VALUE ADDED: The Benefits of Servicing Hubble

Every few years, a team of astronauts carries a full manifest of new equipment on the Space Shuttle for the ultimate "tune-up" in space: maintaining and upgrading the Hubble Space Telescope on orbit.

This ability is one of Hubble's important features. When the Telescope was being designed, the Space Shuttle was being readied for its first flights. NASA realized that if a shuttle crew could service HST, it could be maintained and upgraded indefinitely. So from the beginning, Hubble was designed to be modular and astronaut friendly.

The modular design allows NASA to periodically re-equip HST with state-of-the-art scientific instruments—giving the Telescope exciting new capabilities (see Fig. 7-1). In addition to science upgrades, the servicing missions permit astronauts to replace limited-life components with systems incorporating the latest technology (see Fig. 7-2).

Cost-Effective Modular Design

The 1993 and 1997 servicing missions increased Hubble's scientific exposure time efficiencies 11-fold. Astronauts installed two next-generation scientific instruments, giving the Telescope infrared and ultraviolet vision, and a Solid State Recorder (SSR), further expanding its observing capability.

During Servicing Mission 3B (SM3B), astronauts will add a camera 10 times more powerful than the

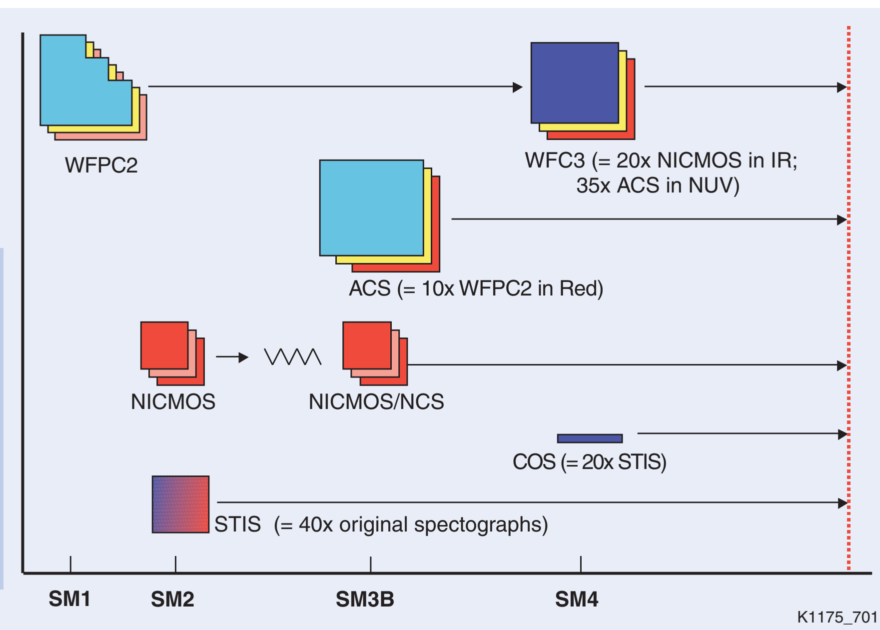

Fig. 7-1 Advanced scientific instruments installed (or to be installed) on HST pave the way to new discoveries.

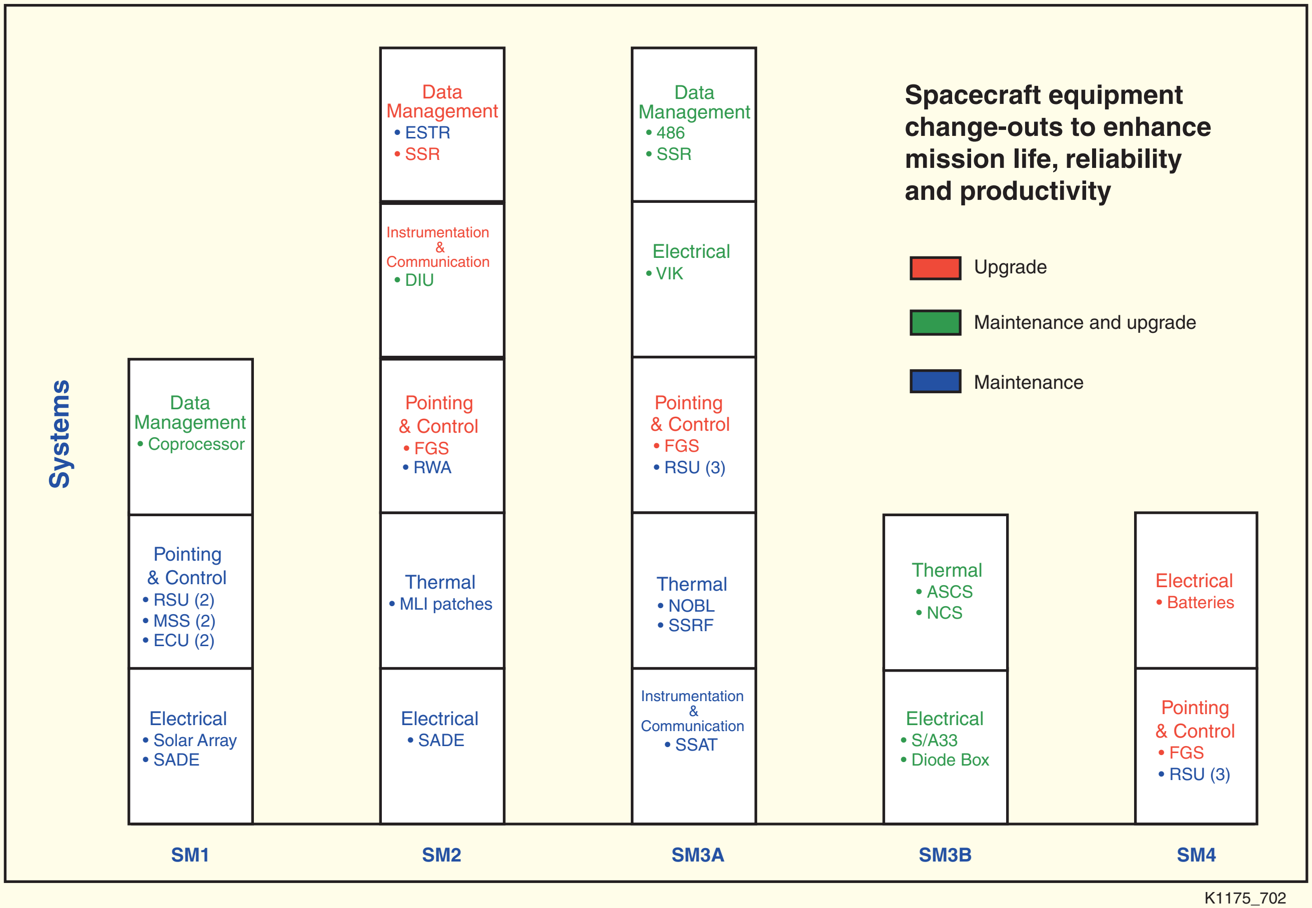

Fig. 7-2 Systems maintained and upgraded during each servicing mission

already extraordinary cameras on board. They also will fit the Telescope with new, super-efficient solar array panels that will allow simultaneous operation of scientific instruments. These technologies were not available when Hubble was designed and launched.

The following sections identify some of the planned upgrades to HST and their anticipated benefits to performance. These improvements demonstrate that servicing HST results in significant new science data at greatly reduced cost.

Processor

During Servicing Mission 3A (SM3A), astronauts replaced Hubble's original main computer, a DF-224/coprocessor combination, with a completely new Advanced Computer based on the Intel 80486 microchip. This computer is 20 times faster and has six times as much memory as the one it replaced (see Fig. 7-3).

In a good example of NASA's goal of "faster, better, cheaper," commercially developed and commonly available equipment was used to build the new computer at a fraction of the cost of a computer designed specifically for the spaceflight environment.

The new computer's capabilities have increased Hubble's productivity by performing more work in space and less work on the ground. In addition, the

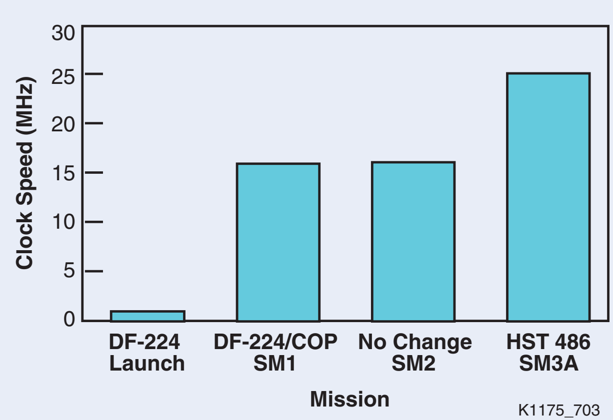

Fig. 7-3 Processor improvements

computer uses a modern programming language, which decreases software maintenance cost.

Data Archiving Rate

The addition of a second SSR during SM3A dramatically increased Hubble's data storage capability. The science data archiving rate is more than 10 times greater than First Servicing Mission (1993) rates (see Fig. 7-4). Prior to the Second Servicing Mission (SM2 in 1997), Hubble used three reel-to-reel tape recorders designed in the 1970s. SM2 astronauts replaced one of the mechanical recorders with a digital SSR.

Unlike the reel-to-reel recorders, the SSRs have no reels, no tape and no moving parts that can wear out and limit lifetime. Data is stored digitally in computer-like memory chips until Hubble operators command its playback.

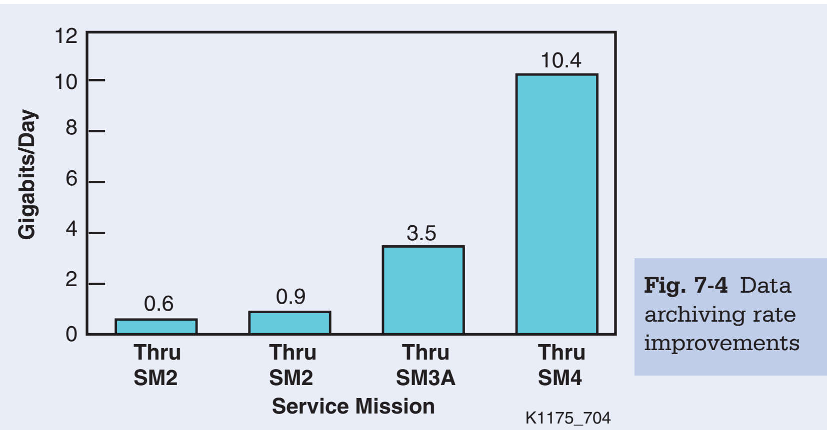

Fig. 7-4 Data archiving rate improvements

Although an SSR is about the same size and shape as a reel-to-reel recorder, it can store 10 times as much data: 12 gigabits instead of only 1.2 gigabits. This greater storage capacity allows Hubble's second- generation scientific instruments to be fully productive.

Detector Technology

Advanced detector technology allows the Telescope to capture and process faint amounts of light from the far reaches of space. Increased power and resolution refinements will enhance Hubble's performance, delivering even sharper, clearer and more distinct images.

Adding the Advanced Camera for Surveys during SM3B will increase the total number of onboard pixels *4800 percent* (see Fig. 7-5).

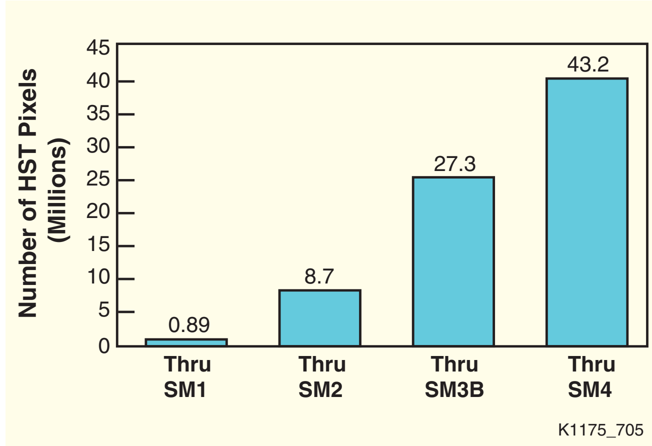

Fig. 7-5 Increase in onboard pixels

Cryogenic Cooler

Installation of the Near Infrared Camera and Multi Object Spectrograph (NICMOS) Cryogenic Cooler (NCC) during SM3B will greatly extend the life of Hubble's infrared cameras.

NICMOS, which was installed on Hubble in 1997, has been a spectacular success. However, in January 1999 it ran out of the coolant necessary for conducting scientific operations. The new NCC will increase NICMOS's lifetime seven-fold—from 1.8 years to 10 years (see Fig. 7-6).

The cost to develop and install the NCC is approximately $21 million, while the cost of NICMOS was $100 million. Installing the cryocooler will preserve and extend the instrument's unique science contribution, ensuring a greater return on the original investment.

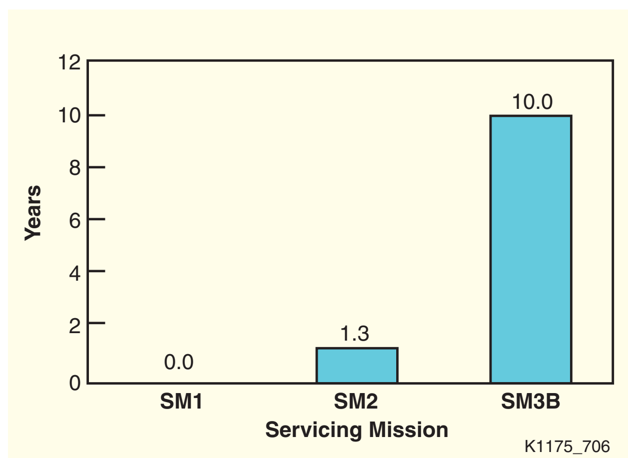

Fig. 7-6 Increase in HST infrared capability

Solar Arrays

New, rigid solar arrays installed during SMB3 will provide substantially more energy to Hubble. The increased power will enhance productivity by allowing simultaneous operation of up to four Hubble instruments (see Fig. 7-7).

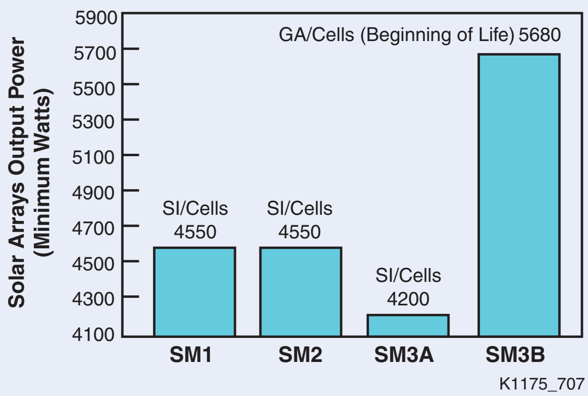

Fig. 7-7 Productivity gains with new solar arrays

Simultaneous Science

One of the most exciting advances afforded by servicing is the ability to double the simultaneous operations of scientific instruments. Originally, the instruments were designed to work in pairs. Following SM3B, developments in solar array technology and thermal transport systems will allow four science instruments to operate at the same time, dramatically increasing Hubble's ability to study the universe (see Fig. 7-8).

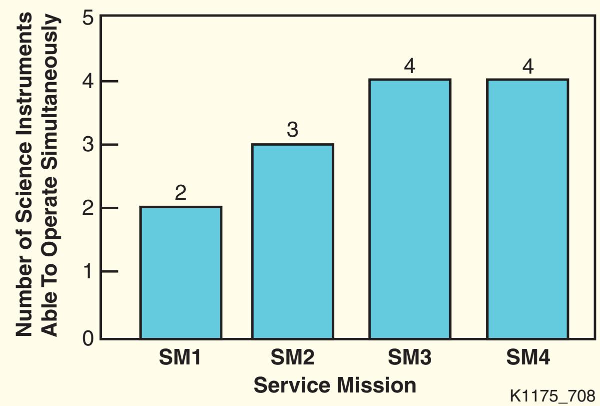

Fig. 7-8 Simultaneous use of science instruments