NASA Facts

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Co-Processor

One of the servicing activities planned for NASA's Hubble Space Telescope maintenance mission is the installation of co-processor on the DF-224 computer. The DF-224 computer, built by Rockwell Autonetics, is a general-purpose digital computer used for onboard engineering computations. The computer executes stored commands, formats data calculations and telemetry, orients the solar arrays toward the sun, monitors the power system and points the antennas. The DF-224 configuration is three central processing units (CPUs), two as backup; six memory units (MUs), with up to 48,000 words total; three input/output units (IOUs), two as backup; and six power converter units (PCUs) assigned with overlapping functions as a safeguard. The DF-224 is 1.5 x 1.5 x 1 foot (0.4 x 0.4 x 0.3 m) and weights 110 pounds (50 kg).

Two of the DF-224 computer's memory units have failed. The HST mission requires a minimum of three working memory units. Three memory units would require more frequent memory load uplinks than are desirable, however, because the mission currently makes use of four memory units. As a second consideration, additional memory units provide more redundancy as a protection against any possible future problems and provide room for improved software algorithms.

NASA's Goddard Space Flight Center, Greenbelt, Md., holds responsibility for the development of the computer co-processor. Fairchild Space, Germantown, Md., is the designer of the box, and Jackson & Tull, Seabrook, MD is the designer of the Shared Memory Input-Output Card (SMIO) and the cables which connect the co-processor to the computer. The dimensions of the co-processor are approximately 8 x 8 x 14 1/2 inches (20 x 20 x 37 cm). Cost of the co-processor is $4.2 million.

How it Works

The co-processor consists of two redundant strings of an Intel 80386/80387 processor and memory capable of operating with the DF-224 computer by means of a shared memory interface. One of the two independent strings will operate while the other is not powered. Each computer string consists of a central processor, shared memory and interface to the DF-224 computer's data bus.

Capacity

The shared memory contains 64K 24-bit words of Random Access Memory (RAM) accessible from the DF-224 and from the 386 board. The memory is organized into eight logical memory units (LMUs) of 8K words each. Any combination of up to eight 8K modules shared RAM and DF-224 internal 8K memory modules can be configured. The co-processor's 386 board is designed with 1M byte of fast RAM for executing application code. Also, the 386 board contains 256K bytes of non-volatile reprogrammable memory for storing application code and 128K bytes of non-volatile memory for storing the initialization and application code. The former can be changed after launch; the latter cannot.

Development

The development of the co-processor included a succession of three higher and higher fidelity engineering models and a flight model. Engineering model testing concluded in the Fall 1992 with a successful integration and test with the engineering model DF-224 in the Vehicle Electrical System Test (VEST) facility at Goddard. An engineering model co-proces-

sor is currently in system testing, and the flight model will be integrated and tested with a single string DF-224, the engineering model DF-224 and with the flight spare DF-224. The checkout with multiple DF-224s is designed to ensure that there will be compatibility with the flight DF-224 on orbit.

Location

The co-processor will reside in Bay 1 of HST and will be mounted on the DF-224.

Installation

The Extra Vehicular Activity (EVA) procedures that will be used in the installation of the co-processor currently are: (1) one astronaut (EV1) will install a portable foot restraint on Bay 1 of the HST (where the DF-224 is located) while the other EVA astronaut (EV2) rides the Remote Manipulator System (mechanical arm) over to the worksite; (2) EV1 will release the Bay 1 door latches and open the door with the assistance of EV2; (3) EV2 moves to the Large Orbital Replacement Unit Protective Enclosure (LOPE) and awaits EV1's request for the co-processor; (4) EV1 disconnects the heater cable of the DF-224 and releases six hooks securing the DF-224 to the HST structure.

Also, (5) EV1 removes the J8 and J9 connector covers on the DF-224, cuts their tethers and stows them in a trash bag, EV2 retrieves the co-processor from the LOPE and transports it to the Bay 1 worksite; (6) EV1 removes the existing EVA handles on the DF-224 to allow for installation of the co-processor and stows them in the trash bag; (7) EV1 receives the co-processor from EV2 and connects the heater leads; (8) EV1 attaches the co-processor mechanically to the DF-224.

Then, (9) EV1 completes the electrical installation of the co-processor by installing the electronics connectors to the two open outlets; (10) EV1 re-installs the DF-224 mechanically to the HST and securing the six hooks released earlier; and (11) EV1 closes the Bay 1 door, engages the latches and egresses the portable foot restraint, EV2 assists in worksite closeout as necessary.

The mechanical installation is relatively straight forward, the only real concern is that one of the two connectors that must be mated might get damaged. The connectors contain as many as 128 pins (similar to the ones that plug into a personal computer), and the astronauts will be wearing gloves that do not provide them with the greatest of dexterity. Available to the spacewalkers will be a pin straightener and a spare cable. The co-processor is being added to the current flight DF-224 because replacing the current DF 224 with the flight spare or the flight spare with the co-processor already installed requires the removal and replacement of seven connectors while the addition of the co-processor requires only the mating of two connectors.

Immediately following installation, a pre-planned aliveness test will be conducted. This test will verify that the co-processor's shared memory is working and properly talking to the DF-224. If the test indicates that neither side of the co-processor works with the current DF-224, and there is no cable problem, the astronauts will install the spare DF-224, which will be carried onboard as a contingency. The installation of the spare DF-224 would take place during a contingency Extra Vehicular Activity (EVA), or space walk.

The Hubble Space Telescope Project is managed by the Goddard Space Flight Center for the Office of Space Science, NASA Headquarters, Washington, DC.