NASA**facts**

Hubble Space Telescope – Tools

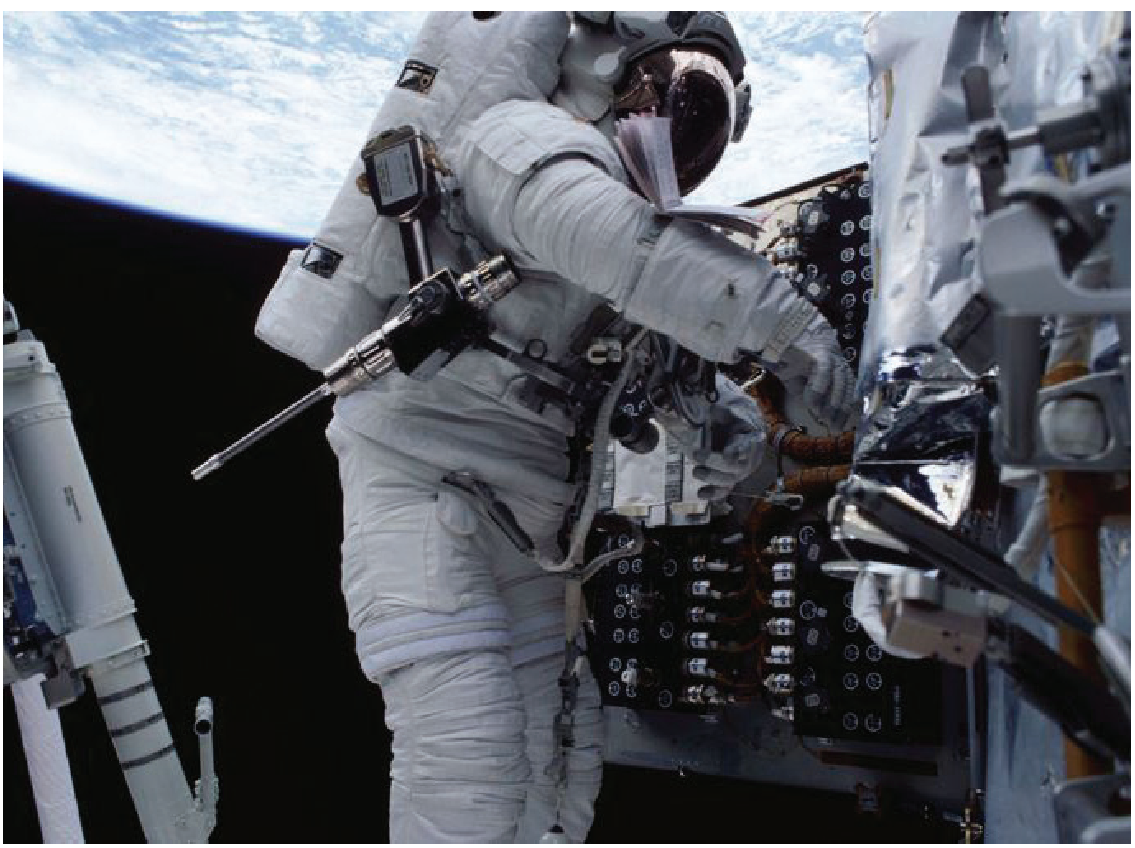
The Hubble Space Telescope was designed to be serviced in space, allowing astronauts to make repairs when components wore out and to upgrade the telescope as technologies advanced on the ground. A variety of specially developed tools had to be created to enable that work. The telescope underwent five servicing missions, which significantly increased its original anticipated scientific life of ~15 years. In 2020, Hubble reached 30 years in orbit.

Many of Hubble's components were designed with standard interfaces so they could be swapped out as smoothly and simply as possible. But astronauts also tackled repairs beyond the scope of Hubble's original design during Servicing Mission 4 in 2009. Two instruments, the Space Telescope Imaging Spectrograph (STIS) and the Advanced Camera for Surveys (ACS), had developed internal electrical shorts. They were restored with the use of specialized tools designed to make such complex repairs possible.

Hubble servicing was performed by astronauts wearing bulky, pressurized spacesuits that limit upper body positioning and arm range of motion, as well as line of sight and field of view. The servicing tasks often required tools that performed similar functions as common Earth-bound tools but had to be quite different to make them "astronaut friendly," or usable for a human in a spacesuit with a limited time to get the job done. Over 300 tools and tool components were designed and developed by engineers and extravehicular activity (EVA) specialists with the Hubble Space Telescope program at Goddard Space Flight Center in Greenbelt, Maryland.

Identifying the Need

Over the course of five servicing missions, the Hubble team became adept at creating and refining the tools to make the astronauts' jobs easier and safer. Ideas for new and improved tool concepts often arose as astronauts trained for missions. Some examples of these innovative designs follow.



Astronaut Richard M. Linnehan, the Pistol Grip Tool secured at his side, works on Hubble during Servicing Mission 3B in 2002. Credit: NASA

Portable Foot Restraint

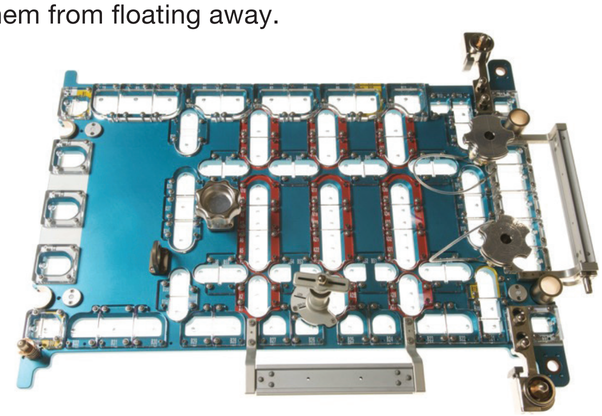
The Portable Foot Restraint (PFR) was created for Servicing Mission 1 in 1993 to provide astronauts with a stable platform that spacesuit boots would lock into, giving them something to push against to turn their bodies and help them work on the telescope. Mounting receptacles for the foot restraint were strategically placed around the telescope's exterior and in the space shuttle's payload bay to provide secure access to worksites. The astronaut would insert the PFR into one of the receptacles, then place each boot toe through one of the stirrups and lock their heel in. The astronaut could then adjust the platform for optimal tilt and positioning.

Pistol Grip Tool

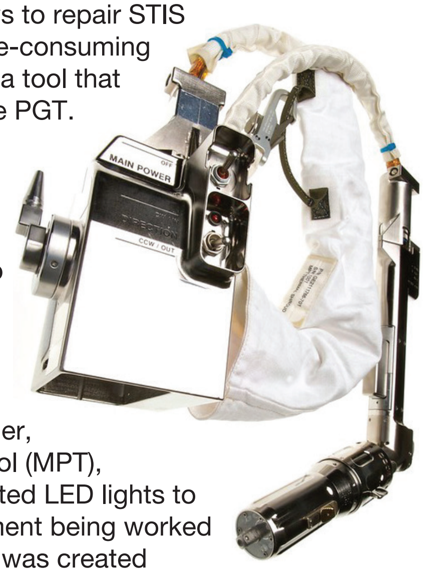
The first successful, self-contained, computer-controlled astronaut power tool used in space was invented to service Hubble. The Pistol Grip Tool (PGT) was the brainchild of a Hubble program engineer, Paul Richards, who later became an astronaut and used the PGT during a spacewalk to service the International Space Station. It was first used during Servicing Mission 2 in 1997 and became the "go-to" tool for all subsequent Hubble servicing. The PGT is a programmable drill with high torque that turns at a deliberately slow speed for increased control. Astronauts can pre-set the speed, number of turns, direction, and other features for each task. The PGT also records its motions and settings, providing a wealth of useful information for subsequent repairs. The PGT would become the standard EVA power tool for the International Space Station and Hubble servicing missions.

Fastener Capture Plate

Hubble's Space Telescope Imaging Spectrograph (STIS) stopped working in August 2004 when its power supply failed. In order to revive STIS, astronauts had to replace an electronics board inside STIS, which had never been attempted before in space. To do this, astronauts faced the challenge of removing 111 tiny screws without letting them drift away, potentially interfering with repairs or getting lost inside of and damaging the electronics. This would have been an extremely difficult task while wearing bulky astronaut gloves. The STIS Fastener Capture Plate, which clamped over the screws, was designed with holes just large enough to allow a power tool bit to access each screw, but small enough to trap the screws and keep them from floating away.



Mini Power Tool



Removing 111 screws to repair STIS was a potentially time-consuming project that required a tool that turned faster than the PGT. Experimenting with tools during training, astronaut Mike Massimino found that the PGT was too bulky for the close quarters inside STIS and obstructed his line of sight. The solution was the leaner, faster Mini Power Tool (MPT), which also incorporated LED lights to illuminate the instrument being worked on. Though the MPT was created specifically for the STIS repair, its success has made it a candidate for use on future space missions.

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