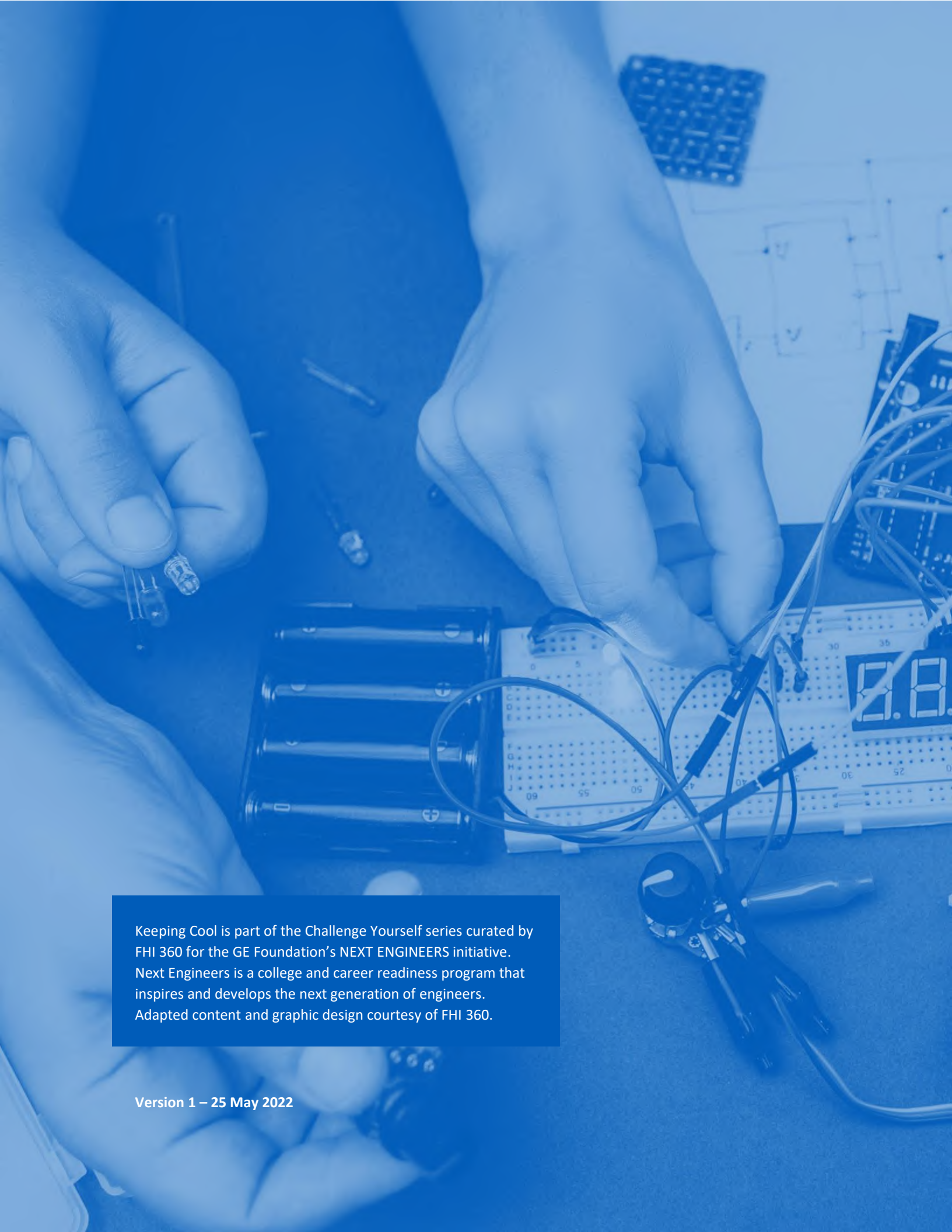
NEXT ENGINEERS

CHALLENGE YOURSELF

The James Webb Space Telescope Part 5: Keeping Cool

Aerospace Engineering

GE Foundation



Keeping Cool is part of the Challenge Yourself series curated by FHI 360 for the GE Foundation's NEXT ENGINEERS initiative. Next Engineers is a college and career readiness program that inspires and develops the next generation of engineers. Adapted content and graphic design courtesy of FHI 360.

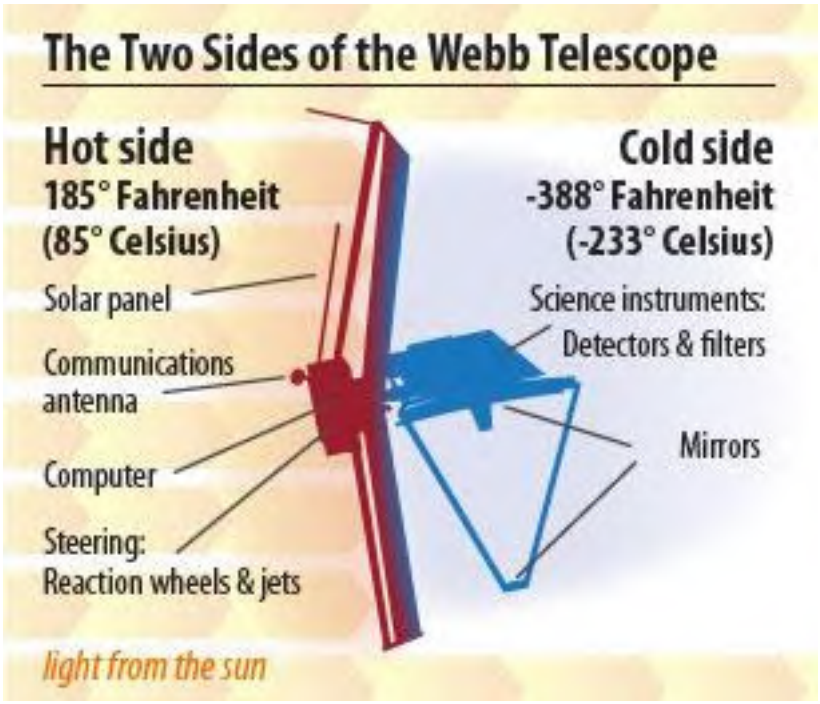
Version 1 – 25 May 2022

The James Webb Space Telescope Part 5: Keeping Cool

NERD OUT

The James Webb Space Telescope is designed to see infrared radiation, the kind of radiation given off by warm things. Webb also needs solar energy to run all its instruments. But if the primary mirror and instruments are bathed in sunlight, they are going to get warm and give off their own infrared radiation. This would interfere with infrared being detected from space.

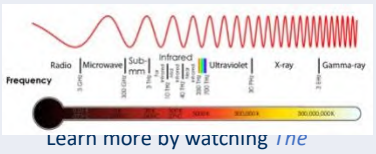
One of the major engineering problems that had to be solved was how to keep the mirrors and instruments very cold (-220°C or -364°F) while still harnessing the Sun's energy for power. The solution? A huge tennis court sized umbrella.



An illustration of the difference in temperature on the hot (Sun) and cold side of Webb
Image by NASA used under fair use
https://webb.nasa.gov/content/about/orbit.html

DID YOU KNOW

Everything in the universe that is even a little warm gives off light. This includes stars, planets, people, and lumps of coal. The hotter an object, the shorter the wavelength of light that is given off. The Sun, being very hot, gives off most light in the visible spectrum. You, being cooler, give off light in the infrared spectrum.



Learn more by watching *The Ultraviolet Catastrophe* (6:31) (https://www.youtube.com/watch?v=FXfrncRey-4) and then playing with the *Blackbody Spectrum simulation* (https://phet.colorado.edu/sims/html/blackbody-spectrum/latest/blackbody-spectrum_en.html).

This umbrella or **sunshield** is made up of five layers of a special material, called Kapton, coated in aluminum. Each layer radiates some of the Sun's heat away. The layers are perfectly spaced so that as much heat energy as possible can be radiated away.

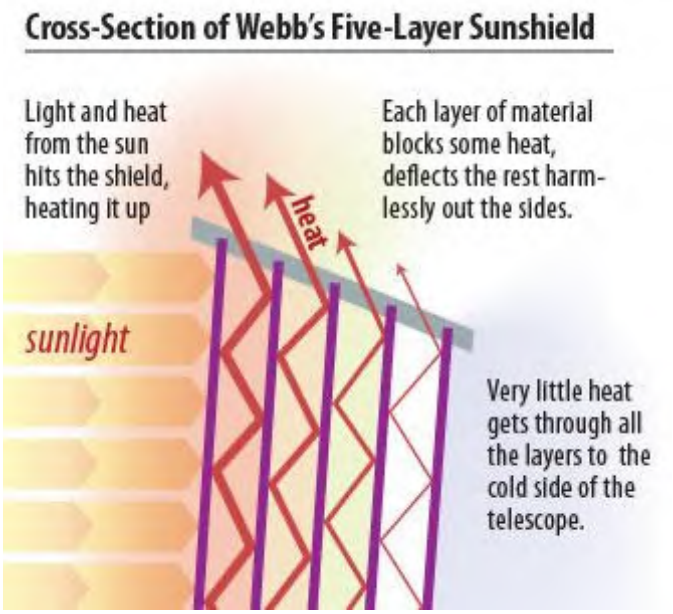
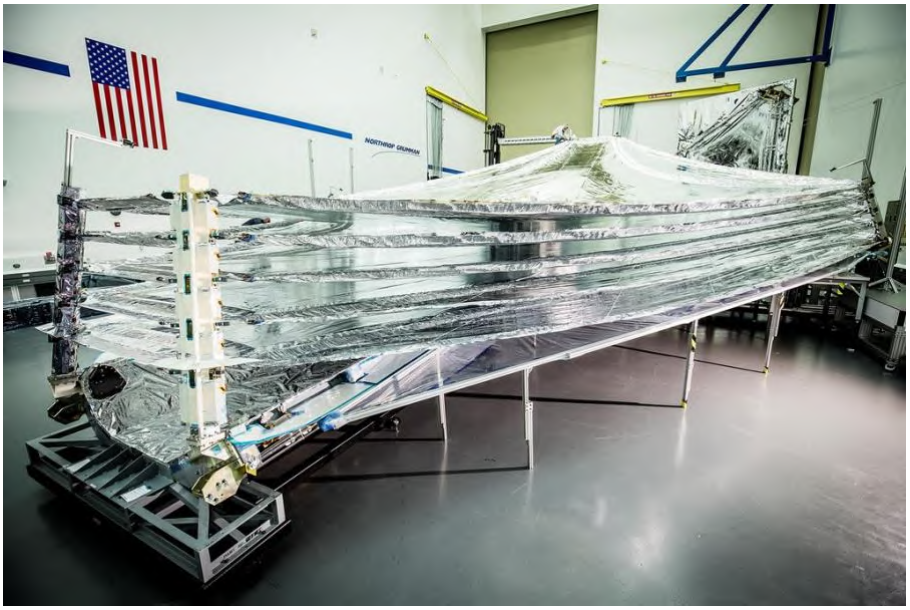


Illustration of the fiver layers of the sunshield and how each layer contributes to radiating away some of the Sun's heat.
Image by STScI is used under fair use
https://webb.nasa.gov/content/observatory/sunshield.html



The five layers of the sunshield
Image by Northrop Grumman is used under fair use
https://webb.nasa.gov/content/observatory/sunshield.html

Learn more about how Webb stays cold.

HAVE A THINK

Why do you think we say something is 'white hot'?

Visit the webpage at http://scienceline.ucsb.edu/getkey.php?key=3167 to see if you are right.

But there's more. A massive space umbrella is not enough to keep Webb's sophisticated instruments cold enough, so Webb also has a first of its kind **cryocooler** to keep the instruments about as cold as it is possible to get. To learn more watch *This is the coolest thing in space. And it's about to get cooler!* (8:40) (https://www.youtube.com/watch?v=5cG1O28XTVQ).

Finally, there is that amazing gold mirror. When things get really cold, they have a tendency to crack or break. A broken or cracked mirror just won't cut it. This is why engineers decided to make the mirror segments out of beryllium – a light and strong metal that is very good at keeping its shape even in extreme temperatures.

Learn more about the *Most Sophisticated Mirror in the Universe* (4:46) (https://www.youtube.com/watch?v=HZXyT969V0Y).

Explore more at Webb Space Telescope.