

***Excerpt with updates from the Hubble Space Telescope
Servicing Mission 4 Media Reference Guide, 2009***

Science Instrument Command and Data Handling Unit

The SI C&DH unit keeps all science instrument systems synchronized. It works with the DMU to process, format and temporarily store information on the data recorders or transmit science and engineering data to the ground.

Components

The SI C&DH unit is a collection of electronic components attached to an Orbital Replacement Unit (ORU) tray mounted on the door of Bay 10 in the SSM Equipment Section. Small remote interface units (RIU), also part of the system, provide the interface to individual science instruments.

Components of the SI C&DH unit are:

- NASA Standard Spacecraft Computer (NSCC-1)
- Two standard interface circuit boards for the computer
- Two control units/science data formatter units (CU/SDF)
- Two central processing unit (CPU) modules • APCU
- Two RIUs
- Various memory, data and command communications lines (buses) connected by couplers.

These components are redundant so the system can recover from any single failure.

NASA Computer. The original SI C&DH NSSC-1 has one CPU and eight memory modules, each holding 8,192 eighteen-bit words. The replacement unit has one CPU and four independent 64K memory modules of Complementary Metal-Oxide Semiconductor (CMOS) memory - one memory module is used operationally, with the other three serving as backups. An embedded software program (the "executive") runs the computer. It moves data, commands and operation programs (called applications) for individual science instruments in and out of the processing unit. The application programs monitor and control specific instruments, and analyze and manipulate the collected data.

The memory stores operational commands for execution when the telescope is not in contact with the ground. Each memory unit has five areas reserved for commands and programs unique to each science instrument. The computer can be reprogrammed from the ground for future requests or for working around failed equipment.

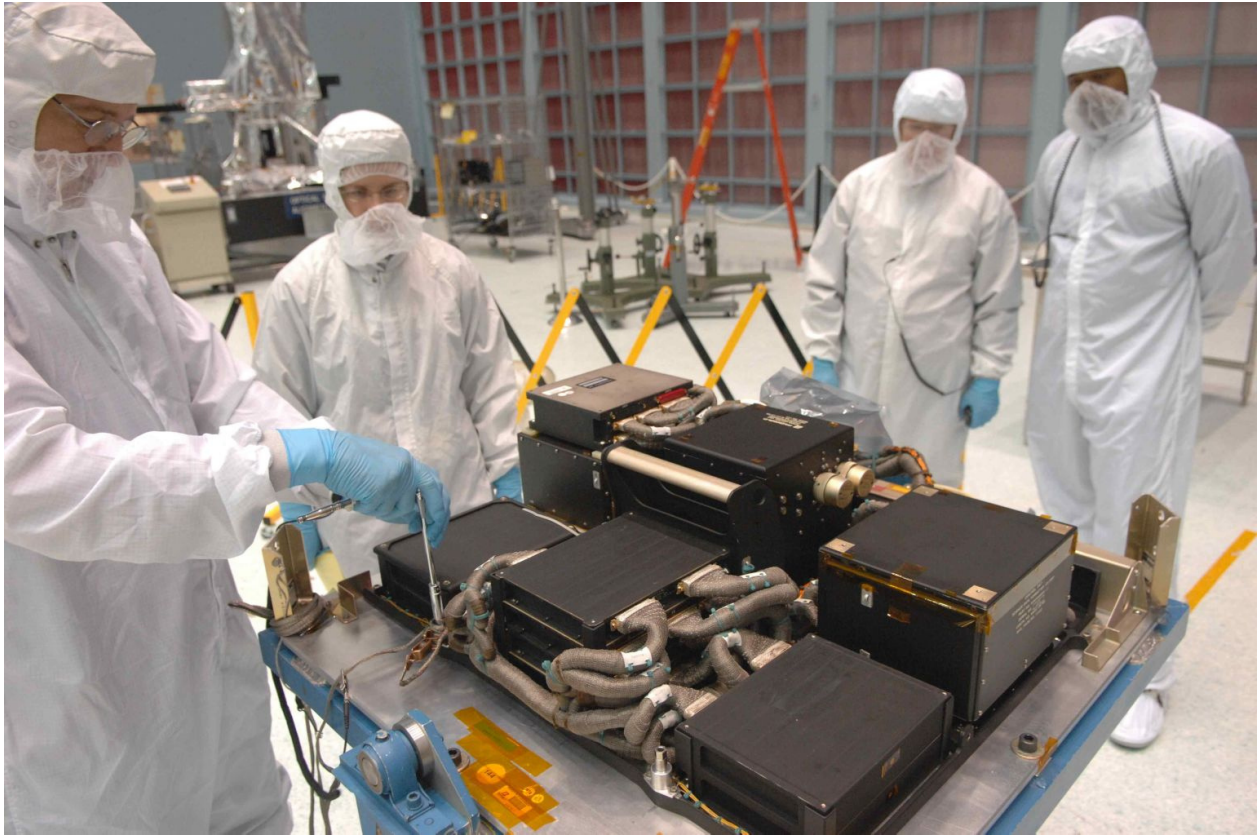


Image above: Engineers in Goddard's large clean room prepare the flight spare Science Instrument Control & Data Handling unit, known as SIC&DH 2, for electrical performance testing.
Image Credit: NASA/Chris Gunn

Standard Interface Board. The circuit board is the communications bridge between the computer and the CU/SDF.

Control Unit/Science Data Formatter. The heart of the SI C&DH unit is the CU/SDF. It formats and sends all commands and data to designated destinations such as the DMU of the SSM, the NASA computer and the science instruments. The unit has a microprocessor for control and formatting functions.

The CU/SDF receives ground commands, data requests, science and engineering data, and system signals. Two examples of system signals are “time tags”—clock signals that synchronize the entire spacecraft—and “processor interface tables”—communications codes. The CU/SDF transmits commands and requests after formatting them so that the specific destination unit can read them. For example, ground commands and SSM commands are transmitted with different formats because ground commands use 27-bit words and SSM commands use 16-bit words.

The formatter translates each command signal into a common format. The CU/SDF also reformats and sends engineering and science data. Onboard analysis of the data is an NSSC-1 function.

Power Control Unit. The PCU distributes and switches power among components of the SI C&DH unit. It also conditions the power required by each unit. For example, the computer memory boards typically need +5 volts, -5 volts and +12 volts while the CU/SDF requires +28 volts. The PCU ensures that all voltage requirements are met.

Remote Interface Unit. RIUs transmit commands, clock and other system signals, and engineering data between the science instruments and the SI C&DH unit. However, the RIUs do not send science data. There are six RIUs in the telescope: five attached to the science instruments and one dedicated to the CU/SDF and PCUs in the SI C&DH unit. Each RIU can be coupled with up to two expander units.

Communications Buses. The SI C&DH unit contains data bus lines that pass signals and data between the unit and the science instruments. Each bus is multiplexed: one line sends system messages, commands and engineering data requests to the module units, and a reply line transmits requested information and science data back to the SI C&DH unit. A coupler attaches the bus to each remote unit. This isolates the module if the RIU fails. The SI C&DH coupler unit is on the ORU tray.

Operation

The SI C&DH unit handles science instrument system monitoring (such as timing and system checks), command processing and data processing.

System Monitoring. Engineering data tell the monitoring computer whether instrument systems are functioning. At regular intervals, varying from every 500 milliseconds to every 40 seconds, the SI C&DH unit scans all monitoring devices for engineering data and passes data to the NSCC-1 or SSM computer. The computers process or store the information. Any failure indicated by these constant tests could initiate a "safing hold" situation and thus a suspension of science operations.

Command Processing. Figure 5-27 shows the flow of commands within the SI C&DH unit. Commands enter the SI C&DH through the SSM Command DIU (ground commands) or the DIU (SSM commands). The CU/SDF checks and reformats the commands, which then go either to the RIUs or to the NSCC-1 for storage. Time-tagged commands, stored in the computer's memory (top right of drawing), also follow this process.

Each command is interpreted as "real time," as if the SI C&DH just received it. Many commands actually are onboard stored commands activated by certain situations. For example, when the telescope is positioned for a programmed observation using the Cosmic Origins Spectrograph, that program is activated. The SI C&DH can issue certain requests to the SSM, such as to execute a limited number of pointing control functions to make small telescope maneuvers.

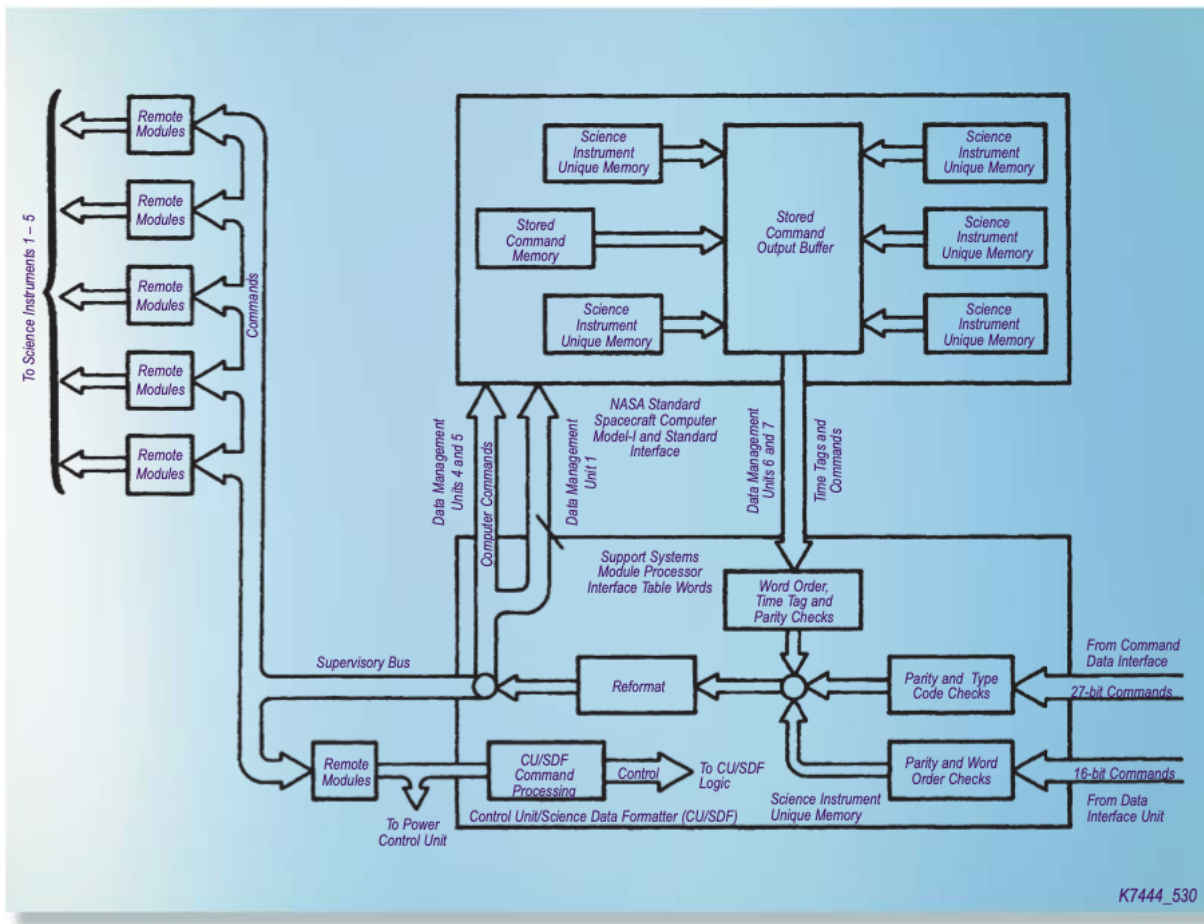


Fig. 5-27 Command flow for Science Instrument Control and Data Handling unit

Science Data Processing. Science data can come from all science instruments at once. The CU/SDF transfers incoming data through computer memory locations called packet buffers. It fills each buffer in order, switching among them as the buffers fill and empty. Each data packet goes from the buffer to the NSCC-1 for further processing, or directly to the SSM for storage in the data recorders or transmission to the ground.

Data return to the CU/SDF after computer processing. When transmitting, the CU/SDF must send a continuous stream of data, either full packet buffers or empty buffers called filler packets, to maintain a synchronized link with the SSM. Special checking codes (Reed-Solomon and pseudo-random noise) can be added to the data as options. Figure 5-28 shows the flow of science data in the telescope.

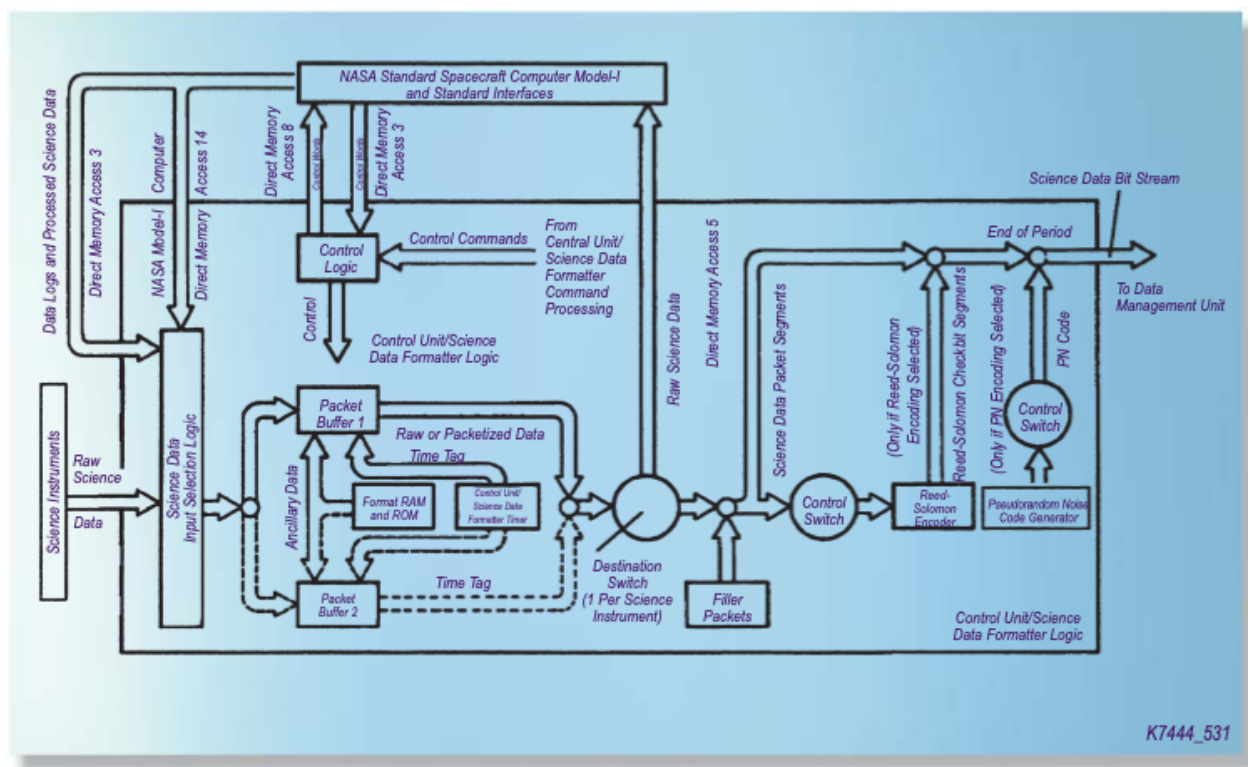


Fig. 5-28 Flow of science data in the Hubble Space Telescope