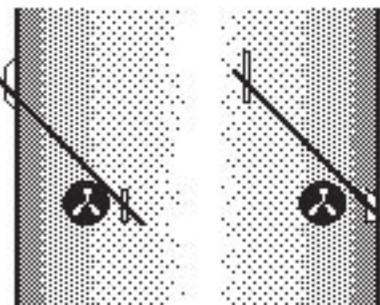
Prepare the three remaining torquers in the same way.

Hold the TELESCOPE TUBE with the word NASA right-side up in front of you. Locate the two black circles near the base of the tube, one to the right, and one to the left of the centerline defined by the keel fitting.

Wet the bottoms of a MAGNETIC TORQUER's pads in glue. Place the short rectangular pad about 1/4 inch to the right of the right-hand black circle on the tube. Align the pad straight fore and aft. The rail of the MAGNETIC TORQUER extends forward at 45 degrees. Set the other pad onto the tube to hold the torquer in place. Apply more glue if necessary, and let dry.

Repeat with another MAGNETIC TORQUER, placing its aft pad about 1/4 inch to the right of the left-hand black circle.

Repeat with the two remaining MAGNETIC TORQUERS, continuing them around on the opposite side of the telescope tube. The four torquers should be equally spaced around the tube.



10. INSTALL THE SOLAR ARRAYS.

You're very near completion of your HST model.

The Solar Arrays twist in unison to follow the Sun as the spacecraft rotates to observe objects in the universe. Covered with photovoltaic cells, the arrays convert sunlight directly into electrical current, to power all the HST's systems.

From sheet B release a SOLAR ARRAY. Bend a 90-degree crease into both of its long, lengthwise dark-grey edge-hinges, folding down away from you. Begin by bending them over a straightedge such as a metal ruler.

Apply glue to the yellow area on a SOLAR ARRAY SUPPORT strut. Position the middle of the SOLAR ARRAY onto the

glue, with the hinge-folds facing away from the support strut. Position it so that the support strut extends halfway across the SOLAR ARRAY. You will be gluing the support strut to half of a gold-colored mid-section on the array. Be careful with alignment. If you view the model from directly above the keel fitting, the two-dimensional impression should be that the solar array and the telescope tube are parallel.

Repeat with the other SOLAR ARRAY, checking for symmetrical alignment.

10. INSTALL THE LOW-GAIN ANTENNAS.

HST's Low-Gain Antennas (LGAs) provide omnidirectional communications for periods when the HGAs are not in touch with TDRSS and Earth. They are small antennas, which provide for wide angular coverage, so they do not have to be pointed precisely. They are incapable of providing high-rate data communications that the HGAs provide.

From Sheet A release the two small LOW GAIN ANTENNAS (LGA). Bend their prongs back about 90 degrees in opposite directions. Apply glue to the prongs of one, and install it on the side of the TELESCOPE TUBE, up at the foremost edge. Set it between a 4 and 5 o'clock position as viewed looking down into the tube, if the APERTURE DOOR were at 12 o'clock. The LGA should point outward and slightly forward.

Apply glue to the prongs of the other LGA, and set it on the AFT BULKHEAD on the letters LGA. It should point slightly outward from the center. NOTE: skip this step if you want to display your completed HST model by standing it upright on its AFT BULKHEAD.



Congratulations! This completes your HST SCIENCE KIT Model.