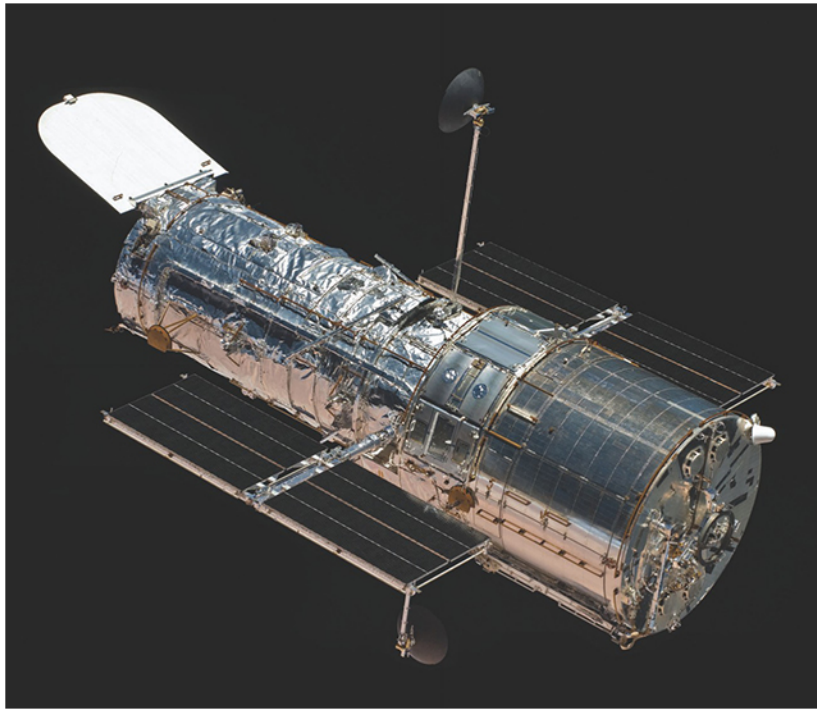


Hubble Space Telescope



Few telescopes in history have had such a profound impact on astronomical research as the HubbleSpace Telescope. In its 31 years of operation, Hubble has not only helped shape scientists' view of the universe, but it has also brought a glimpse of the wonders of the cosmos to homes worldwide.

This magnificent telescope has allowed us to see, forthe first time, features of the universe that humans were once able to probe only with their imaginations.

Hubble's launch and deployment in April 24, 1990 (from space shuttle Discovery (STS-31) marked the most significant advance in astronomy since Galileo's telescope. Thanks to five servicing missions and more than 30 years of operation, our view of the universe and our place within it has never been the same.

One of the most iconic satellites in history, is still in use but has lost altitude due to atmospheric drag and deteriorated mechanically due to system degradation over its thirty years in orbit. The original deorbit plan for HST was to use the space shuttle to retrieve it at end of its life; however, no one foresaw that it would outlive the Space Shuttle Program.

Within weeks of the launch of the telescope, the returned images indicated a serious problem with the optical system. Although the first images appeared to be sharper than those of ground-based telescopes, Hubble failed to achieve a final sharp focus and the best image quality obtained was drastically lower than expected.

Analysis of the flawed images revealed that the primary mirror had been polished to the wrong shape. Although it was believed to be one of the most precisely figured optical mirrors ever made, smooth to about 10 nanometers, the outer perimeter was too flat by about 2200 nanometers (about $1/450$ mm or $1/11000$ inch). This difference was catastrophic, introducing severe spherical aberration, a flaw in which light reflecting off the edge of a mirror focuses on a different point from the light reflecting off its center.

Hubble was designed to accommodate regular servicing and equipment upgrades while in orbit. Instruments and limited life items were designed as orbital replacement units. Five servicing missions (SM 1, 2, 3A, 3B, and 4) were flown by NASA space shuttles, the first in December 1993 and the last in May 2009.

After a visual inspection of the telescope, astronauts conducted repairs, replaced failed or degraded components, upgraded equipment, and installed new instruments. Once work was completed, the telescope was redeployed.

Hubble Space Telescope

Many objective measures show the positive impact of Hubble data on astronomy. Over 15,000 papers based on Hubble data have been published in peer-reviewed journals, and countless more have appeared in conference proceedings.

Since its launch in April 1990, Hubble has provided scientific data and images of unprecedented resolution that have generated many new and exciting discoveries. Even when reduced to raw numbers, the accomplishments of the 12.5-ton orbiting observatory are impressive:

- ☒ Hubble has made more than 1.3 million observations since its mission began in 1990.
- ☒ Astronomers using Hubble data have published more than 15,000 scientific papers, making it one of the most productive scientific instruments ever built. Those papers have been cited in other papers 738,000 times.
- ☒ Hubble has the pointing accuracy of .007 arcseconds, which is like being able to shine a laser beam on President Roosevelt's head on a dime about 200 miles away.
- ☒ Outside the haze of our atmosphere, it can see astronomical objects with an angular size of 0.05 arcseconds, which is like seeing a pair of fireflies in Tokyo that are less than 10 feet apart from Washington, DC.
- ☒ Due to the combination of optics and sensitive detectors and with no atmosphere to interfere with the light reaching it, Hubble can spot a night light on the surface of the Moon from Earth.
- ☒ Hubble has peered back into the very distant past, to locations more than 13.4 billion light-years from Earth.
- ☒ Hubble generates about 10 terabytes of new data per year. The total archive is currently over 150 TB in size.
- ☒ Hubble weighed about 24,000 pounds at launch but if returned to Earth today would weigh about 27,000 pounds — on the order of two full-grown African elephants.

This unique observatory operates around the clock above Earth's atmosphere gathering information for teams of scientists who study the origin, evolution and nature of the universe. The telescope is an invaluable tool for examining planets, stars, star-forming regions of the Milky Way, distant galaxies and quasars, and the tenuous hydrogen gas lying between the galaxies.

NASA named the world's first space-based optical telescope after American astronomer Edwin P. Hubble (1889 – 1953). Dr. Hubble confirmed an "expanding" universe, which provided the foundation for the big-bang theory.

Well into its third operational decade, Hubble is still extremely productive. The orbiting telescope has taken over a million observations and provided data that astronomers have used to write more than 18,000 peer-reviewed scientific publications on a broad range of topics, from planet formation to gigantic black holes. These papers have been referenced in other publications over 900,000 times, and this total increases, on average, by more than 150 per day. Every current astronomy textbook includes contributions from the observatory. Today's college undergraduates have not known a time in their lives when astronomers were not actively making discoveries with Hubble data.

Hubble's discoveries and memorable photos have also reinvigorated the public's interest in astronomy. Along with pictures of the telescope and the astronauts who launched and serviced it during six space shuttle missions, certain memorable science images have become cultural icons. They appear regularly on book covers, musical albums, clothing, TV shows, movies and even ecclesiastical stained-glass windows.

The telescope has tracked interstellar objects as they soared through our solar system, watched a comet collide with Jupiter, and discovered moons around Pluto. It has found dusty disks and stellar nurseries throughout the Milky Way that may one day become fully fledged planetary systems and studied the atmospheres of planets that orbit other stars. Hubble has peered back into our universe's distant past, to locations more than 13.4 billion light-years from Earth, capturing galaxies merging, probing the supermassive black holes that lurk in their depths, and helping us better understand the history of the expanding universe.

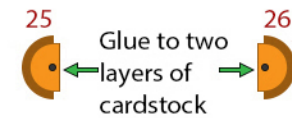
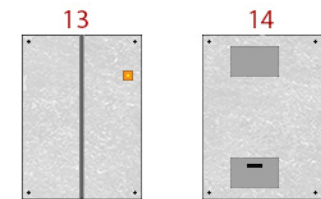
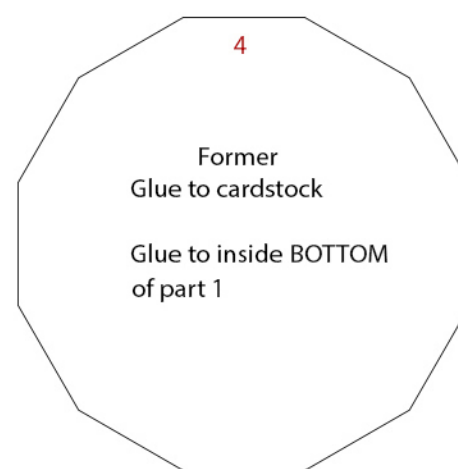
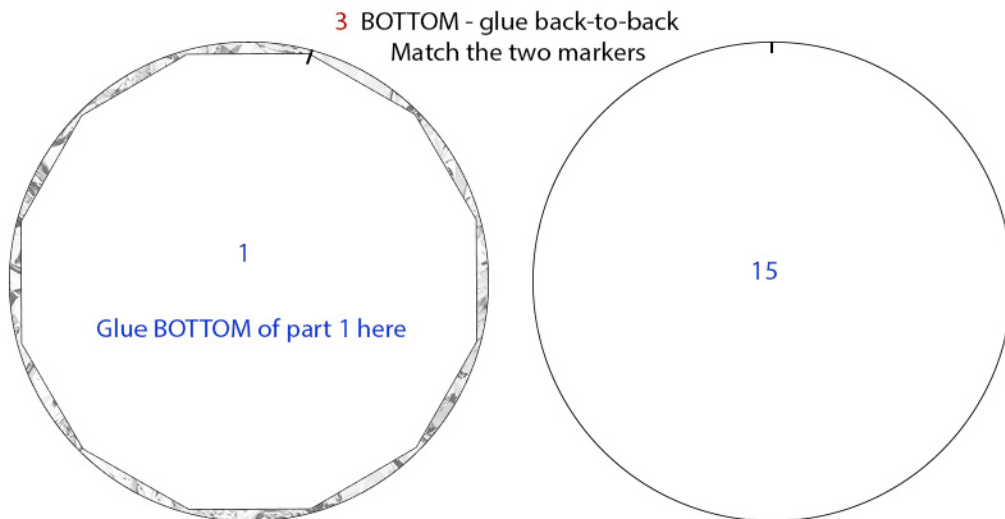
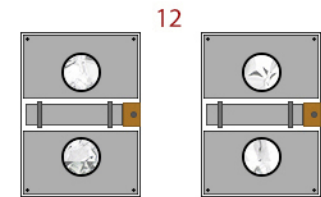
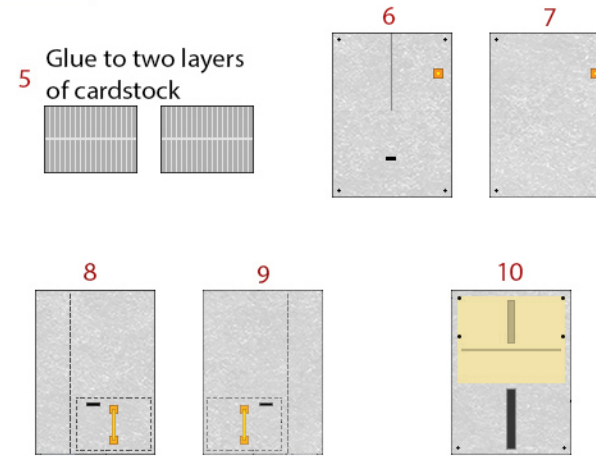
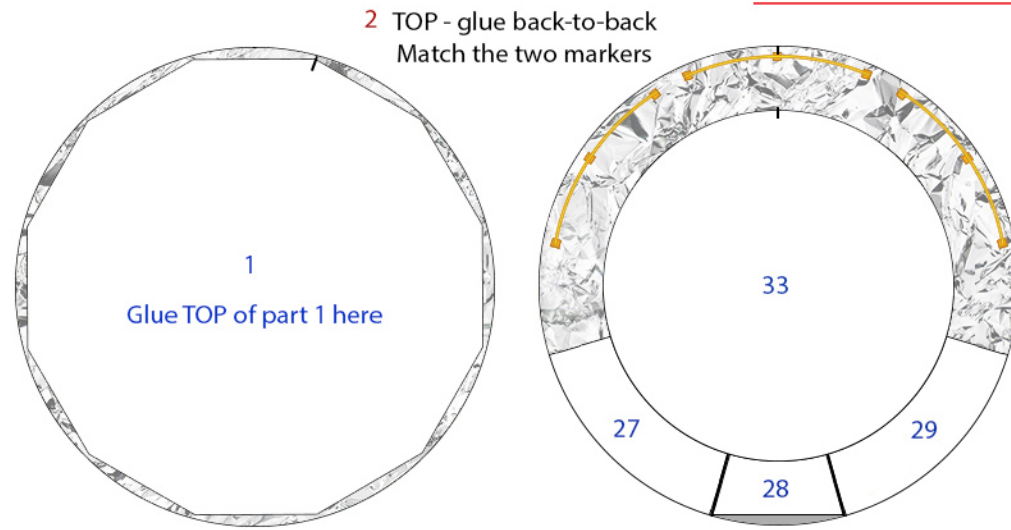
Based on solar activity and atmospheric drag, or lack thereof, a natural atmospheric reentry for Hubble will occur between 2028 and 2040. In June 2016, NASA extended the service contract for Hubble until June 2021.

As of 2017, the Trump Administration was considering a proposal by the Sierra Nevada Corporation to use a crewed version of its Dream Chaser spacecraft to service Hubble some time in the 2020s both as a continuation of its scientific capabilities and as insurance against any malfunctions in the to-be-launched James Webb Space Telescope. In 2020, John Grunsfeld said that SpaceX Crew Dragon or Orion could perform another repair mission within ten years. While robotic technology is not yet sophisticated enough, he said, with another manned visit "We could keep Hubble going for another few decades" with new gyros and instruments.

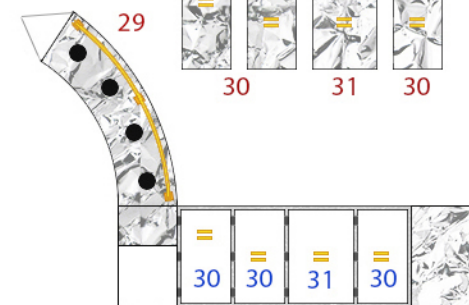
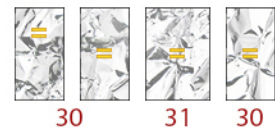
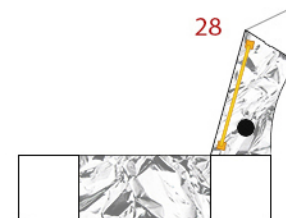
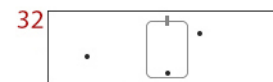
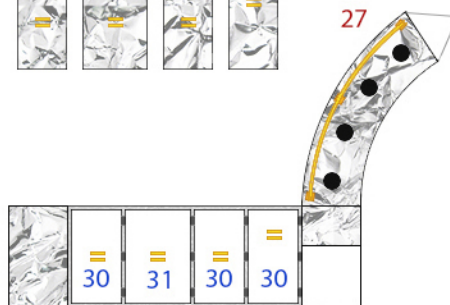
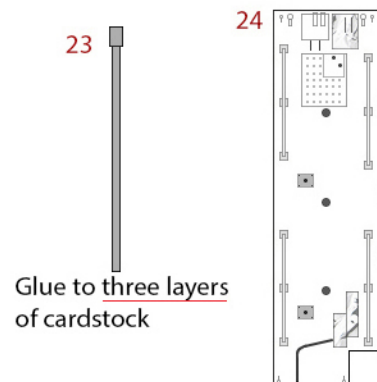
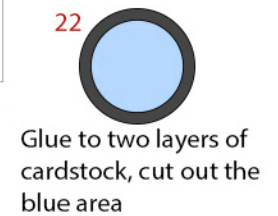
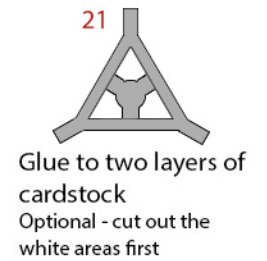
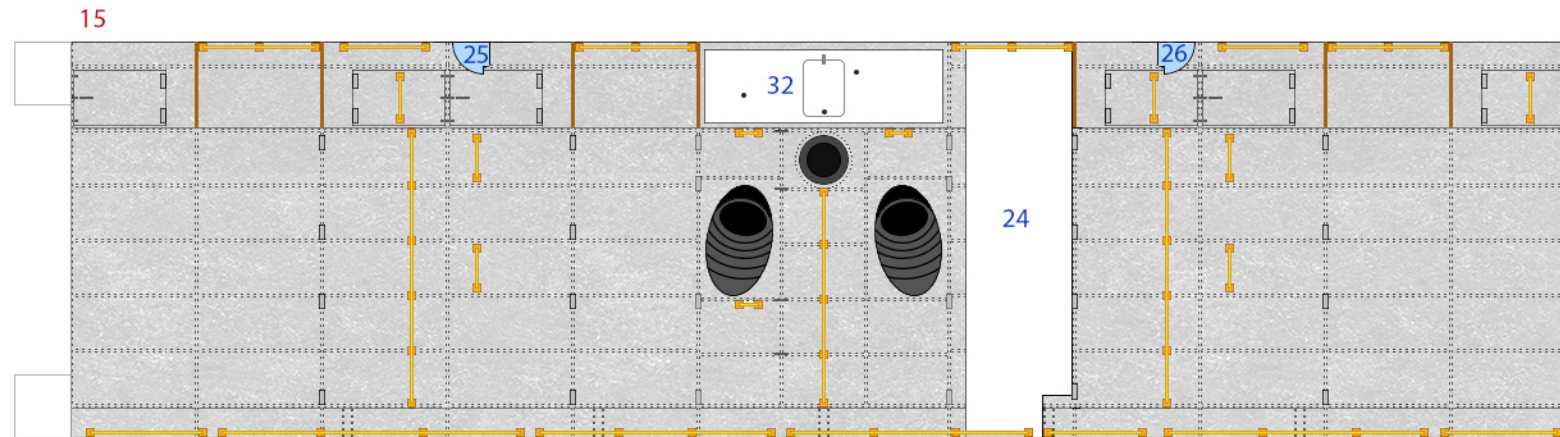
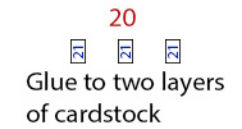
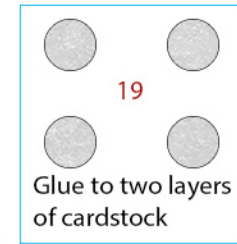
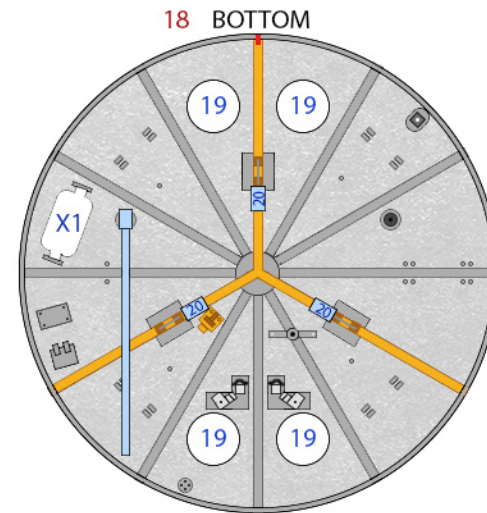
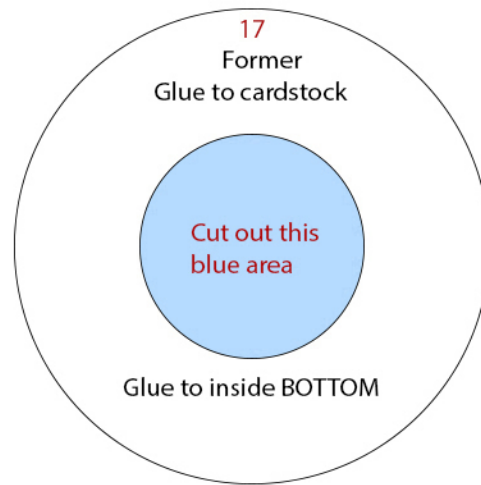
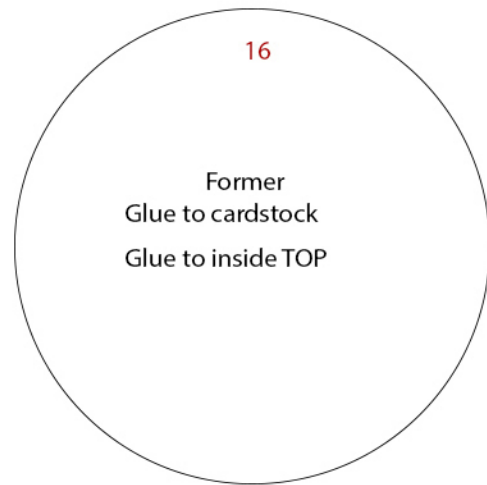


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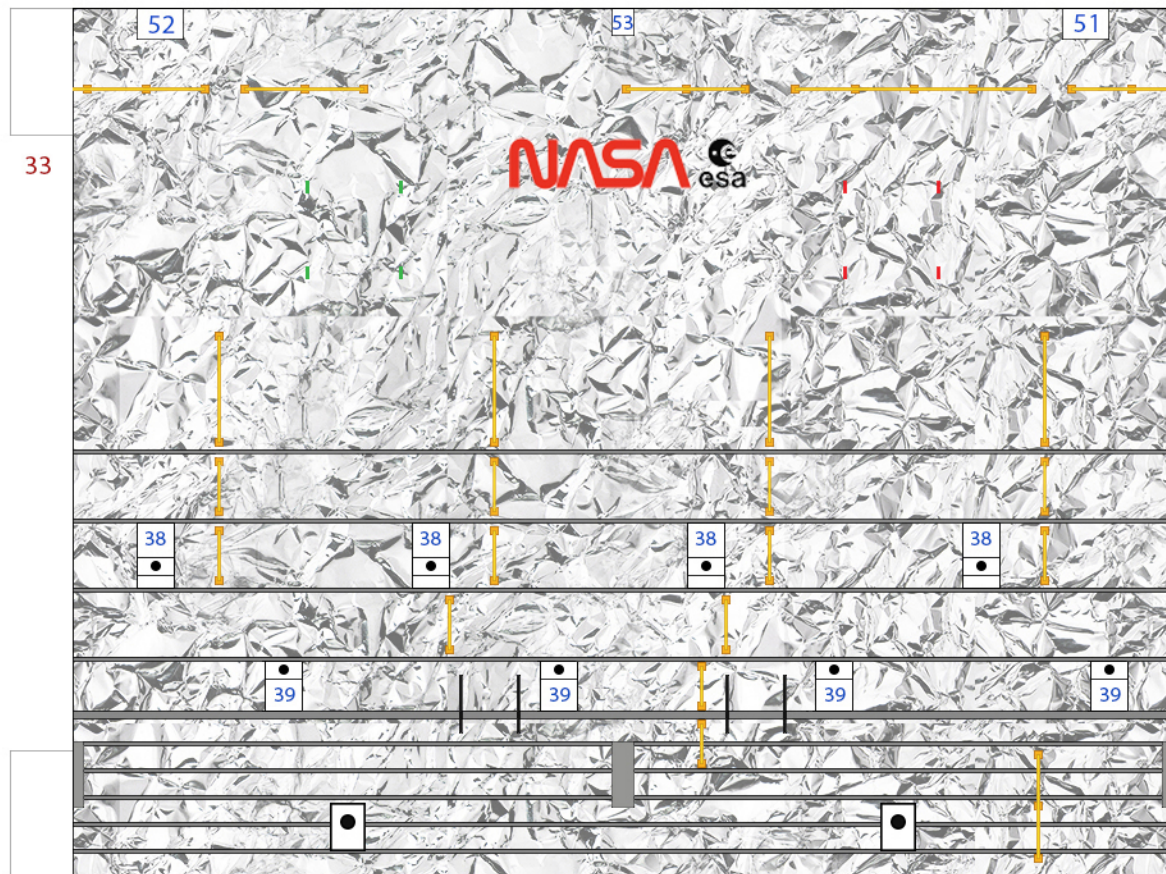
Print model on 65lb paper



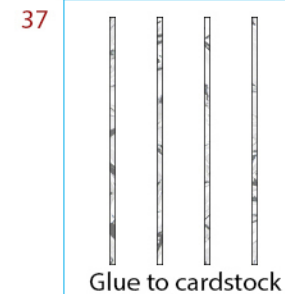
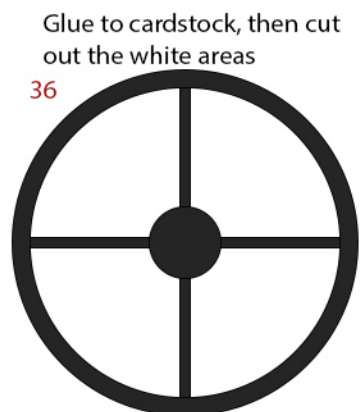
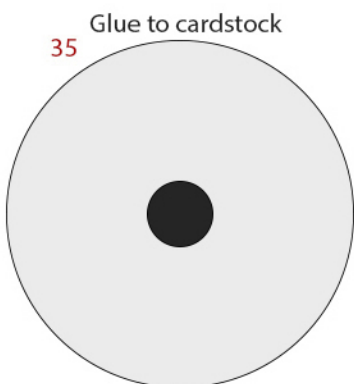
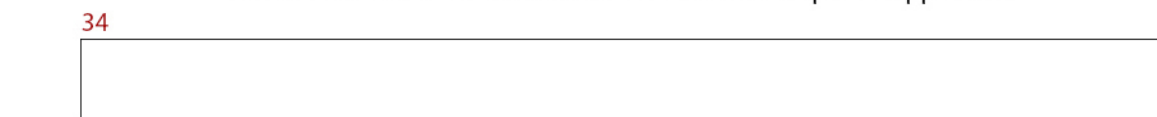
Hubble Space Telescope



Hubble Space Telescope



Poke holes on the two black dots above for the solar panel support rod



38

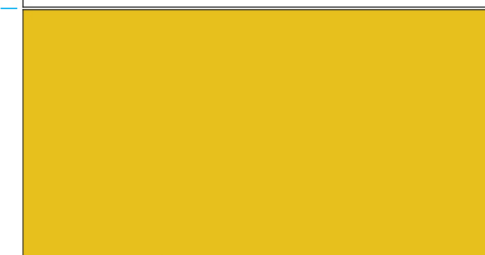
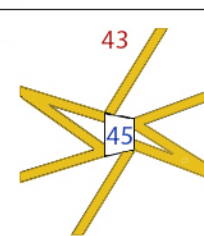
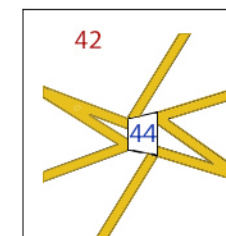
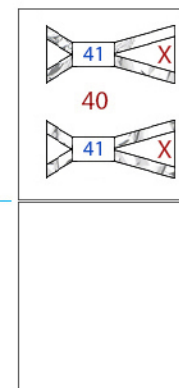


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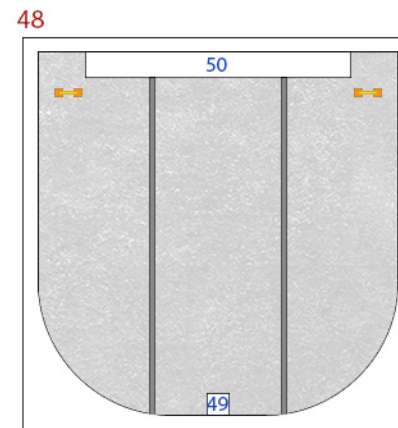
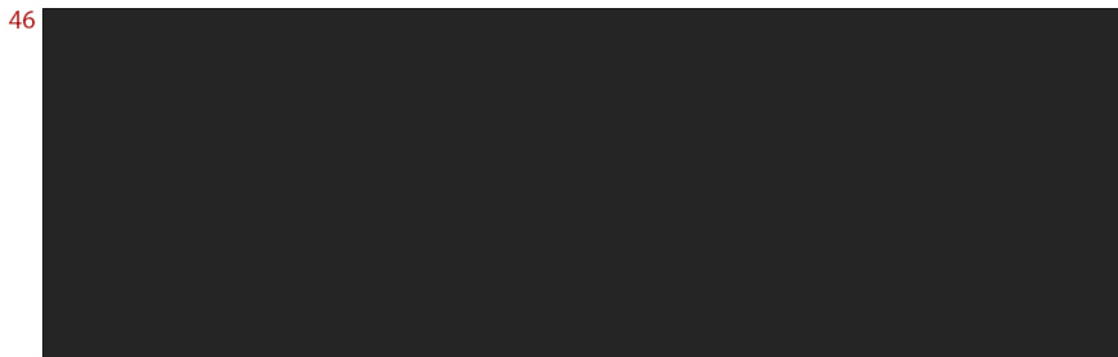
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Fold-glue back-to-back
Cut out the white areas
with the X

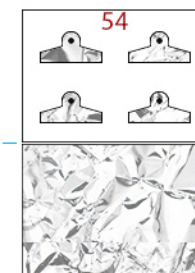


Fold-glue back-to-back

Hubble Space Telescope

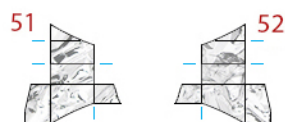
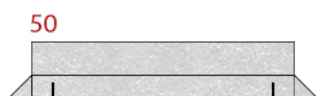


49
Glue to cardstock



Fold-glue back-to-back

Fold-glue back-to-back



Score-fold at the blue lines

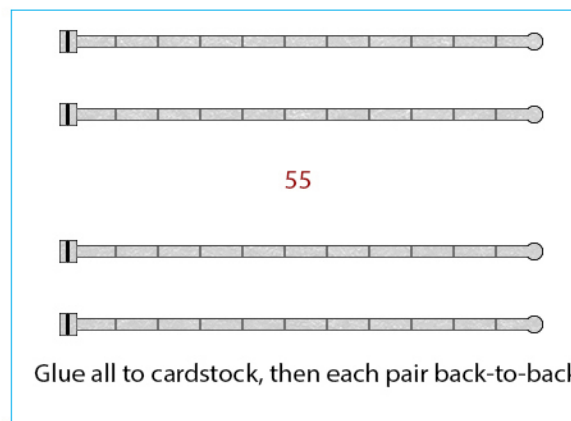


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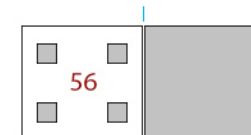
Poke small pin hole on the grey dots to help hold the rods in place.



Need two plastic broom straws or similar material cut at the same length as the line below, colored black

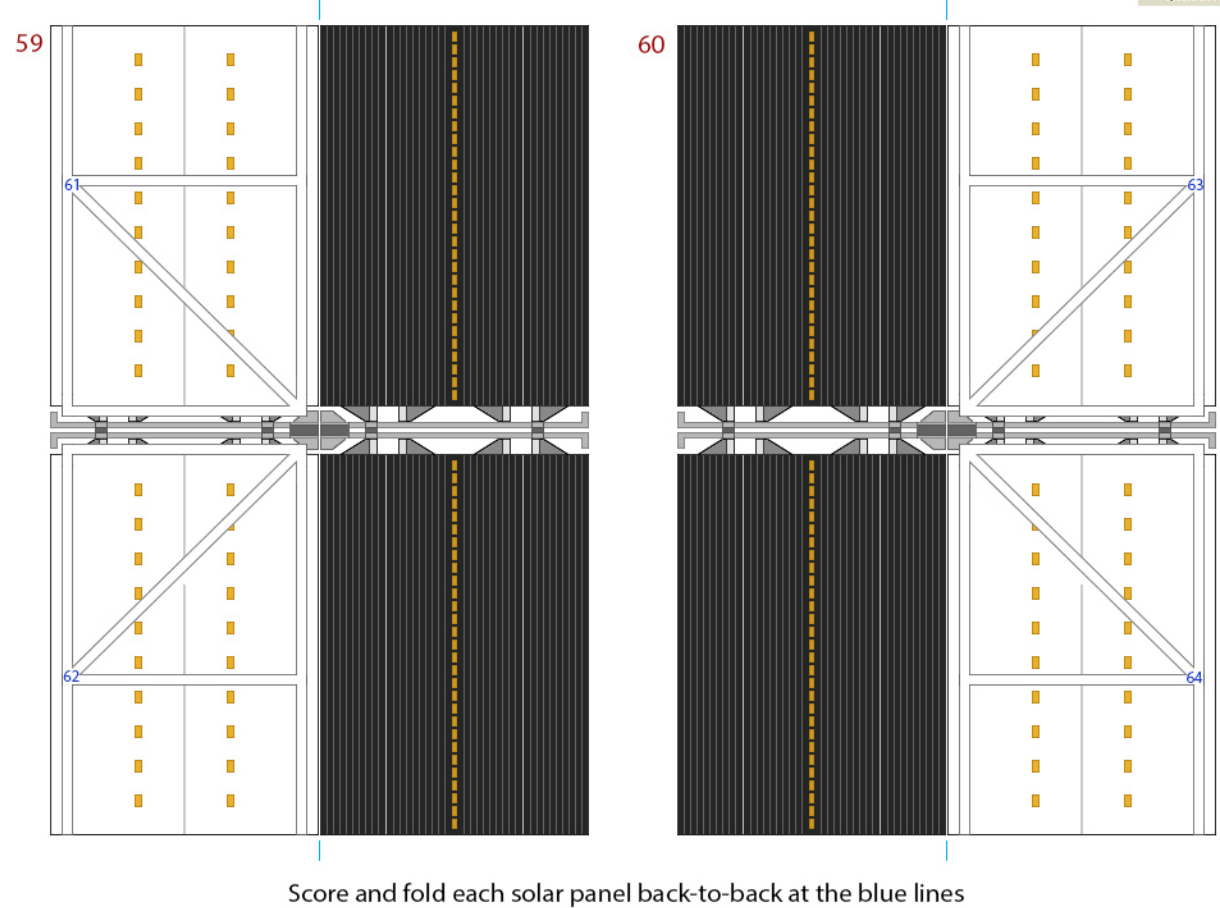
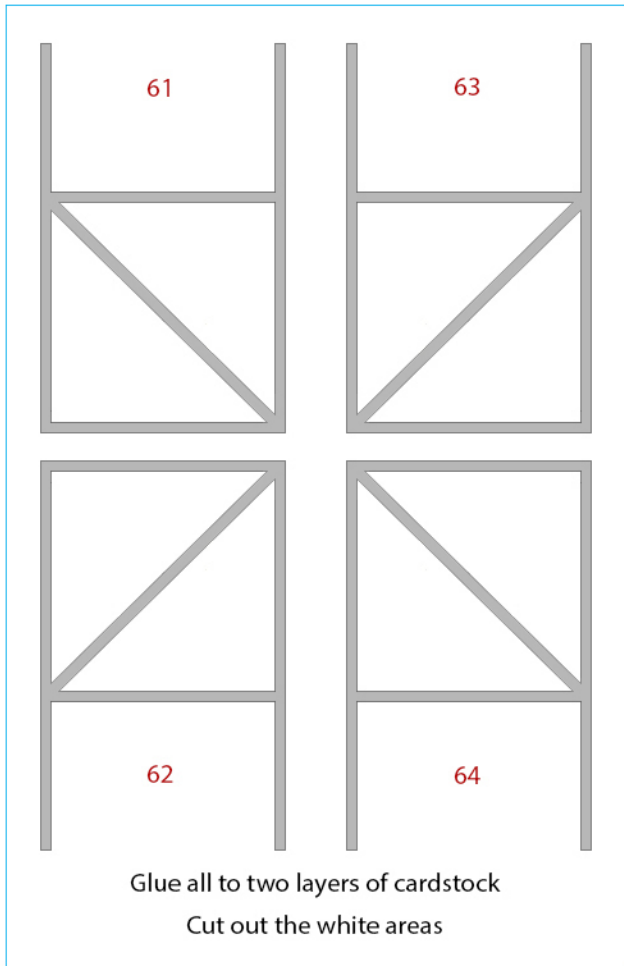


Glue all to cardstock, then each pair back-to-back



Fold-glue back-to-back

Hubble Space Telescope



Cut wooden skewer or similar material around 2mm diameter the same length as the line below, colored light grey or silver for the solar panel support rod.

