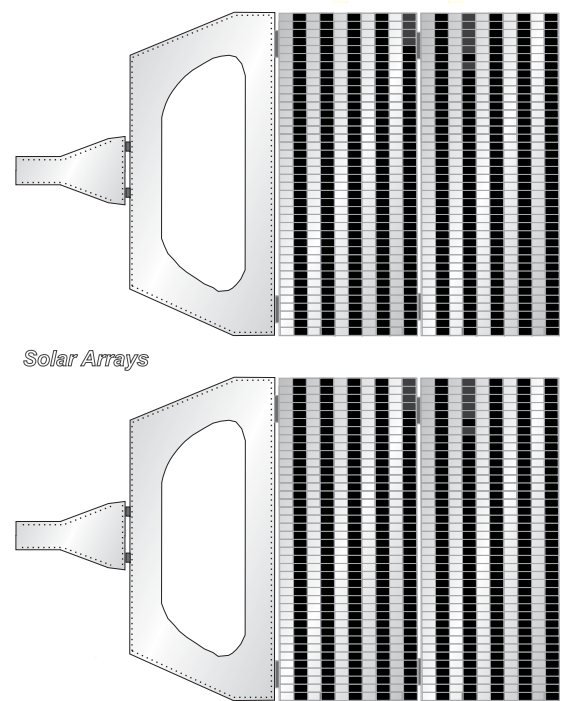
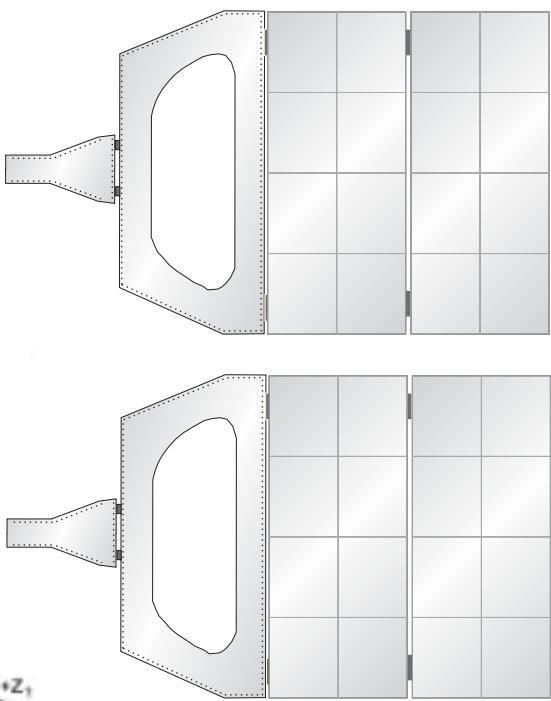
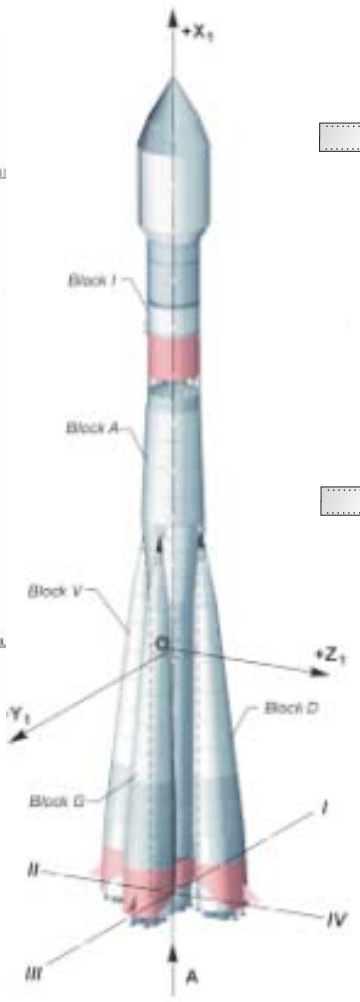
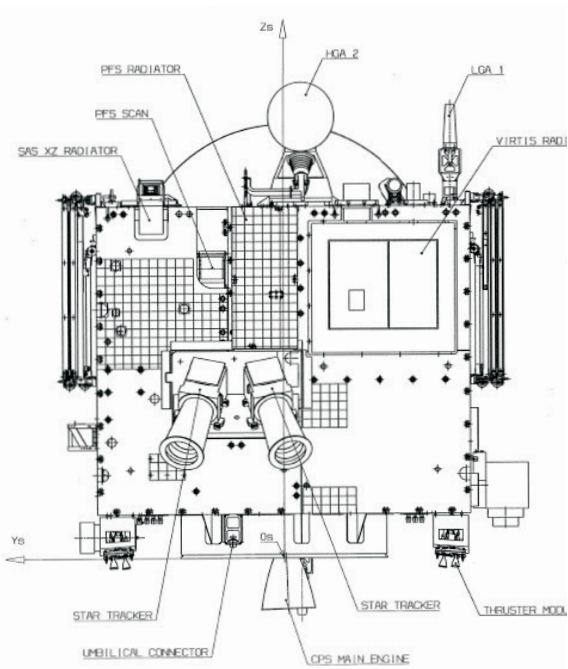


Instruction Manual

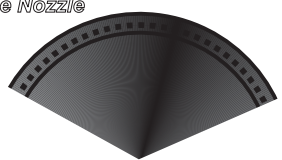
Venus Express

Scale Model 1:40



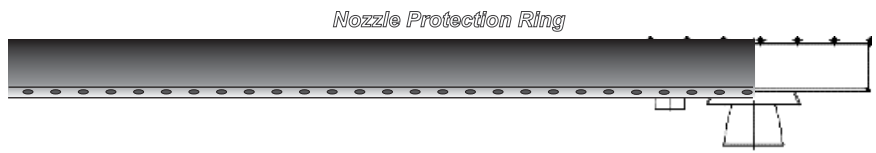
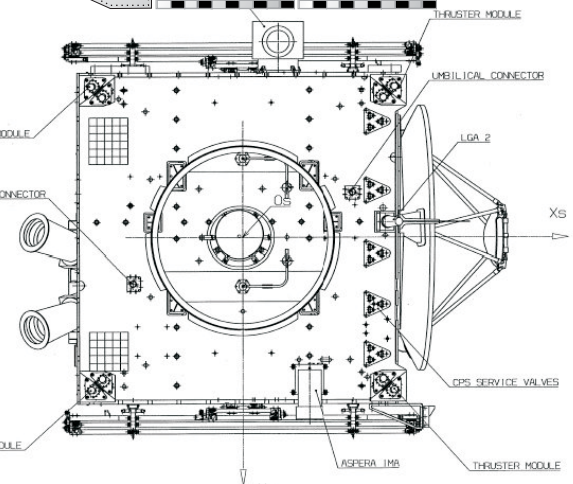
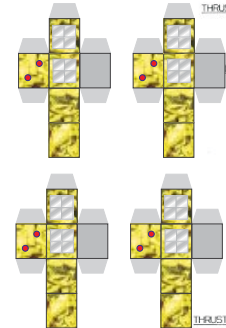


Main Engine Nozzle

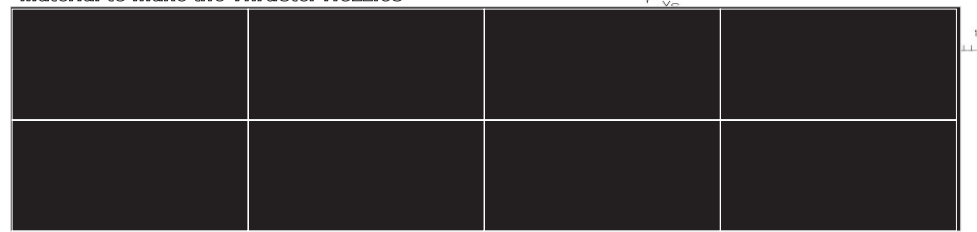


Secondary High Gain Antenna

Attitude Control Thruster



Material to make the Thruster Nozzles



Sheet: 2



VENUS EXPRESS

spacecraft by



Paper-model by Thorsten.Siwitza@esa.int

This is the instruction Manual for the scale model of the *ESA Venus Express* spacecraft. It is a step by step manual and it will probably take you a good evening to complete it. Words in *Italic* are names of actual spacecraft units and instruments.

But let's get started. What is needed?

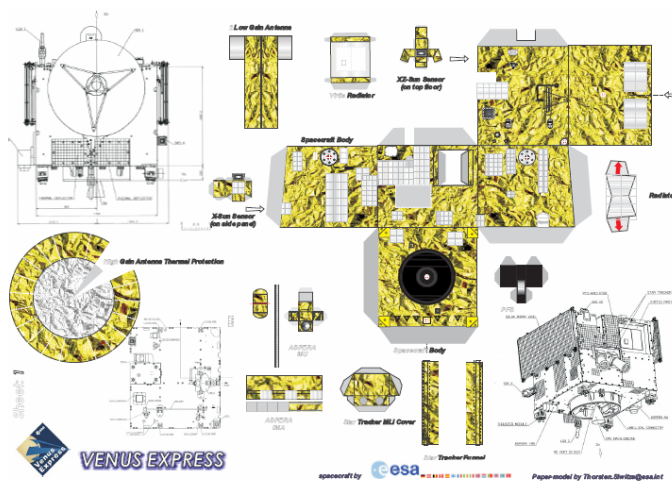
- Cardboard
- Glue
- Scissors, small and standard
- Ruler
- Knife
- Needles
- Toothpicks
- Barbecue sticks
- Aluminium Foil
- Thread



Take the first sheet with the two white circles on it - they will become the *High Gain Antenna* - and find the main body of the spacecraft.

It is yellow, and if you look carefully you can count the six surfaces, the so-called panels of the spacecraft.

Then find the small red dots on the body. Pierce them all with a needle. Locate the two in the centres of the



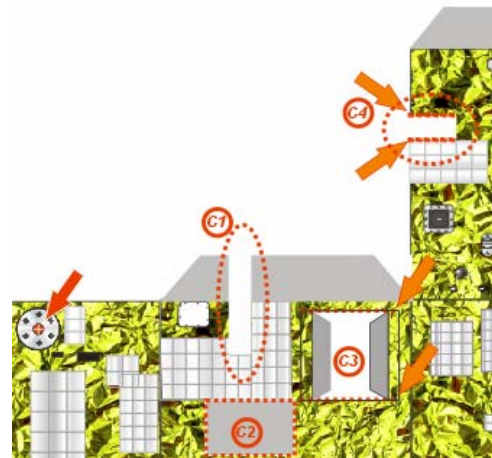
grey circles - they will become the *Solar Array Drive Mechanisms* - and pierce them first with toothpicks, then with barbecue sticks. Roll the sticks between your fingertips while making the holes to avoid tearing the edges. Using only tooth-picks repeat the piercing for the two red marks for the

Low Gain Antennas on the top and bottom floor. Perform one cut on the front panel, where the little arrow points to a dotted black line.

You have now finished the preparation.

Read the instructions of the next two paragraphs carefully before cutting out the spacecraft's main body.

Note the cut-outs that have been made on the top, on one side panel of the spacecraft body and on one in its rear panel. They are marked (C1) to (C4). The cut-outs (C1) and (C4) will be used for one of the scientific instruments, *PFS*. The one in the centre of the rear panel (C2) will be used for the *Star Tracker*. The cut-out marked (C3) is tricky. Cut

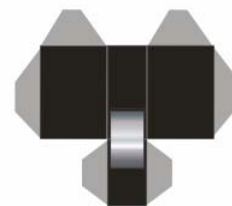


along the red lines and remove the white part only. The remaining grey flap will be used as a connecting strip and will be folded and glued. Do not cut it off. All grey side flaps are for gluing different parts together.

When you have cut out the shape, take a ruler and a knife and prepare the folding edges as follows: lay the ruler along an edge and run the blunt edge of the knife along it, but do not cut. This makes folding easier. Now fold against the edge of the ruler to get a nice sharp crease.

With a little imagination you will see how the parts fit together, but it is not yet time to glue the body.

Next to the large part of the spacecraft body of Sheet 1 you find a little black piece to be cut out and folded into a flat half-cube. It belongs to the science instrument *PFS*. Fold it so that the inside is black. The two flaps either side of the black rectangle on the left must be glued to the back of the two larger black squares.



This is how the finished part looks like. Keep this first sub-assembly apart for later integration.

Now cut out the three elements of the *Star Tracker*, the body and the two funnels and remembering to prepare the folds with a knife first. The larger part holds the two *Star Tracker* funnels in an angle.

Fold and glue the three elements to produce two boxes and a ramp. The ramp will become the mounting platform for the two *Star Trackers* (on sheet 1 is called Star Tracker MLI Cover).

Take one of the two yellow strips that have black lines down one side and roll the funnel pieces tightly around a toothpick, so that it becomes a little tube. Repeat for the other strip. The tubes will



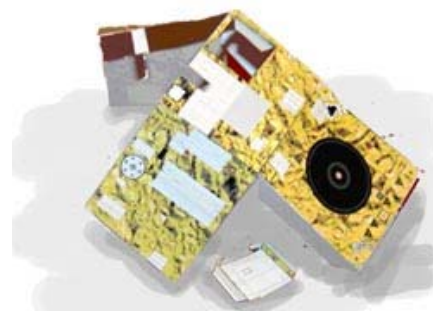
eventually be glued onto the grey circles on the steep end of the ramp. If the tubes are cut at an angle at the end where they are glued to, they will point slightly off-centre later on. **Do not glue yet!** The completed second sub-assembly should look like above

Again, keep the three parts together for the later integration.

If you want to improve the spacecraft body, take the aluminium foil and cut little pieces the same size as the white areas with light grey lines on the spacecraft's main body. These are the *Coolers*. This is a tedious job, but the reflective surface makes the finished model look really good.

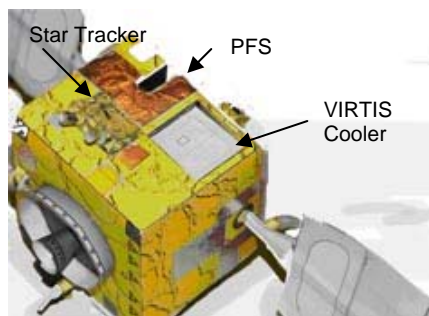
Now cut out and pre-fold the main body of the spacecraft.

The *VIRTIS* cooler are indent. The cut-out cooler is shown as the single part in the picture on the right. It is to be mounted in the cut-out (C3) of the main body. Now glue the *Star Tracker* ramp into the cut-out of (C2), so that the yellow ramp is protruding from the spacecraft body and



Pre-folded spacecraft body

the grey circles are pointing downward. The *Star Tracker* funnels are glued onto the circles at the appropriate angle looking outwards. When you have finished, the tubes of the *Star Tracker* funnels should point down and sideways. Finally the *PFS* instrument is mounted into the cut-outs (C1) and (C2).



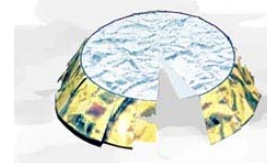
Last not least there is the *Radiator* panel that is to be mounted on the front panel.

Glue the two sides together, keeping the flaps free of glue. Slide the flaps in the slit that you cut earlier on the front panel. Glue and mount it from the inside.

Careful pre-fitting is advised for all of these elements.

When the glue has set for the integration of all subassemblies , pre-fit, but do not yet glue the sides of the spacecraft body together to form a cube. It will not of course be an exact cube, since the *High Gain Antenna* panel is slightly inclined.

While the side panels of the spacecraft body are being closed and glued one at a time you might want to get started on some other equipment.



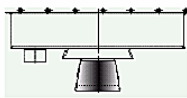
The large white disc with the wide yellow border is the front cover and side cover of the *High Gain Antenna*. Cut it out and cut along the white lines to make square flaps from the wide yellow border. Note that the V-shape cut out still has a grey flap to glue the two opposite sides together. As a result you get a white flat cone, with the overlapping yellow flaps looking



down. When the grey flap is glued to fix the white cone, shape and bend the flaps so long until they join to form a circle on the lower end with a smaller diameter than the white cone (see picture previous page). Apply glue from the inside and fix the subassembly like this.

Now you finished the High Gain Antenna (HGA), which is covered by a thermal blanket to withstand the heat of the sun in the Venus orbit. You can glue the HGA in the centre of the front panel, just above the radiator. The centre is marked with a red dot that is not pierced. Apply plenty of glue on the inside of the Antenna and let it rest in the flat surface of the panel.

The spacecraft's main body should look like the illustration on the previous page, although you have not yet mounted the solar panels. On the left bottom of the picture you see a dark ring and the nozzle of the main engine. The ring will be glued to the circle on the underside of the spacecraft body, which is facing you in the photograph. It will be the *Separation Ring* to the *Soyuz Fregat upper stage*. At the centre of the circle is one of the little red dots that you pierced earlier. Cut out the dark circle segment, which will be the nozzle on the spacecraft's *main engine*. When the glue has set, enlarge the hole in the main body so that the nozzle's sharp end fits into it and can be mounted. Now mount the *nozzle protection ring*. Cut it to size to fit the footprint around the nozzle. Note that the shape must be angled. The largest footprint belongs to the *Separation Ring*. Cut it out, glue the ring together, give it the right shape and



Above: The main engine with separation and protection ring.

Below: shape of the main engine nozzle on sheet 2

mount it on the body. On



Left:

Spacecraft separation ring

the bottom of the previous page and below are the three elements from Sheet 2

Now you are getting more experienced, you might want to start building the external scientific instruments and antennas. In this model there are two external units that make up the experiment called *Aspera*, mounted at the top and bottom of the spacecraft, the *Sun Sensor* and the *Low Gain Antennas*. Starting with *Aspera MU*, cut it out and prepare the folds. The stripe next to the instrument cut-out can be rolled on the tip of a toothpick and glued to make a tight, short roll. This will be mounted onto the grey, circular front of the instrument to form the detector.

The part of the *Aspera* instrument called IMA is a tight roll of the larger rectangle. This detector tube is hold with the yellow



band on the grey folded footprint. Fold the four grey rectangles to form a package with the same footprint and use the attached yellow stripe to wrap around one end of the tube. The finished *Aspera MU* looks like below:



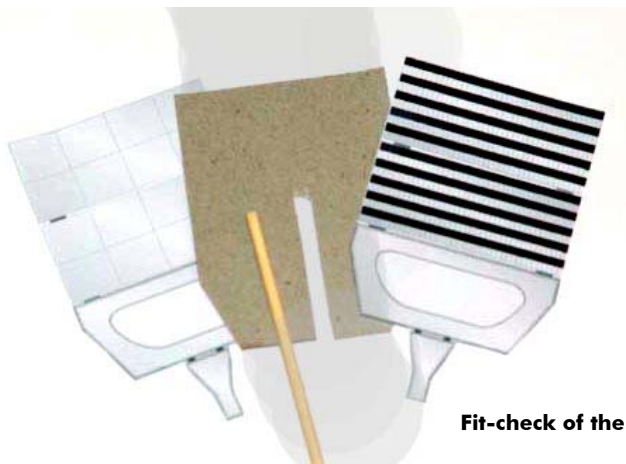
When they are assembled mount the two instruments at the assigned locations on the top and bottom panels. Look for the instrument's grey footprint.

Next come the antennas. On Sheet 1 next to the radiator you will find two identical strips with white attachments. Make them into two tight rolls. You can then bent the white end a little. Assemble the two antennas and leave them to harden. With a pair of pliers cut the head off a needle and insert it, coated in glue, into the antenna stem. A short piece of the pointed end of the needle should be visible. When the composite has hardened, apply glue to the needle and to the bottom of the antenna, then insert it into the pre-pierced red hole on the top left of the spacecraft. The needle gives it some additional support.

The small *Sun Sensors* are easy to pre-assemble and should be mounted onto the side panel as visible in the above picture, the other one on the top panel.

Last but not least - the *Solar Panels*:

Cut out two pieces of card the size and shape of the *Solar Panels*. Cut slots to take the barbecue stick. Check the correct assembly: Only one long stick is used. It has to go through the spacecraft body, it has to cover the distance of the short grey arms and, finally, enter the card of the *Solar Panel* on each side. Mark the sticks accordingly. Verify with the tips of the stick the size of the openings in the spacecraft body and enlarge them if necessary, so that the barbecue stick will fit through it with only little resistance. Do not force the stick, turn it instead.



As shown in the photograph, the blunt end of the barbecue stick is used in the first panel assembly. Glue the black back panels onto the card, glue the barbecue stick into the slot and cover with the front panel like a sandwich. At that stage your first Solar Array sandwich mounted with the long barbecue stick should look like in the picture above. When the glue of this assembly set, use the point of the stick to pierce carefully through the spacecraft body. Repeat the sandwiching procedure for the second *Solar Panel*. This is when you will realise that you need an extra pair of hands to hold the body, glue the elements together and hold them in place until they harden...

There is also the rather tricky option to add the Attitude Control Thrusters on the bottom corners of the spacecraft. On sheet 2 you find eight black fields as material to make small thruster-nozzles by rolling it tight around the tip of a toothpick to make sharp, pointed cones. After gluing them together like this, cut the cones to about 5 mm. The nozzles can either be glued directly as pairs on the corner of the spacecraft as outlined on the body. Alternatively you can build the actual Attitude Control Thruster boxes from the four yellow outlines on sheet 2. Pierce the surface as indicated by the red dots where the nozzles are to be mounted before assembly. The boxes are glued with the gray surface to the spacecraft body and with the two radiator surfaces are pointing outward to space.

After mounting the coolers under the HGA and attaching a fine string to suspend the spacecraft, you're done.

Congratulations, you have now successfully built the model of the Venus Express spacecraft.