

Mars'98 Orbiter

1/24 Scale Model Assembly Instructions

This scale model of the Mars'98 spacecraft is designed for anyone interested, although it might be inappropriate for children younger than about ten years of age. Children should have adult supervision to assemble the model.

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1 SETUP

1.1 DOWNLOAD AND PRINT

- o You'll need Adobe Acrobat Reader software to read the Parts Sheet file. You'll find instructions for downloading the software free of charge from Adobe on the web page where you found this model.
- o Download the Parts file from the web page to your computer. It contains paper model parts on several pages of annotated graphics.
- o Print the Parts file with a black & white printer; a laser printer gives best results. It is highly recommended to print onto card stock (such as 110 pound cover paper). If you can't print onto card stock, regular paper will do, but assembly will be more difficult, and the model will be much more fragile. In any case, the card stock or paper should be white. The Parts file is designed for either 8.5x11-inch or A4 sheet sizes.
- o Check the "PRINTING CALIBRATION" on each Parts Sheet with a ruler, to be sure the cm or inch scale is full size. If it isn't, adjust the printout size in your printing software.
- o Print out these instructions, too.

1.2 YOU WILL NEED THE FOLLOWING TOOLS

- o A good pair of scissors.
- o An art knife, such as X-ACTO #11, with a sharp new blade. Children must have adult supervision, of course, to use an art knife. You'll also need a cutting surface such as a linoleum pad, or thick chipboard, when using the art knife. Use caution: one can hurt oneself, or the furniture, with an art knife.
- o Glue. Use regular white glue (Elmer's Glue-All® or equivalent). You might also try a thick white glue, sold in art and fabric stores, called "TACKY GLUE" (Aleen's or equivalent).
- o Low Moisture Glue, such as a glue stick.

- o A round pencil or dowel to warp curvature into some parts.
- o A metal ruler to use as a straight edge.
- o A BLACK wide tip marker to use for coloring some parts.
- o A YELLOW wide tip highlighter to use for coloring some parts.
- o A BLUE wide tip highlighter to use for coloring some parts.
- o OPTIONAL: Flat Black spray paint.
- o Space. Set up a well lighted, comfortable work area, with room to set glued parts to dry.
- o Time. Don't hurry. Plan to spend several hours for assembly. About 5 hours would probably be minimum if you concentrate solely on assembly. It can easily be done in shorter steps, however, over a period of several days.
- o Patience. There may be trying times. But remember that extra care, and time, will pay off with a surprisingly accurate representation of the spacecraft.

1.3 BEFORE BEGINNING ASSEMBLY

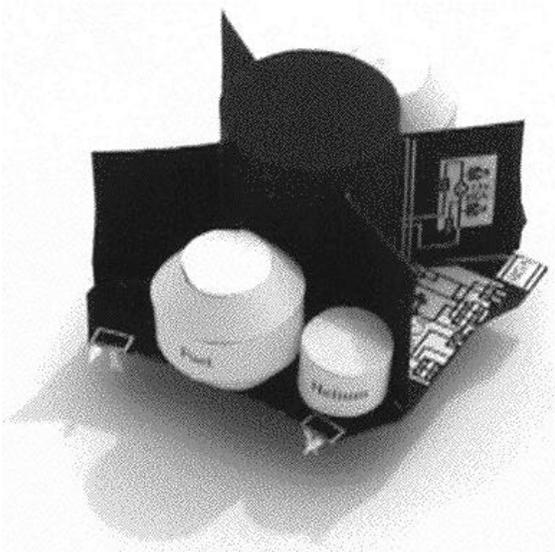
- o **Read all of these instructions.** Compare model parts with images. Examine the Parts Sheets and read the names of all the parts.
- o Get your bearings: During assembly, you'll notice that the spacecraft's axes are indicated. These three imaginary lines pass through the center of mass of the spacecraft, and are labeled X, Y, and Z. The Z axis goes up and down. The general directions for the X and Y axes are indicated on the parts. The axis directions can also be used to point to a side of the spacecraft. INBOARD means toward the center, OUTBOARD means outward from center.

1.4 OTHER NOTES

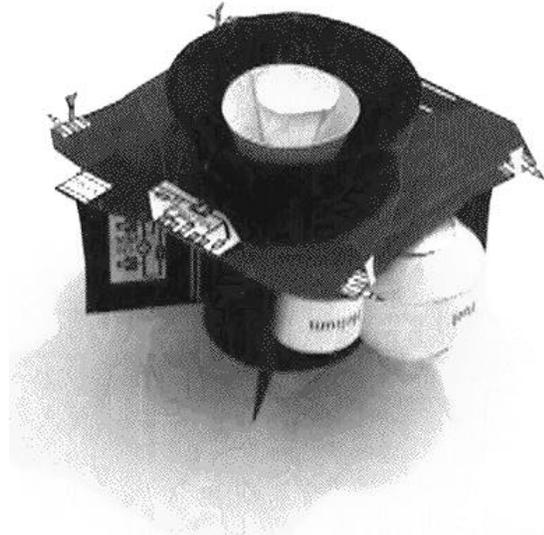
- o Sections marked with a • may be accomplished at the same time if two or more people are working on assembly, or if you wish to work on one section while glue dries on another. In fact these steps were performed separately in building the actual spacecraft.
- o What to cut out? Each part is drawn against a shaded background. This shading appears gray when printed on a black & white printer. Each part should be completely cut away from its shaded back-ground. Some parts have areas within them of shaded gray. These areas should be cut out of the part. Spacecraft details are printed on most of the parts. Don't confuse these with background shading. If there's any question, look at it on a color computer monitor: all the background shading appears blue: if it isn't blue, don't cut it away.
- o When you finish cutting out a part, flatten it.
- o If an instruction doesn't say which way to fold something, then fold with the printed side on the inside of the part.

- o When instructed to fold a part, consider scoring it first. To do this, line up a metal ruler or straight edge along the line to be folded, and very lightly scratch it with an art knife, only breaking the surface of the card stock. You have to be very careful not to cut through if you do this. While this is more time consuming, it will result in much neater folds, and will help the parts fit together properly.
- o If you cannot print the model parts onto card stock (such as 110 pound cover paper), then skip over the steps which indicate to “VERY lightly score using a modeling knife.” It is highly recommended to print onto card stock.
- o When instructed to roll a part, wrap the part around a dowel or round pencil. This will make a more even curvature in the part. Alternatively, try “drawing” the part between your finger and the sharp edge of a table or desk to warp curvature into the part.

• 2 ASSEMBLE THE PROPULSION MODULE



Propulsion Module (Top View)



Propulsion Module (Bottom View)

a. Prepare Propulsion Module Deck

- 1) Cut out the Propulsion Module Deck from Parts Sheet 1. Cut out the inside hole of the Propulsion Module Deck before cutting the remaining portion of the part from the parts sheet. Cut out the SA Mount Doubler from Parts Sheet 1. For this step, use a low-moisture glue such as a glue stick. Smear a thin film of glue on the back (non-printed) side of the SA Mount Doubler and apply to the bottom (non-printed) side of the Propulsion Module Deck, aligning the notches of the SA Mount below the +Y side of the Propulsion Module Deck.
- 2) Cut out the Fuel PIA (Propellant Isolation Assembly) from Parts Sheet 1. For this step, use a low-moisture glue such as a glue stick. Smear a thin film of glue on the back (non-printed) side of the Fuel PIA and apply to the bottom (non-printed) side of the Propulsion Module Deck, aligning the notches of the HGA Mount on the Propulsion Module Deck. The Fuel and Oxygen Propellant Isolation Assemblies isolate all components between the propellant tanks and the thrusters.
- 3) Place the part under something heavy (like a book) on a flat surface, and allow to dry.

b. Assemble Lower Propulsion Module

- 1) Cut out the L/V (Launch Vehicle) Interface Ring from Parts Sheet 1. Using a BLACK marker, color the unprinted side black. Using a pencil or dowel, form the part into cone by rolling the part to impart a curved shape with the printed shading on the outside. Smear a thin film of glue on the uncolored tab, overlap the opposite edge onto the glue, and adjust as necessary to make an even conic section.

- 2) Cut out the Main Engine Lower Mount from Parts Sheet 1. Form the part into cone by rolling the part to impart a curved shape with the printed shading on the INSIDE. Smear a thin film of glue on the uncolored tab, overlap the opposite edge onto the glue, and adjust as necessary to make an even conic section.
- 3) Apply a thin bead of glue to the smaller opening of the L/V Interface Ring, and place the larger opening of the L/V Interface Ring on the work surface. Place the larger opening of the Main Engine Lower Mount onto the L/V Interface Ring, centering the part over the Interface Ring.
- 4) Cut out the Main Engine Upper Mount from Parts Sheet 1. Apply a thin bead of glue to the smaller opening of the Main Engine Lower Mount, and place the printed side of the Main Engine Upper Mount onto the Main Engine Lower Mount. This will build a set of parts with black printing on the inside of the conic sections.

c. Assemble the Main Engine

- 1) Cut out the Main Engine Heatshield from Parts Sheet 1. Form the part into cone by rolling the part to impart a curved shape. Smear a thin film of glue on the tab marked GLUE, overlap the opposite edge onto the glue, and adjust as necessary to make an even conic section.
- 2) Cut out the Main Engine Lower Bell from Parts Sheet 1. Form the part into cone by rolling the part to impart a curved shape. Smear a thin film of glue on the tab marked GLUE, overlap the opposite edge onto the glue, and adjust as necessary to make an even conic section.
- 3) Cut out the Main Engine Upper Bell from Parts Sheet 1. Form the part into cone by rolling the part to impart a curved shape. Smear a thin film of glue on the tab marked GLUE, overlap the opposite edge onto the glue, and adjust as necessary to make an even cone. Apply glue to the edge of the Main Engine Upper Bell, and glue the part to the smaller opening of the Main Engine Lower Bell, stacking the two parts together.
- 4) Cut out the Main Engine Nozzle from Parts Sheet 1. Form the part into a cylinder by rolling the part to impart a curved shape. Smear a thin film of glue on the tab marked G, overlap the opposite edge onto the glue, and adjust as necessary to make an even cylinder. Apply glue to the point of the Main Engine Upper Bell, and glue the nozzle to the Main Engine Upper Bell by placing one opening of the nozzle over the point of the Main Engine Upper Bell.
- 5) Apply a thin bead of glue to the smaller opening of the Main Engine Heatshield, and place the part into the inside of the Main Engine Upper Mount. Center the Main Engine Heatshield around the thin light colored circle inside the Main Engine Mount.
- 6) Apply a drop of glue to the Main Engine Nozzle, and place the Main Engine into the inside of the Main Engine Upper Mount. Center the Main Engine Heatshield around the small light colored circle inside the Main Engine Mount. The Main Engine should be inside the Main Engine Heatshield.

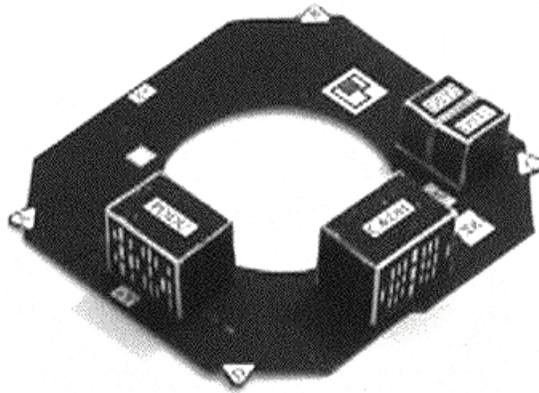
- d. Assemble the Propulsion Module (PM) Core
- 1) Cut out the Propulsion Module Core from Parts Sheet 1. Form the part into a cylinder by rolling the part to impart a curved shape with the printed side on the outside. Smear a thin film of glue on the tab marked GLUE, overlap the opposite edge onto the glue, and adjust as necessary to make an even cylinder.
 - 2) Cut out the Propulsion Module Top from Parts Sheet 1. Apply a thin bead of glue along the top of the Propulsion Module Core, and attach the PM Top.
 - 3) Apply a thin bead of glue along the bottom of the Propulsion Module Core, and attach core to the L/V Interface Ring, covering the Main Engine Mount. Adjust the core so it is vertical when the L/V Interface Ring is resting on a flat level surface.
- e. Assemble the Propulsion Module Deck and Gussets
- 1) Using a BLACK marker, color the bottom (non-printed) side of the Propulsion Module Deck black (don't color the SA Mount Doubler and Fuel PIA).
 - 2) Cut out the four Thruster assemblies from Parts Sheet 1. Each thruster assembly has a 0.2 pound roll thruster, and a 5 pound pitch/yaw thruster. The 0.2 pound thrusters have a small "pointed" gas exit, and the larger 5 pound thrusters have a conic opening. Apply glue to the rectangular portion on the non-printed side of the thruster assembly and glue the assembly to the bottom side of the Propulsion Module Deck, directly below the equal sized rectangles on each corner of the deck. Each thruster assembly should be mounted with the 5 pound thrusters oriented closest toward the X axis. Repeat for all four thruster assemblies, and allow the glue to dry. Bend each of the four 5 pound thrusters 90 degrees toward the printed side of the thruster assembly (down toward the Main Engine).
 - 3) Apply a thin bead of glue along the edges of the circular cutout in the Propulsion Module Deck and slide the Deck down onto the Propulsion Module Core. The PM Deck should rest on the L/V interface Ring. Align the +Y on the Deck with the +Y on the Propulsion Module Core. Adjust the Deck so it is flat and level when the L/V Interface Ring is resting on a flat level surface.
 - 4) Cut out the four Propulsion Module Gussets from Parts Sheet 1. Using a BLACK marker, color the non-printed side of each gusset all black.
 - 5) Select the Gusset with the Ox PIA and apply glue along the two edges nearest the corner with the small 45 degree notch. Place the two glued edges of this gusset along the thin white lines of the Propulsion Module Core and the Propulsion Module Deck nearest the HGA Mount.

- 6) Select the Gusset with the “He” marking and apply glue along the two edges nearest the corner with the small 45 degree notch. Place the two glued edges of this gusset along the thin white lines of the Propulsion Module Core and the Propulsion Module Deck nearest the small “h” on the Deck (opposite of the Pressurant Control Assembly (PCA) Plate). The PCA isolates all components between the Gaseous Helium (GHe) tank and the propellant tanks.
 - 7) Glue the two remaining gussets to the Propulsion Module using the same method as above.
- f. Assemble the Propulsion Tanks
 - 1) OPTIONAL STEP (easier method): Two different sets of propulsion tanks are provided. The easier assembly method uses the parts marked “Optional”, and are assembled in the following two steps.
 - a) Cut out the Fuel Tank Assembly (FTA) halves marked “Optional” from Parts Sheet 2. Fit them together at right angles, slot into slot, and secure with glue. Repeat with the other set of FUEL TANK Assembly (FTA) halves. These intersecting pieces represent two domed cylindrical tanks.
 - b) Cut out the Helium Tank Assembly (HTA) halves marked “Optional” from Parts Sheet 2. Fit them together at right angles, slot into slot, and secure with glue. These intersecting pieces represent a domed cylindrical tank.
 - c) Skip the steps in the following section which build solid body tanks.
 - 2) Assemble Solid Body Propulsion Tanks
 - a) Cut out one set of Fuel Tank Assembly (FTA) parts from Parts Sheet 2 (there are five parts per tank). Form the long part marked “Fuel” into a cylinder by rolling the part to impart a curved shape. Smear a thin film of glue on the tab marked G, overlap the opposite edge onto the glue, and adjust as necessary to make an even cylinder.
 - b) Form one of the small parts into cone by rolling the part to impart a curved shape. Smear a thin film of glue on the tab marked “g”, overlap the opposite edge onto the glue, and adjust as necessary to make an even cone. Repeat with the other small part.
 - c) Form the larger circular part into cone by rolling the part to impart a curved shape. Smear a thin film of glue on the tab marked “glue”, overlap the opposite edge onto the glue, and adjust as necessary to make an even conic section. Apply glue to the edges of the smaller opening on the conic section. Attach the edges of the small cone to the smaller opening on the conic section. Adjust as necessary to make an even dome. Hint: align overlap edges of each part to be co-located on the same side of the part. Repeat with the other larger circular part.

- d) Apply glue along the edge of one of the domed parts and attach the cylindrical part marked “Fuel” to the domed part. Hint: align overlap edges of each part to be co-located on the same side of the part. Repeat with the other domed part.
 - e) Repeat the above steps using the other set of Fuel Tank Assembly (FTA) parts from Parts Sheet 2 (there are five parts per tank).
 - f) Cut out the Helium Tank Assembly (HTA) parts from Parts Sheet 2 (there are three parts). Form the long part marked “Helium” into a cylinder by rolling the part to impart a curved shape. Smear a thin film of glue on the tab marked “G”, overlap the opposite edge onto the glue, and adjust as necessary to make an even cylinder.
 - g) Form one of the small parts into cone by rolling the part to impart a curved shape. Smear a thin film of glue on the tab marked “g”, overlap the opposite edge onto the glue, and adjust as necessary to make an even cone. Repeat with the other small part.
 - h) Apply glue along the one of the edges of the cylindrical part marked “Helium” and attach one of the small cone parts. Hint: align overlap edges of each part to be co-located on the same side of the part. Repeat with the other small cone part.
- 3) Apply a small drop of glue to one of the Fuel Tank mounts marked “FTA” on the side of the Propulsion Module Core, and on the bottom of one of the Fuel Tanks. Attach the Fuel Tank to the Propulsion Module Core with one edge of the Fuel Tank touching the “FTA” and the bottom resting on the Propulsion Module Deck. Adjust as necessary to make the tank even with the Propulsion Module structure. Repeat with the other Fuel Tank.
- 4) Apply a small drop of glue to the Helium Tank mount marked “He” on the Propulsion Module Gusset, and on the bottom of one of the Helium Tank. Attach the Helium Tank to the Propulsion Module Core with one edge of the Helium Tank touching the “He” and the bottom resting on the Propulsion Module Deck marked “h”. Adjust as necessary to make the tank even with the Propulsion Module structure.

Note: The Oxidizer Tank is not represented for this model. The Oxidizer Tank is located inside the Propulsion Module Core, above the Main Engine.

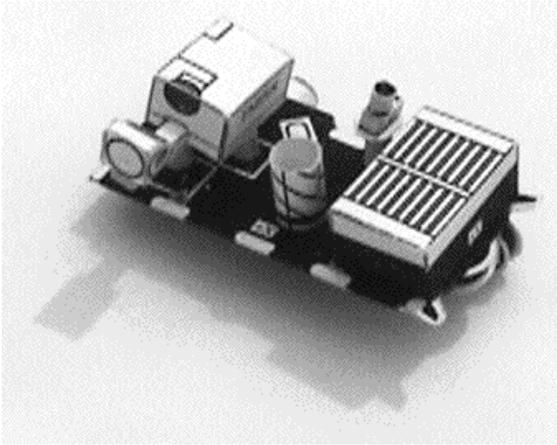
• 3 **ASSEMBLE THE COMPONENT DECK**



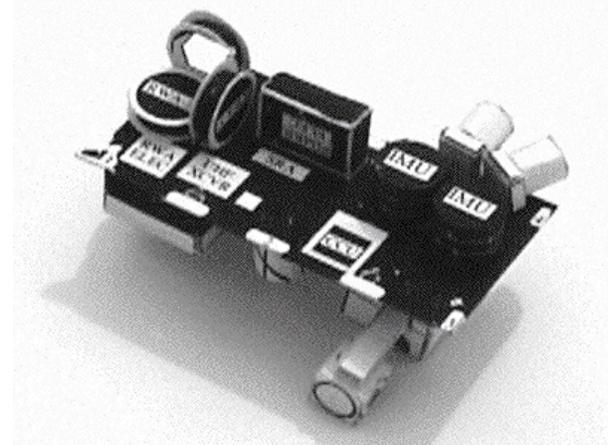
- a. Cut out the Component Deck from Parts Sheet 2. Cut out the inside hole of the Component Deck before cutting the remaining portion of the part from the parts sheet. The bottom of the Component Deck should remain white.
- b. Cut out the two Deep Space Transponders (DST) from Parts Sheet 2. VERY lightly score between the tabs and sides using a modeling knife along the edge of a ruler (do not cut through the paper). Make a total of eleven different scores on each part. This will allow easier bending of the tabs. Fold the part with the printed side on the outside to form a box. Apply a small amount of glue to each of the 7 tabs and refold the part to form a box. Repeat with the other part. Smear a thin film of glue on the bottom of each part and attach the parts to the Component Deck.
- c. Cut out the Power Distribution and Drive Unit (PDDU) from Parts Sheet 2. VERY lightly score between the tabs and sides using a modeling knife. Make a total of eleven different scores on each part. Fold the part with the printed side on the outside to form a box. Apply a small amount of glue to each of the 7 tabs and refold the part to form a box. Repeat with the other part. Smear a thin film of glue on the bottom of the part and attach the PDDU to the Component Deck with the harness connectors oriented away from the center of the Component Deck.
- d. Cut out the Command and Data Handling (C&DH) box from Parts Sheet 2. VERY lightly score between the tabs and sides using a modeling knife. Make a total of eleven different scores on each part. Fold the part with the printed side on the outside to form a box. Apply a small amount of glue to each of the 7 tabs and refold the part to form a box. Repeat with the other part. Smear a thin film of glue on the bottom of the part and attach the C&DH to the Component Deck with the harness connectors oriented away from the center of the Component Deck.
- e. Apply a thin bead of glue to the top edges of the four Propulsion Module Gussets and slide the Component Deck down onto the Propulsion Module Core. Align the +Y on the Deck with the +Y on the Propulsion Module Core. Adjust the Deck so it is flat and level when the L/V Interface Ring is resting on a flat level surface.

Note: The 2 Telemetry Modulation Units (TMU), and 2 Command Decoder Units (CDU) are too small to be built into boxes and therefore only marked on the top of the Component Deck.

• 4 ASSEMBLE THE SCIENCE DECK



Science Deck Top (without PMIRR Hood)



Science Deck Bottom

- a. Cut out the two Science Deck parts (top and bottom) from Parts Sheet 3. For this step, use a low-moisture glue such as a glue stick. Smear a thin film of glue on the back (non-printed) side of the Science Deck Top and apply to the bottom (non-printed) side of the Science Deck Bottom, aligning the notches of the two parts. Place the part under something heavy (like a book) on a flat surface, and allow to dry.
- b. Assemble the Reaction Wheels
 - 1) Cut out the nine Reaction Wheel Assembly (RWA) parts from Parts Sheet 3. Be sure not to cut into the small uncolored edge along the outside of each round part.
 - 2) Form the long part into a cylinder with the dark printing on the outside of the part. Smear a thin film of glue on the tab marked “glue”, overlap the opposite edge onto the glue, and adjust as necessary to make an even cylinder.
 - 3) Apply glue along one of the edges of the cylinder and attach one of the light colored round pieces with the printed ring on the outside. The round piece should be a larger diameter than the cylinder, and evenly overlap the edges of the cylinder.
 - 4) Apply glue along other edge of the cylinder and attach one of the dark colored round pieces with the printed letters “RWA” on the outside.
 - 5) Repeat with the other two sets of RWA parts to complete a set of three Reaction Wheel Assemblies.
 - 6) Cut out the RWA Bracket from Parts Sheet 3. VERY lightly score between the tab and sides using a modeling knife along the edge of a ruler (do not cut through the paper). This will allow easier bending of the tabs. Fold the part with the printed side on the outside. Smear a thin film of glue on the tab marked “glue”, overlap the edge onto the glue, and adjust as necessary to make a bracket with 90 degree bends.

- 7) Smear a thin film of glue to the light colored side of the X axis RWA and attach the part to the corresponding location on the RWA Bracket. Repeat with the Y axis RWA.
 - 8) Apply glue along the two adjoining long edges of the RWA bracket and attach the part to the corresponding location on the Science Deck, surrounding the Z axis RWA mount location.
 - 9) Smear a thin film of glue to the light colored side of the Z axis RWA and attach the part to the corresponding location on the Science Deck.
- c. Assemble the IMUs
- 1) Cut out the six Inertial Measurement Unit (IMU) parts from Parts Sheet 3.
 - 2) Form the long part into a cylinder with the dark printing on the outside of the part. Smear a thin film of glue on the tab marked “glue”, overlap the opposite edge onto the glue, and adjust as necessary to make an even cylinder.
 - 3) Apply glue along the top edge of the cylinder and attach the part marked “IMU” with the printed ring on the outside. The round piece should be the same diameter as the cylinder, and evenly touch the edges of the cylinder.
 - 4) Apply glue along other edge of the cylinder and attach the round part marked “bottom”.
 - 5) Repeat with the other sets of IMU parts to complete a set of two Inertial Measurement Units.
 - 6) Smear a thin film of glue to the bottom of one of the IMUs and attach the part to the corresponding location on the Science Deck. Repeat with the other IMU.
- d. Cut out the Black Pressure Modulated Infrared Radiometer (PMIRR) Electronics box from Parts Sheet 3. VERY lightly score between the tabs and sides using a modeling knife along the edge of a ruler. Make a total of eleven different scores on the part. Fold the part with the printed side on the outside to form a box. Apply a small amount of glue to each of the 7 tabs and refold the part to form a box. Smear a thin film of glue on the bottom of the part and attach the PMIRR Electronics box to the Science Deck.
- e. Assemble the Star Cameras
- 1) On Parts Sheet 3, VERY lightly score the two STAR CAMERAs between the tabs and sides using a modeling knife along the edge of a ruler. Make a total of eight different scores on each Star Camera Body. Cut out the four STAR CAMERA parts from Parts Sheet 2 (two camera bodies and two lens hoods).

- 2) Fold the 6 tabs away from the printed sides of the Star Camera Body, and fold along the two lines between the top and bottom of the camera body. Apply a small drop of glue to the three tabs marked GLUE and overlap the other opposing three tabs onto the glue tabs. This should make a small box with a dark circle on one side and an “S” on the other side. Repeat with the other Star Camera Body.
- 3) Roll the square shaped piece into a small cylinder with the dark printing on the inside, allowing the sides to overlap along the edge marked GLUE. Roll the piece around a pencil or dowel to make a smooth cylinder. Smear some glue along the tab of this piece marked GLUE, overlap the opposite end onto the glue, press together, and allow the glue to dry.
- 4) Apply glue to the edges on one end of the small cylinder, and glue the cylinder to the side of the camera body with the round dark spot, and let the glue dry. Repeat with the other small cylinder and camera body.
- 5) Cut out the two small donut shaped lens hood parts from Parts Sheet 2. Cut out the inside hole of the lens hood before cutting the remaining portion of the part from the parts sheet. Apply glue to the edges of the small lens hood cylinder, and glue the donut shaped lens hood to the cylinder. Repeat with the other small cylinder and camera body.
- 6) Apply a small drop of glue to one of the four sides of a Star Camera Body, and attach the part to one of the positions marked “SC” on the Science Deck. The lens of the Star Camera should point away from the Science Deck, slightly down and away from the Top of the Science Deck. Repeat with the other Star Camera. The two Star Cameras are mounted with their lenses oriented non-parallel with respect to each other; use the “SC” outline on the Science Deck as a guide.

Note: The Reaction Wheel Assembly Electronics, UHF Transceiver, SRA, and CCU are too small to be built into boxes and therefore only marked on the Science Deck Bottom.

- f. Cut out the Battery Enclosure from Parts Sheet 3. Note the location of the fold lines before cutting the part from the sheet (four arrows). VERY lightly score between the tabs and sides using a modeling knife along the edge of a ruler. Make a total of eight different scores on the part. Smear a thin film of glue on each of the four tabs marked “glue” and form the part to make a box with the printing on the outside. Apply glue along the four edges of the open side of the box, and attach the box to the Science Deck Top over the cylindrical shaped batteries. Note the +Y side of the Battery Enclosure should be oriented with the +Y side of the Science Deck. The Battery Enclosure has moveable louvers on the top of the enclosure to provide thermal control of the batteries.
- g. Cut out the UHF Antenna from Parts Sheet 3. Roll the part to make an even cylinder with the printing on the outside. Smear a thin film of glue on the tabs marked “glue”, overlap the opposite edge onto the glue, and adjust as necessary to make an even cylinder. Apply glue to the bottom edge of the cylinder (edge closest to the thick line), and attach the part to the Science Deck Top over the circle marked “UHF”.

h. Assemble the Mars Color Imager (MARCI)

The MARCI instrument has two cameras, a wide angle camera and a medium angle camera. Each camera has a small electronics package inside the camera body. The medium angle camera has a cylindrical lens hood. The wide angle camera has two small lenses; one round lens hood and one rectangular lens hood.

- 1) Cut out the MARCI Pedestal from Parts Sheet 3. Roll the part to make an even cylinder with the printed alignment mark on the outside. Note the top of the cylinder is not even and should have a slight drop on one side. Smear a thin film of glue on the tabs marked “glue”, overlap the opposite edge onto the glue, and adjust as necessary to make an even cylinder. Apply glue to the bottom edge of the cylinder (edge closest to the printed alignment mark), and attach the part to the Science Deck Top over the circle marked “M”, aligning the two alignment marks together.
- 2) Cut out the MARCI Camera Mount from Parts Sheet 3. Apply a small drop of glue to the top of the MARCI Pedestal and attach the Camera Mount to the Pedestal. Orient the Camera Mount with the small rectangle toward the -X side of the Science Deck. The Camera is not mounted perpendicular to the Science Deck; The Camera Mount should be tilted toward the -X side of the Science Deck and slightly toward the Battery Enclosure.
- 3) Cut out the MARCI Camera Bodies from Parts Sheet 3. VERY lightly score between the tabs and sides using a modeling knife along the edge of a ruler (score the thin lines, but not the thick lines). Make a total of six different scores on the part (the small ends do not have glue tabs). Smear a thin film of glue on the tab marked “g” and form the part to make a rectangular box with the printing on the outside. Bend the two small ends down and attach with a small drop of glue. Smear a thin film of glue on the bottom of the camera bodies marked “b” and attach the part to the MARCI Camera Mount. Orient the Camera Bodies with the small “m” (for medium camera) toward the +X side of the Science Deck.
- 4) Cut out the MARCI Medium Lens and Hood from Parts Sheet 3. Roll the piece into a small cylinder with the dark printing on the inside, allowing the sides to overlap along the edge marked “g”. Smear some glue along the tab of this piece marked “g”, overlap the opposite end onto the glue, and adjust as necessary to make an even cylinder. Apply glue to the edges on one end of the small cylinder, and glue the cylinder to the Camera Body over the small circle marked “m”.

i. Assemble the Pressure Modulated Infrared Radiometer (PMIRR)

- 1) Cut out the PMIRR Instrument from Parts Sheet 3. VERY lightly score between the tabs and sides using a modeling knife. Make a total of eleven different scores on the part (similar to the C&DH and PDDU). Fold the part with the printed side on the outside to form a box. Apply a small amount of glue to each of the 7 tabs and refold the part to form a box. There will be a small square hole below the dark colored circle (detector).

- 2) Cut out the Scan Mirror Arm from Parts Sheet 3. VERY lightly score between the sides and tab using a modeling knife (make a total of four scores). Fold the part with the printed side on the outside to form a rectangular tube. Smear some glue along the tab marked “glue, overlap the opposite side marked “bottom” onto the glue, and adjust as necessary to make an even rectangular tube. Smear a small drop of glue along the portion marked “bottom” and insert the shaded portion of the Scan Mirror Arm into the square opening of the PMIRR Instrument. The small “s” on the Scan Mirror Arm should point at the dark colored circle (detector).
- 3) Cut out the Scan Mirror from Parts Sheet 3. VERY lightly score between the tabs and sides using a modeling knife (make a total of twelve scores). Fold the part with the printed side on the outside to form a box with one flattened edge (a box with 8 sides). Apply a small amount of glue to each of the five tabs tab marked “glue” or “g”, and refold the part to form a box. Apply a small drop of glue to the small “s” on the bottom of the Scan Mirror and attach the part to the small “s” on the Scan Mirror Arm. The dark circle (Scan Mirror) should be slanted toward the dark colored circle (detector) on the PMIRR Instrument.
- 4) Cut out the three PMIRR Mounts from Parts Sheet 3. Note each of these parts is a different size. Form each part into a cylinder by rolling the part to impart a curved shape, with the printing on the outside of the cylinder. Smear a thin film of glue on the tab marked “g”, overlap the opposite edge onto the glue, and adjust as necessary to make an even cylinder. Repeat for all three parts. Apply glue along the bottom edge of one of the parts and attach it to the corresponding location on the Science Deck Top. Repeat for all three PMIRR Mounts.
- 5) Apply glue along the top edge of each of the three PMIRR Mounts and attach the PMIRR Instrument to the PMIRR Mounts. Match each of the mounts with the corresponding numbered location on the bottom of the PMIRR Instrument. The PMIRR Instrument should be canted when viewed from the side of the instrument, but the instrument should be parallel with the edges of the Science Desk when viewed from the top.
- 6) Cut out the PMIRR Radiator Hood and PMIRR Radiator from Parts Sheet 3. Form the Radiator Hood into a conic section by rolling the part to impart a curved shape with the printed marks on the outside. Smear a thin film of glue on the tab marked “glue”, overlap the opposite edge onto the glue, and adjust as necessary to make an even conic section. Apply glue along the edges of the smaller opening of the Radiator Hood and attach the unprinted side of the PMIRR Radiator to the Radiator Hood, aligning the two small alignment marks on each part. Using a yellow highlighter, color the outside of the PMIRR Radiator Hood and the printed side of the PMIRR Radiator (do not color the inside of the part).

- 7) Cut out the PMIRR Radiator Hood Mount from Parts Sheet 3. VERY lightly score the four dark lines using a modeling knife. Do not score the small alignment mark near the “R” marking. Note the sides of the mount are different lengths. Smear a thin film of glue on the tab marked “g”, overlap the opposite edge onto the glue, and adjust as necessary to make an even square section. Using a yellow highlighter, color the outside of the Radiator Hood Mount. Apply glue along the edges of the mount near the “R” alignment marking and attach the part to the printed side of the PMIRR Radiator, aligning the two small alignment marks on each part.
- 8) Cut out the PMIRR Sun Shade Mount from Parts Sheet 3. Cut out the inside hole of the Sun Shade Mount before cutting the remaining portion of the part from the parts sheet. Cut out the PMIRR Sun Shade from Parts Sheet 3. VERY lightly score the each of the dark lines using a modeling knife. Fold the sides and glues tabs of the Sun Shade Mount away from the printed side, smear glue on the two glue tabs and overlap the sides onto the tabs.
- 9) Cut out the PMIRR Sun Shade from Parts Sheet 3. VERY lightly score the each of the dark lines using a modeling knife, and fold the sides and glue tabs of the Sun Shade Mount away from the printed side. Apply a small drop of glue to each of the small triangles on the PMIRR Sun Shade Mount and attach the sharp pointed edges of the PMIRR Sun Shade to the Mount.
- 10) Apply glue along the larger opening edge of the PMIRR Radiator Hood and attach the PMIRR Sun Shade Mount, aligning the two alignment marks. The three sides of the PMIRR Sun Shade Mount should partially cover the yellow colored sides of the PMIRR Radiator Hood. Set the part aside for later assembly.

j. Final Science Deck Assembly

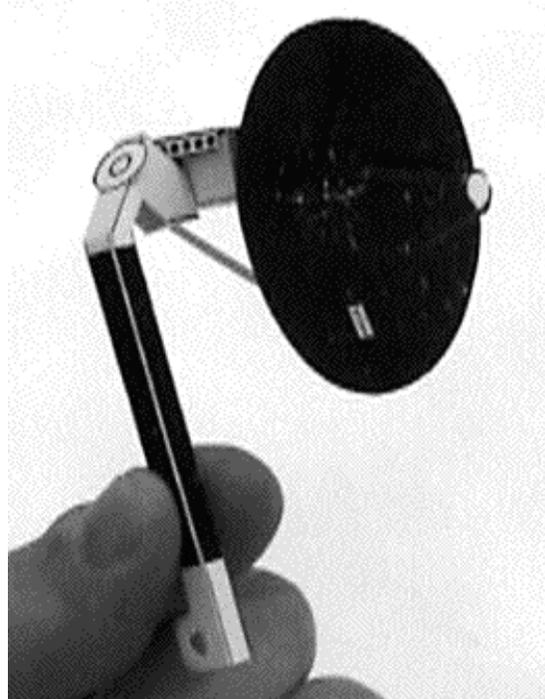
- 1) Cut out the Science Deck Struts from Parts Sheet 3. Consider using a sharp modeling knife and metal ruler to cut the parts from the sheet, being careful not to cut into the uncolored strut “brackets”. Color the unprinted side of each strut with a Black marker to match the printed side. VERY lightly score the two small fold lines near the “B” and “D” brackets using a modeling knife, and fold the struts marked “3” and “4” away from the printed side. Make a 90 degree bend at the fold line.
- 2) Apply a small drop of glue to the bottom edge of the strut brackets marked “A” and “B” and attach the part to the corresponding locations on top of the Component Deck. Repeat with the strut brackets marked “C” and “D” and attach the part to the corresponding locations on top of the Component Deck. Tilt the upper portion each of the Science Deck Strut toward each other until the struts marked “3” touch and the struts marked “4” touch. Apply a small drop of glue the two struts marked “3” and glue them together. Repeat with the two struts marked “4”. Adjust the struts so the top edges are parallel with the Component Deck top AND edges. Allow the glue to dry before proceeding.

- 3) Apply a drop of glue to the top edge of each of the 6 struts, marked “1” through “6”. Attach the corresponding locations on the bottom of the Science Deck to the 6 struts. Adjust the Science Deck to be parallel with the Component Deck top AND edges. Allow the glue to dry before proceeding.
- 4) Apply glue to the edges of the small square PMIRR Radiator Hood Mount and attach the part to the PMIRR Instrument, aligning the two small alignment marks marked “R”. Note the PMIRR Radiator is tilted and rotated with respect to the PMIRR Instrument.

• 5 ASSEMBLE THE HIGH GAIN ANTENNA



HGA and SSPA (Back View)



HGA and SSPA (Front View)

a. Assemble the HGA and SSPA

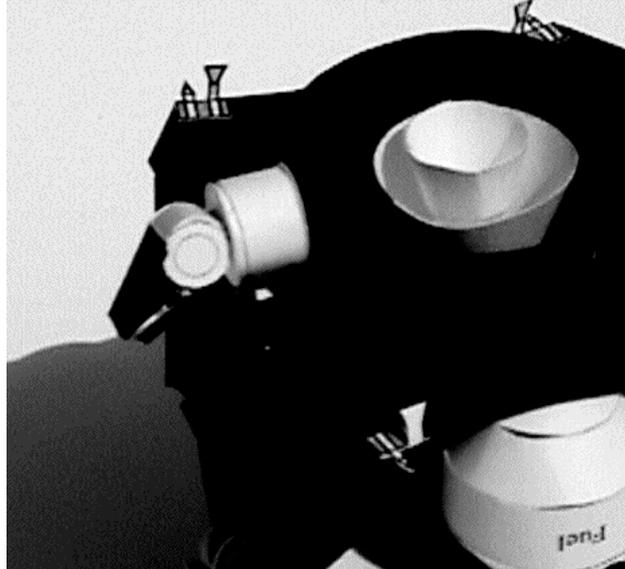
- 1) Cut out the High Gain Antenna (HGA) from Parts Sheet 4. Form the circle into cone by rolling the part to impart a curved shape with the printed circles on the inside. For this step, use a low-moisture glue such as a glue stick. Smear a thin film of glue on the tab marked GLUE. Overlap the opposite edge onto the glue, bringing the circle up into a cone, with the printing on the inside. Adjust so the edge aligns with, and just overlaps the line which separates the glue tab. Using a Black Marker, color the unprinted side of the antenna black. Once the glue is thoroughly dry, set the cone on your work surface with the point facing down, and crush the point by pressing the cone down onto the work surface. Crush the cone to make the center point flat, about 1/4 inch diameter.
- 2) Cut out the HGA Feed from Parts Sheet 4. Use a sharp modeling knife and metal ruler to cut the part from the sheet, being careful not to cut into the uncolored strut "brackets". Color the unprinted side of each strut with a Black marker to match the printed side. Bend the three struts of the antenna HGA Feed about 80 degrees at the point where they meet the unprinted circle, away from the printed side. Apply a small drop of glue to the ends of the three struts and attach the struts to the three small dots on the HGA.

- 3) On Parts Sheet 4, note the locations of the arrows indicating fold lines on the Solid State Power Amplifier (SSPA) Enclosure. Using a modeling knife and ruler, VERY lightly score between the points of the corresponding arrows (do not cut through the paper). Also, VERY lightly score the 8 lines which separate the 3 sides and glue tabs near the "SSPA" marking. This will allow easier bending of the tabs. Cut out the SSPA Enclosure from Parts Sheet 4. Fold the glue tabs and 3 sides of the enclosure away from the printed side. Make 4 more folds AWAY from the printed side along the edges with the small "•" holes. Apply glue to the 5 glue tabs and overlap the sides to make a box. The top of the SSPA Enclosure has thermally controlled louvers to provide thermal control of the two SSPAs inside the SSPA Enclosure.
- 4) Bend the small tab marked "g" on the SSPA Enclosure struts about 160 degrees away from the printed side. Make two more bends where the SSPA Enclosure struts attach to the enclosure, away from the printed side. Apply a small drop of glue to the tab marked "g", and glue to strut to the unprinted side of the "T" shaped HGA Mount.
- 5) Apply glue to the center of the circle marked "HGA" on the "T" shaped HGA Mount, and attached the crushed point of the HGA. The small rectangle marked "MGA" (Medium Gain Antenna) should be oriented toward the bottom of the "T" shaped HGA Mount. Adjust the HGA as necessary to make it sit even on the SSPA Enclosure.

b. Assemble the HGA Boom

- 1) Cut out the HGA Mount from Parts Sheet 2. Cut out the two small holes before cutting out the part from the parts sheet. VERY lightly score the each of the dark lines using a modeling knife. Fold the sides and glue tabs of the AWAY from the printed side. When properly folded, the shaded line on the long rectangle will be BEHIND the shaded line marked "+Y" (the shaded line on the long rectangle will be inside the mount). Smear glue on the four glue tabs and overlap the sides onto the tabs. Do not cover the slots on the sides of the mount.
- 2) Apply glue to the slots on the HGA Mount and attach the part to the Propulsion Deck. The "+Y" marking on the HGA Mount should be oriented toward the "+Y" side of the Propulsion Deck. The "+Y" marking should not be visible after attaching the mount to the Propulsion Deck.
- 3) Cut out the HGA Boom from Parts Sheet 2. Cut out the two small holes before cutting out the part from the parts sheet. VERY lightly score the each of the dark lines using a modeling knife. Make a total of 12 different score lines. Fold the sides and glue tabs of the AWAY from the printed side. The circles represent Inner and Outer Gimbal motors. Smear a thin film of glue on the tabs marked "glue", overlap the opposite edges onto the glue, and adjust as necessary to make an even boom and gimbal assembly.
- 4) Apply glue to the side marked "SS" on the HGA Boom, and attach the part to the corresponding location on the SSPA Enclosure, aligning the parts using the alignment mark near the "SS". Allow the glue to dry before proceeding.

• **6** **ASSEMBLE THE SOLAR ARRAY**



Solar Array Gimbal attached to Bottom of Propulsion Deck

a. Assemble the Solar Array Inner Gimbal

- 1) Cut out the two Inner Gimbal Gussets from Parts Sheet 4. Using a Black Marker, color the unprinted side of each part black. Apply a thin bead of glue along the long straight edge of each part and glue them to the bottom of the Propulsion Deck on the SA Mount Doubler. The long edge of the Inner Gimbal Gussets should be glued along the corresponding lines centered over the “SA” marking. The Inner Gimbal Gussets hang down from the Propulsion Deck.
- 2) Cut out the two Inner Gimbal parts from Parts Sheet 4; “inner gimbal-o” and “inner gimbal-i”. Form each part into a cylinder by rolling the part to impart a curved shape, with the printing on the inside of the cylinder. Note each part is a different length and width. The part marked “inner gimbal-i” will slide inside the part marked “inner gimbal-o”. On the part marked “inner gimbal-i”, smear a thin film of glue on the tab marked “glue”, overlap the opposite edge onto the glue, and adjust as necessary to make an even cylinder. Repeat with the part marked “inner gimbal-o”, adjusting the cylinder snugly around the inner part. Separate the two parts and allow to dry.
- 3) Cut out the Outer Gimbal Mount from Parts Sheet 4. Apply glue to the edges on ONE end of the narrower cylinder marked “inner gimbal-i” and attach it to the center of the unprinted side of the Outer Gimbal Mount. The small rectangle marked “glue” should be opposite of the cylinder. Allow the glue to dry.
- 4) **OPTIONAL STEP:** If you want to have the ability to detach the solar array (for storage), then do not perform the following step:

- a) Cut out the Inner Gimbal Retainer from Parts Sheet 4. Fit the “inner gimbal-i” inside the wider part, “inner gimbal-o”. The parts should be snug, but not difficult to slide. Slide the outside cylinder toward the Outer Gimbal Mount to expose the end of the inside cylinder. Apply glue to the edges on the end of the INSIDE cylinder and attach the printed side of the Inner Gimbal Retainer. Be careful not to allow any glue to touch the outside cylinder.
- b. Assemble the Solar Array Outer Gimbal
 - 1) Cut out the two Outer Gimbal parts from Parts Sheet 4; “outer gimbal-o” and “outer gimbal-i”. Form each part into a cylinder by rolling the part to impart a curved shape, with the printing on the inside of the cylinder. Note each part is a different length and width. The part marked “outer gimbal-i” will slide inside the part marked “outer gimbal-o”. On the part marked “outer gimbal-o”, smear a thin film of glue on the tab marked “glue”, overlap the opposite edge onto the glue, and adjust as necessary to make an even cylinder. Repeat with the part marked “outer gimbal-i”, adjusting the cylinder snugly inside the outer part. Separate the two parts and allow to dry.
 - 3) Cut out the Outer Gimbal Clamp from Parts Sheet 4. VERY lightly score the two lines using a modeling knife (do not cut through the paper). Fold each scored edge of the part 90 degrees toward the unprinted side. Apply glue to the edges on ONE end of the narrower cylinder marked “outer gimbal-i” and attach it to the center of the circle on the unprinted side of the Outer Gimbal Clamp. Allow the glue to dry.
 - 4) Fit the “outer gimbal-i” inside the wider part, “outer gimbal-o”. The parts should be snug, but not difficult to slide. Slide the outside cylinder toward the end glued to the Outer Gimbal Clamp to expose the end of the inside cylinder. Apply glue to the edges on the end of the inside cylinder and attach the other end of the Outer Gimbal Clamp. Be careful not to allow any glue to touch the outside cylinder. Allow the glue to dry.
- c. Apply a SMALL drop of glue to the small rectangle marked “glue” on the Outer Gimbal Mount and attach the outside cylinder of the Outer Gimbal. Be careful not to allow any glue to touch the Outer Gimbal Clamp. Allow the glue to dry. Do not be concerned if the gimbal feels too snug; some amount of stiffness is desired.
- d. Apply glue along the circumference of each Inner Gimbal Gusset attached to the bottom of the Propulsion Deck. Attach the outside cylinder of the Solar Array Inner Gimbal to the gussets, with the Outer Gimbal Mount flush with the edge of the Propulsion Deck. Be very careful not to allow any glue to touch the moving parts.
- e. Solar Array Preparation
 - 1) OPTIONAL STEP: Using a modeling knife and ruler, cut out the 11 gray rectangular cut-outs from the Solar Array on Parts Sheet 4. These cut-outs are covered with fabric on the spacecraft to provide more aerodynamic drag during the aerobraking mission phase. Using a modeling knife and ruler, cut out the two small gray areas between the three Solar Array panels.

- 2) Using a BLUE highlighter, color the three large uncolored panels on the Solar Array (on the printed side of the array). Best results will be obtained by using the highlighter along the edge of a ruler. Do not color the hinges or space between each panel.
- 3) Cut out the Solar Array from Parts Sheet 4. Cut out the Solar Array Gimbal Stiffener from Parts Sheet 4. For this step, use a low-moisture glue such as a glue stick. Smear a thin film of glue on the back (non-printed) side of the Solar Array Gimbal Stiffener and apply to the back (non-printed) side of the Propulsion Module Deck, aligning the notches of the Solar Array Gimbal Mount.
- 4) OPTIONAL STEP: Spray black spray paint on the unprinted side of the Solar Array panels.
- 5) Using a Modeling knife and ruler, VERY lightly score along the lightly colored line near edge of all three Solar Array panels. Fold the long skinny printed strip along the top edges of the Solar Array Panels 90 degrees away from the printed side to make a stiffener.

7 FINAL ASSEMBLY

- a. Cut out the HGA Boom Hinge Pin from Parts Sheet 4. Roll the part into a small cylinder (do not use any glue). Position the HGA Boom into the HGA Mount with the SSPA near the “+X” edge of the Science Deck. The tabs with two small holes in the HGA Boom should fit between the tabs of the HGA Mount. Insert the HGA Boom Hinge Pin through the tabs. Apply a small drop of glue to the Hinge Pin and the HGA Mount, being careful not to allow any glue to touch the HGA Boom. This will allow the HGA to swing from the stowed position to the deployed position.
- b. Apply glue to the two lines marked “gimbal” on each side of the Solar Array and slide the array onto the Outer Gimbal Clamp. The “out” marking on the Outer Gimbal Clamp should be on the printed side of the Solar Array (the blue solar cell substrate (printed side) of the solar panel should be oriented away from the spacecraft). Be careful not to allow any glue to touch the moving parts.
- c. The Orbiter model can be configured for several different spacecraft configurations. Pick one of the following configurations:
 - 1) Cruise Configuration - The HGA remains stowed in the Launch and Cruise mission phases. The spacecraft will be oriented with the HGA pointed at Earth, and the Solar Array +X panel rotated toward the top of the spacecraft and out, away from the +Y axis of the spacecraft.
 - 2) Mars Orbit Insertion (MOI) and Aerobraking Configuration - The HGA remains stowed in the MOI and Aerobraking mission phases. The Solar Array will be moved to the “stowed” position with the blue solar cell substrate (printed side) of the solar panel oriented away from the spacecraft. During an aerobraking pass, the direction of travel will be toward the -Y axis of the spacecraft.
 - 3) Mapping Configuration - The HGA will be deployed after the MOI event (the HGA cannot be un-deployed). The Science Deck of the spacecraft will be Nadir pointing throughout each orbit (Science Deck pointed toward the center of the planet). The Solar Array will be gimbaled to follow the Sun throughout the Mars orbit. The HGA will be gimbaled to track the Earth during communication sessions.

THIS COMPLETES YOUR MODEL

8 ABOUT YOUR MODEL

The Orbiter is 3-axis stabilized in all mission phases following separation from the launch vehicle. The primary attitude determination is via star camera and an inertial measurement unit, and is backed up by analog sun sensors. Reaction wheels provide primary attitude control during most mission phases, and are desaturated via RCS thrusters. The IMUs will be turned off during significant portions of Cruise and Mapping, and the vehicle operated in all-stellar mode (except during maneuvers). The RCS thrusters also provide attitude control during Trajectory Correction Maneuvers, Mars Orbit Insertion, aerobraking drag pass, Orbital Trim Maneuvers, and safe mode [until rates are damped, at which point RW control is used]. In all, four 5-pound thrusters are used for Trajectory Correction Maneuvers and pitch/yaw control. Four 0.2-pound thrusters are used for roll control. The Spacecraft Computer (C&DH) uses the RAD6000 processor (predecessor to the PowerPC). The X-band link with Earth employs Cassini Deep Space Transponders, 15 W RF solid state power amplifiers (SSPA's), one 1.3 meter transmit/receive high gain antenna (HGA), one transmit-only medium gain antenna (MGA), and one receive-only low gain antenna. A 10 Watt RF UHF system supports the 2-way link with the Lander. The 3-panel, single wing solar array (SA) uses GaAs/Ge solar cells and also functions as the primary drag brake during aerobraking. The batteries are NiH₂ CPV batteries, while the electrical power electronics are based on the SSTI spacecraft electronics. The thermal control subsystem is passive, with louvers to control the temperature of the batteries and SSPA's and combinations of MLI, Kapton, paints, and dedicated radiators for certain other components. Both thermostatically controlled and computer controlled heater circuits are used. The Orbiter equipment module (EM) is a composite truss structure with titanium end fittings and two Aluminum honeycomb panels with composite face sheets. The solar array and HGA track the Sun and Earth, respectively, with 2-axis gimbals. The propulsion subsystem is dual mode, employing a bipropellant main engine for Mars Orbit Insertion (MOI) and TCM (hydrazine) thrusters for all other propulsive events. Most subsystem components are redundant, with critical items cross strapped.

The "Volatiles and Climate History" theme for the 1998 Mars Surveyor missions was recommended by the Mars Science Working Group and is aligned directly with NASA's Mars exploration strategy for the next decade focusing on: Evidence of past or present life, Climate, and Resources. The 1998 Orbiter mission will carry a rebuilt version of the Mars Observer Pressure Modulated Infrared Radiometer (PMIRR) with Dr. Daniel McCleese of JPL as Principal Investigator, and the Mars Color Imaging (MARCI) system with Dr. Michael Malin, of Malin Space Science Systems (MSSS) as Principal Investigator. PMIRR will observe the global distribution and time variation of temperature, pressure, dust, water vapor, and condensates in the Martian atmosphere. MARCI will observe synoptically Martian atmospheric processes at global scale and study details of the interaction of the atmosphere with the surface at a variety of scales in both space and time. In addition to the science payload, the Orbiter spacecraft will provide an on-orbit data relay capability for future U.S. and/or international surface stations.

The Mars Surveyor Spacecraft was designed and manufactured at Lockheed Martin Astronautics, Denver, Colorado, under contract with the Jet Propulsion Laboratory.

Model design completed 12 September 1998 by G. Bollendonk, Mars Surveyor Program, Lockheed Martin Astronautics, Denver, Colorado. An after-hours project.

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