The Secret Behind the Nobeyama 45-m Radio Telescope’ s Excellent

Even now over 30 years after its completion in 1982, the 45 m diameter radio telescope at NAOJ’ s Nobeyama Radio Observatory boasts world class performance for observing the comparatively short-wavelength radio waves known as millimeter waves. Let's try to understand the structure of the Nobeyama 45-m Radio Telescope and investigate the secrets behind its high accuracy and sensitivity by making a paper model of this telescope.

Main Performance Specifications

Diameter of main reflector: 45 m

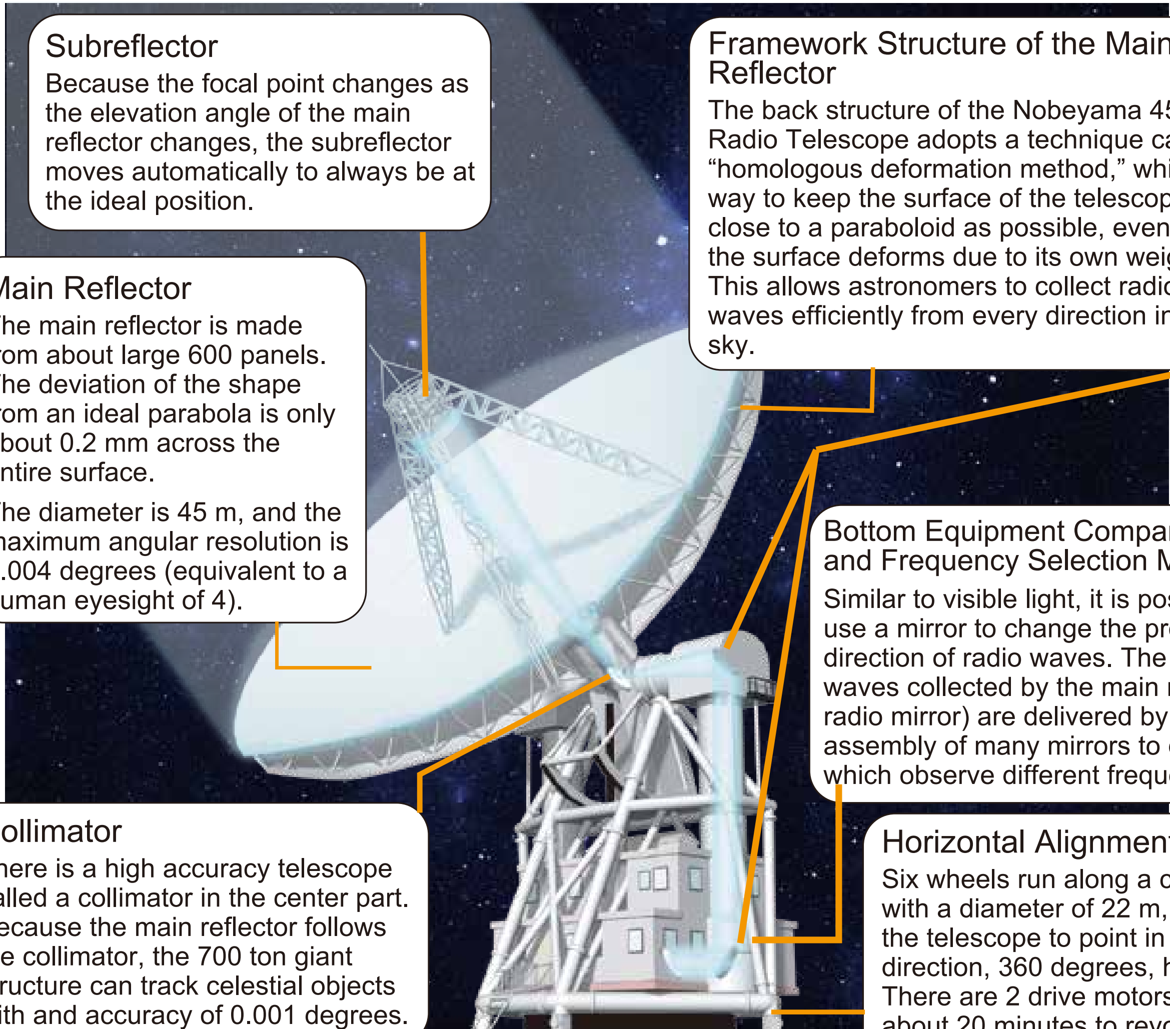
Weight: about 700 tons

Mount: Altazimuth mounting

Reflector surface error: about 0.2 mm

Pointing error:
less than 4 arcseconds (about 0.001 degrees)

Observational wavelengths:
about 2 mm – 30 cm
(Frequency: about 1 – 150 GHz)



Subreflector
Because the focal point changes as the elevation angle of the main reflector changes, the subreflector moves automatically to always be at the ideal position.

Framework Structure of the Main Reflector
The back structure of the Nobeyama 45-m Radio Telescope adopts a technique called “homologous deformation method,” which is a way to keep the surface of the telescope as close to a paraboloid as possible, even when the surface deforms due to its own weight. This allows astronomers to collect radio waves efficiently from every direction in the sky.

Main Reflector
The main reflector is made from about large 600 panels. The deviation of the shape from an ideal parabola is only about 0.2 mm across the entire surface.

The diameter is 45 m, and the maximum angular resolution is 0.004 degrees (equivalent to a human eyesight of 4).

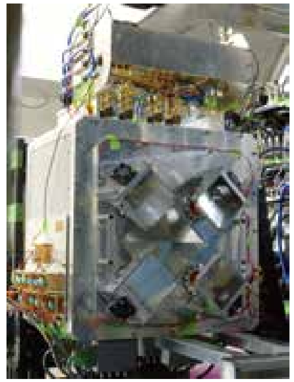
Bottom Equipment Compartment and Frequency Selection Mirrors
Similar to visible light, it is possible to use a mirror to change the propagation direction of radio waves. The radio waves collected by the main reflector (a radio mirror) are delivered by an assembly of many mirrors to detectors which observe different frequencies.

Collimator
There is a high accuracy telescope called a collimator in the center part. Because the main reflector follows the collimator, the 700 ton giant structure can track celestial objects with and accuracy of 0.001 degrees.

Horizontal Alignment Wheels
Six wheels run along a circular rail with a diameter of 22 m, allowing the telescope to point in any direction, 360 degrees, horizontally. There are 2 drive motors. It takes about 20 minutes to revolve once in the horizontal direction.

Second, Third Reflector Mirrors
In 2015, the second and third reflector mirrors inside the radio telescope were renewed. By applying a thick gold leaf, the efficiency of the observations increased 15%. (The second reflector mirror is pictured.)

FOREST Receiver
This is the latest detector, having opened for joint use in 2015. It can perform wide-band, 4-beam, multi-line observations.



Receivers
In the detector room, there are various receivers for capturing radio waves of millimeter wavelength. To be able to detect weak radio waves, their cores are cooled to -269 ° C.

(c) NAOJ

Nobeyama 45-m Radio Telescope Paper Model Construction Project for a Child with Adult Assistance, Expert Course (Instructions)

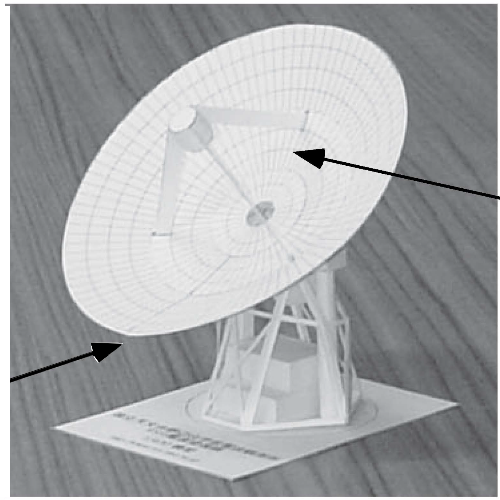
Materials and tools: box cutter and glue

1. Preparation: Cut out all of the 24 components along the thick lines. Cut along the thick lines to form incisions or holes where indicated. Mountain fold along dot-dash lines and valley fold along dashed lines. Cut out and remove parts marked with an X.

2. Pedestal: Make the pedestal by folding and gluing it so that it matches the photo. Construct the two-storied bottom equipment compartment, insert it from under the pedestal, and glue it in place.

3. Center hub/beam transmission system/elevating equipment: Assemble the center hub and attach the elevation axis gears to both sides. Insert the elevation axis through the upper side of pedestal and the center hub. Assemble the beam transmission system and elevating equipment, and insert these into the pedestal temporarily. Then carefully insert the elevation axis into the beam transmission system (upper part) from the side and glue it. After that, glue the elevation axis to the bottom of the pedestal.

For both the main reflector and the Sun shield panel, the seam is down.



When seen from the front, the sub-reflector stays form an upside-down Y.

4. Subreflector: Attach the subreflector to the tip of the triangular prism shaped subreflector drive. Next, glue the subreflector stays to the 3 sides of the subreflector drive, enclosing it to form a tower structure.

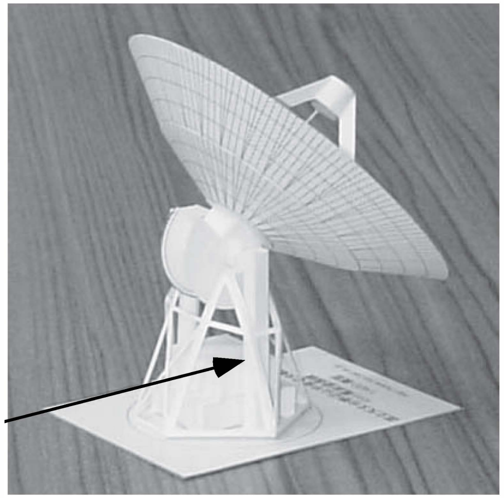
5. Sun shield panel: Assemble the inner and outer portions of the Sun shield panel so that they form cones with the printed surfaces on the outside. Put glue on the tabs of the outer portion and cover them from above with the inner portion so that they bond. Attach the main reflector collar to the base of the Sun shield panel.

6. Main reflector panel: Assemble the inner and middle portions of the main reflector panel so that the printed surfaces are on the inside. Put glue on the tabs around the perimeter of the central hole in the outer portion and attach the middle portion. Similarly, attach the inner portion to the inside of the middle portion.

7. Main reflector: Insert the legs of the sub-reflector stays into the 3 slots in the main reflector panel and glue them from the back side. Put glue along the outer periphery of unprinted sides of the main reflector panel and Sun shield panel, line them up, and affix them to each other.

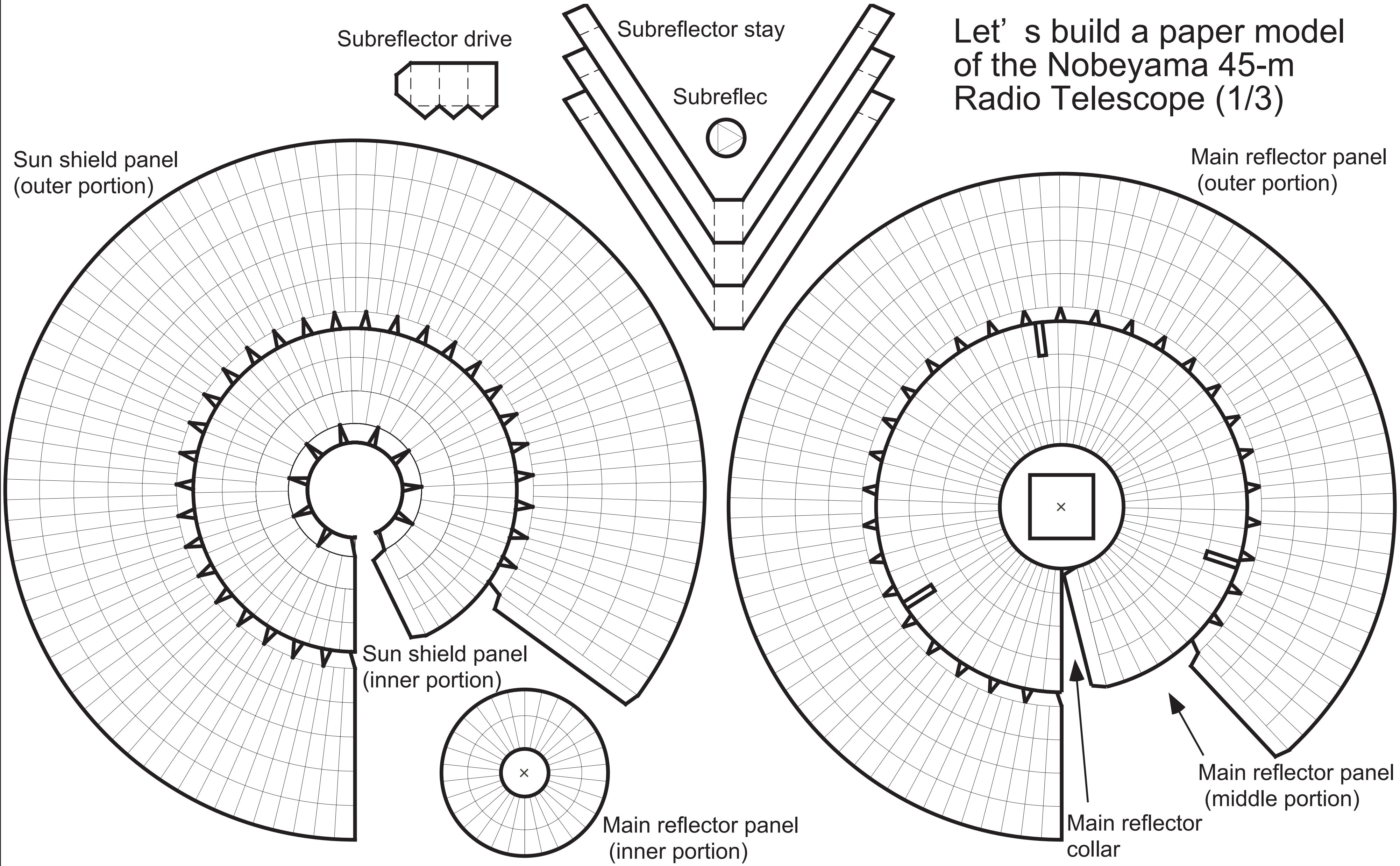
8. Overall assembly: Attach the main reflector so that the sub-reflector stays form an upside-down Y as seen from the front, when placed so that the elevating equipment is on the left side. Attach the azimuth axis rail to the base and mount the telescope.

The square pole shaped elevating equipment is on the left side as seen from the front.



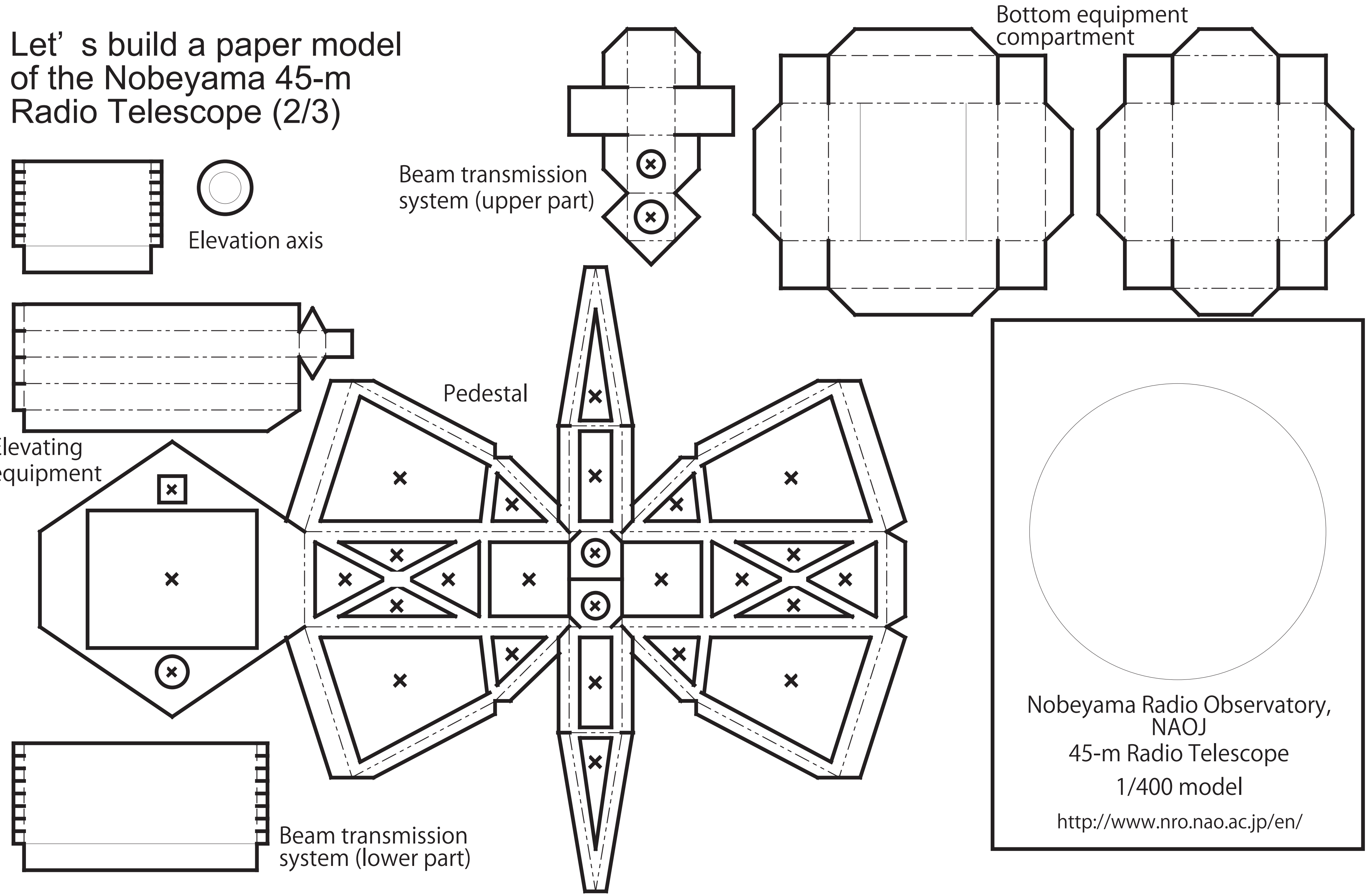
(c) NAOJ

Let’s build a paper model of the Nobeyama 45-m Radio Telescope (1/3)



(c) NAOJ

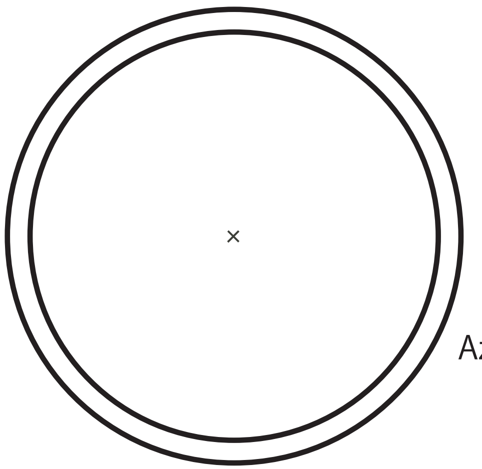
Let’s build a paper model of the Nobeyama 45-m Radio Telescope (2/3)



(c) NAOJ

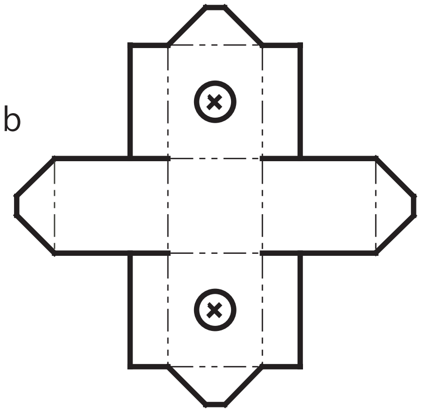
Let’s build a paper model of the Nobeyama 45-m Radio Telescope (3/3)

Elevation axis gear



Azimuth axis rail

Center hub



(c) NAOJ