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Hubblecast Episode 20: Technology to the rescue **FOR IMMEDIATE RELEASE 19:00 (CEST)/13:00 PM EDT 25 September, 2008**		
00:00 **[Visual starts]**		
00:12 **[Intro]**		Intro graphics
00:18 **[Woman]**		Hubblecast logo
This is the Hubblecast! News and images from the NASA/ESA Hubble Space Telescope. Travelling through time and space with our host Doctor J a.k.a. Dr. Joe Liske.		Episode 20: Technology to the rescue
00:29 **[Dr. J]** Welcome to this third, special episode of the Hubblecast, celebrating the International Year of Astronomy in 2009.		Dr. J in virtual studio
In the last episode, we saw how astronomers use bigger and bigger mirrors to see further than ever before. Today's topic is the advance of technology through the 1970s and '80s, that really revolutionised astronomy.		Dr. J text
Just as modern cars don't look like a Model T Ford anymore, so are present day telescopes radically different from their classic predecessors, like the five metre Hale telescope. For one thing, their mounts are much smaller.		Three strips of images, two showing telescopes
The old-style mount is an equatorial one where one of the axis is always mounted parallel to the Earth's rotation axis. In order to keep track of the sky's motion, the telescope simply has to rotate around this axis at the same speed with which the Earth rotates.		Animation of equatorial mount
Easy, but space-hungry.		Dr. J in front of the three strips

The modern day altitude azimuth mounts are much more compact. With a mount like that, the telescope is pointed much like a cannon. One simply chooses the bearing, chooses the altitude, and off you go.		Animation of alt-azi mount
The problem is to keep track of the sky's motion. The telescope pretty much has to rotate around both axis, and at varying speeds.		Dr. J in front of the three strips
Essentially this only became possible once telescopes were computer controlled.		Panning video of large telescope
A smaller mount is cheaper to build. Moreover, it fits into a smaller dome which reduces the cost even further and it improves the image quality.		Dr. J in front of digital telescope
Take the twin Keck Telescopes on Hawaii, for example. Although their 10 metre mirrors are twice as large as the one of the Hale telescope, they nevertheless fit into smaller domes than the one on Palomar Mountain.		Ariel footage of the Keck telescopes Video of telescope mirror
02:15 **[Narrator]** Telescope mirrors have evolved too. They used to be thick and heavy. Now they're thin and lightweight. Mirror shells that can be many metres wide are cast in giant, rotating ovens. And they are still less than 20 centimetres thick. An intricate support structure prevents the thin mirror from cracking under its own weight. Computer controlled pistons and actuators also help to keep the mirror in perfect shape.		Time-lapse video of large mirror construction
02:44 **[Dr. J]** This system is called active optics. The idea is to compensate and to correct any deformations of the main mirror caused by gravity, the wind, or temperature changes. Now, a thin mirror also weighs much less. That means that its whole supporting structure, including the mount, can also be a lot trimmer and lighter. And cheaper!		Dr. J in virtual studio, in front of a screen showing an animated explanation of adaptive optics and mirrors.
Now here's the 3.6 metre New Technology Telescope, built by European astronomers in the late 1980s. It served as a testbed for many of the new technologies in telescope building. And even its enclosure has nothing in common with traditional telescope domes. The New Technology Telescope was a great success. It was time to break the six metre barrier.		Rotating photograph of NTT
03:28 **[Narrator]** Mauna Kea Observatory sits on the highest point in the Pacific, 4200 metres above sea level.		Zoom into image of Mauna Kea

On the beaches of Hawaii, tourists enjoy the Sun and the surf. But high above them astronomers face chilling temperatures and altitude sickness in their quest to unravel the mysteries of the Universe.		Time-lapse footage of Mauna Kea and clouds
The Keck Telescopes are among the largest in the world. Their mirrors are 10 metres across, and wafer-thin.		Ariel footage of Keck telescopes Zoom into photos of the mirrors
Tiled like a bathroom floor, they consist of 36 hexagonal segments, each controlled to nanometre precision.		Detail video of hexagonal mirror
These are true giants, devoted to observing the heavens. The cathedrals of science.		Exterior video
Nightfall on Mauna Kea. The Keck Telescopes begin collecting photons from the far reaches of the cosmos. Their twin mirrors combining to be effectively larger than all earlier telescopes.		Time-lapse video of nightfall over Mauna Kea Panning photo of mirror
What will be tonight’s catch?		Panning across the night sky
A pair of colliding galaxies, billions of light-years away?		Fading montage of astronomical objects
A dying star, gasping its last breath into a planetary nebula?		
Or maybe an extrasolar planet that might harbour life?		
On Cerro Paranal in the Chilean Atacama Desert — the driest place on Earth — we find by far the biggest astronomy machine ever built: the European Very Large Telescope.		Overhead animation of VLT
The VLT is really four telescopes in one. Each sporting an 8.2 metre mirror.		Montage of VLT time-lapse videos Animated tour of VLT site
Antu. Kueyen. Melipal. Yepun. Native Mapuche names for the Sun, the Moon, the Southern Cross and Venus.		
The huge mirrors were cast in Germany, polished in France, shipped to Chile, and then slowly transported across the desert.		Photos of the mirrors’ journey
At sunset, the telescope enclosures open up. Starlight rains down on the VLT mirrors. New discoveries are made.		Video of VLT beneath starry sky
05:56 **[Dr. J]** A laser pierces the night sky. It projects an artificial star into the atmosphere, 90 kilometres above our heads.		Dr. J in virtual studio, background TV showing a laser from a telescope
Wavefront sensors measure how the star’s image is distorted by the atmospheric turbulence.		Animated explanation of wavefront sensors
Then, fast computers tell a flexible mirror how it has to deform itself in order to correct the distortion. In effect untwinkling the stars.		
This is called adaptive optics and it’s the big magic trick of present day astronomy. Without it, our view of the Universe would look blurred by the atmosphere. But with it, our images are razor-sharp.		Blurry astronomical image Sharp astronomical image
The other piece of optical wizardry is known as interferometry.		

The idea is to take the light from two separate telescopes and to bring it together in a single point, while preserving the relative shifts between the lightwaves. If it is done precisely enough the result is that the two telescopes act as if they were part of a single, colossal mirror as large as the distance between them.		Dr. J in virtual studio, TVs showing production line
In effect, interferometry gives your telescope eagle-like vision. It allows smaller telescopes to reveal a level of detail that would otherwise only be visible with a much larger telescope.		Photo of large telescopes
The twin Keck Telescopes on Mauna Kea regularly team up as an interferometer.		Dr. J in virtual studio, background TVs showing images of telescopes
In the case of the VLT, all four telescopes can work together. In addition, several smaller auxiliary telescopes can also join the ranks in order to sharpen up the view even more.		
07:30 **[Narrator]** Other big telescopes can be found all over the globe.		Time-lapse montages of large telescope observing
Subaru and Gemini North on Mauna Kea.		
Gemini South and the Magellan Telescopes in Chile.		
The Large Binocular Telescope in Arizona.		
They are constructed at the best available sites. High and dry, clear and dark.		Zooming out of photo showing telescope site
Their eyes are as large as swimming pools.		Photographs of LBT
All kitted out with adaptive optics to counteract the blurring effects of the atmosphere.		
And sometimes they can have the resolution of a virtual behemoth, thanks to interferometry.		Telescope domes
Here’s what they’ve shown us.		Montage of astronomical images
Planets.		
Nebulae.		
The actual sizes – and squashed shapes – of some stars.		
A cool planet orbiting a brown dwarf.		
And giant stars whirling around the core of our Milky Way Galaxy, governed by the gravity of a supermassive black hole.		Animation of stars orbiting a black hole.
We’ve come quite a way since Galileo’s day.		
08:41 **[Dr. J]** Thank you for joining me in this third episode of the special series. Next time we will see how astronomers have detected and measured light over the years, from hand-drawings to electronic detectors.		Dr. J in virtual studio, background time-lapse video

This is Dr. J, signing off for the Hubblecast. Once again nature has surprised us beyond our wildest imagination. **09:23 END**		Hubblecast is produced by ESA/Hubble at the European Southern Observatory in Germany. The Hubble mission is a project of international cooperation between NASA and the European Space Agency. Credits