



<http://amazing-space.stsci.edu>



HELP! THE MISSION'S IN A MESS!

While NASA was preparing for Servicing Mission 3B (SM3B), technicians found that a computer virus had scrambled the mission masterplan! The masterplan is the sequence of events for the mission, including the shuttle launch and EVAs (extra-vehicular activities, or spacewalks).

We're depending on you to un-muddle the mission! Help put the events back in order!

WHAT TO DO:

You'll receive 10 pages, each depicting a different stage or event in the mission. Read each page carefully and keep track of clues on your Mission Mastermind worksheet. Then use your notes to reconstruct the logical order of events. Fill in the correct order in the area provided on your worksheet.

Help keep Hubble humming in 2002!



SM3B mission patch

**MASTER-
MIND
BEHIND
the
MISSION**

A

Redeployment

Following repairs, the telescope is redeployed in its boosted orbit. To do this, the shuttle arm grasps the telescope, places it safely away from the shuttle, and releases it. The shuttle then gently pulls away and the Hubble Space Telescope is ready to begin to put its new components to work.

Release from the shuttle arm



B

Hubble Gets a New Camera and a Boost

New Camera: Seeing More for Less

With its wide **field of view**, superb image quality, and exquisite sensitivity, Hubble's newest science **instrument**, the Advanced Camera for Surveys (ACS) will have 10 times more "discovery power" than the Faint Object Camera (FOC) it replaces. In other words, the ACS will be able to collect 10 times more data than the FOC was capable of gathering.

ACS sees in wavelengths ranging from visible to far **ultraviolet**. It is actually a team of three different cameras with specialized capabilities: Its high-resolution camera will take very detailed pictures of the inner regions of galaxies and search neighboring stars for planets and planets-to-be. Its "solar blind" camera, which blocks visible light to enhance ultraviolet sensitivity, will study weather on planets in our own solar system, among other things. And its "wide field" camera will help scientists understand how our universe evolved by surveying the nature and distribution of galaxies.

The ACS is the only new instrument being added to the telescope on this mission. After it is installed, the rest of the mission is devoted to bringing an old instrument back to life.

Getting a Lift

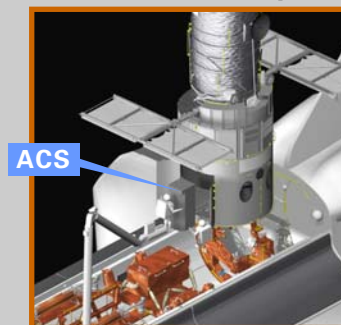
If possible, before the last EVA, the shuttle will carry Hubble to a higher **altitude**.

Although the atmosphere is quite thin at satellite altitudes, it is not a perfect vacuum. Over time, all Low Earth Orbiting (LEO) satellites feel the effects of atmospheric drag and lose altitude. If the altitude is not restored, the satellite will eventually re-enter the Earth's atmosphere and fall to Earth. Hubble has no on-board propulsion, so the only way to restore lost altitude is by carefully firing the shuttle's jets, boosting the telescope's orbit while it is still attached to the shuttle.

The ACS



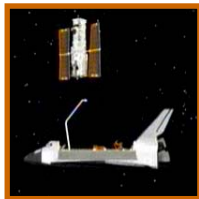
Installation mock-up



**MASTER-
MIND
BEHIND
the
MISSION**

C

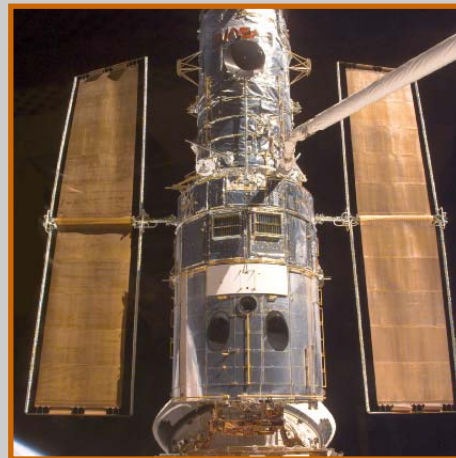
Capturing the Telescope



Before the astronauts can service the Hubble Space Telescope, they must "capture" it by using the shuttle

arm. Both the shuttle and the telescope must be precisely positioned for the capture to proceed without risk of damaging the telescope. Once secured on the arm, the telescope can be maneuvered into the shuttle's cargo bay for servicing. These delicate procedures take hours of practice on Earth before the mission flight.

The telescope on shuttle arm



D

Astronaut Training in Water Tanks

Becoming skilled at any activity, whether it's playing a sport, making music, baking a cake, or installing sensitive equipment on the Hubble Space Telescope, requires practice.

Amazingly, astronauts rehearse their servicing mission tasks in very large swimming pools. Floating underwater simulates the weightlessness the astronauts experience in space.

Being weightless and bundled in bulky space suits during space walks makes even simple tasks very difficult. So, astronauts in training "suit up" and are lowered into the water to practice every activity over and over again on a submerged model of the space telescope.

The National Aeronautics and Space Administration (NASA) uses information gathered from these practice sessions to plan the actual mission and to create a **manifest**.

Training underwater



E

Hubble Gets a New Heart: The Power Control Unit

As Hubble's power-switching station, the Power Control Unit (PCU) controls and distributes electricity from the solar arrays and batteries to other parts of the telescope.

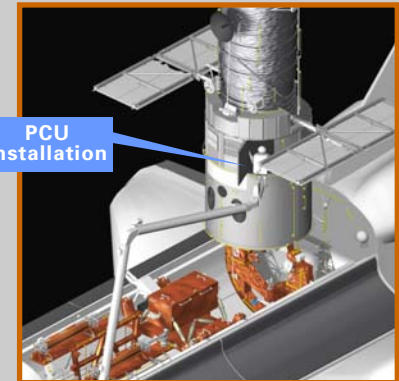
The new PCU increases the reliability and longevity of the telescope. It handles the increased power from the new solar arrays better than the old PCU could have.

Replacing the original PCU, which has been on the job for 11 years, will require the Hubble to be completely powered down for the first time since its launch in 1990. Anytime something is "turned off," there is a risk that it may not "turn on" again.

The **switch-out** is a very complicated process: there are 36 different connectors that have to be taken off the old PCU and put on the new one. This will take a lot of time, so an entire day is devoted to making this change.

The PCU is the heart of the Hubble Space Telescope. Its successful replacement is this mission's second most important task, after replacement of the solar arrays.

PCU installation mock-up



F

Preparing the Mission Priorities and EVA Schedule

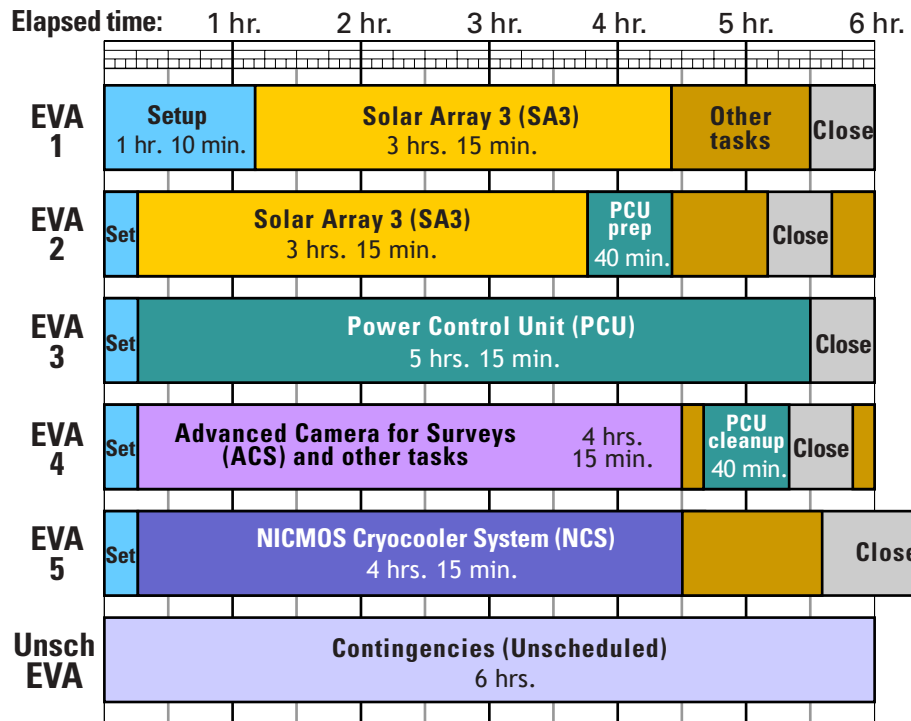
The National Aeronautics and Space Administration (NASA) creates a **manifest** for each mission. The manifest displays the new components that will be installed on the telescope, in order of importance.

From information in the manifest, NASA prepares the "Extra-Vehicular Activity (EVA) schedule" (see below). The EVA schedule lists the space walks the astronauts will perform to service the Hubble Space Telescope, showing when tasks will be conducted and the time it will take to complete them.

In this mission, Hubble gets vital replacement parts that take advantage of the newest technology and will help ensure the health and well-being of the telescope. It also gets one new **instrument** that replaces an older, less advanced one.

Notice that scientific instruments and equipment are listed on the EVA schedule as **acronyms**. Scientists use these abbreviations because many projects and instruments have long names. The shorter acronym saves space on the chart.

Proposed HST SM-3B EVA Schedule



**MASTER-
MIND**
BEHIND
the
MISSION

G

Launching the Shuttle



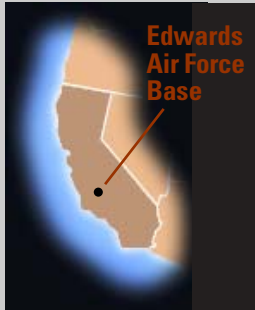
All space shuttles launch from Cape Canaveral on Florida's eastern coast. The Cape, a strip of marsh and sand midway

between Jacksonville and Miami, is ideal for launches and landings because of its open spaces and year-round mild weather.

From this latitude, the earth's rotational speed adds 600 mph to the shuttle's eventual orbital speed of about 17,500 mph. This is fast enough to circle the earth in 90 minutes, enabling the crew to enjoy a sunrise or sunset every 45 minutes!



**MASTER-
MIND
BEHIND
the
MISSION**



H

Landing



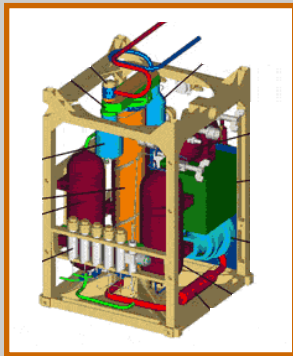
Most shuttles land at Cape Canaveral in eastern Florida. Since each shuttle is refitted and launched at the Cape, it is more economical to end each mission there, too.

Edwards Air Force Base, in southern California, is the secondary landing facility. Weather conditions at each landing facility determine which one is used.



MASTER-MIND BEHIND the MISSION

High-tech refrigerator
for NICMOS



I

NICMOS Cryocooler

The last piece of equipment on the **manifest** is the NICMOS **cryocooler**. Astronauts will **retrofit** an existing but dormant **instrument** called the Near Infrared Camera and Multi-Object **Spectrometer** (NICMOS) with a new, experimental cooling system to return it to active duty.

NICMOS was Hubble's **infrared** "eyes" until it lost the coolant necessary to chill its infrared detectors. Infrared detectors must be kept cold in order to sense the heat of infrared light. By fitting NICMOS

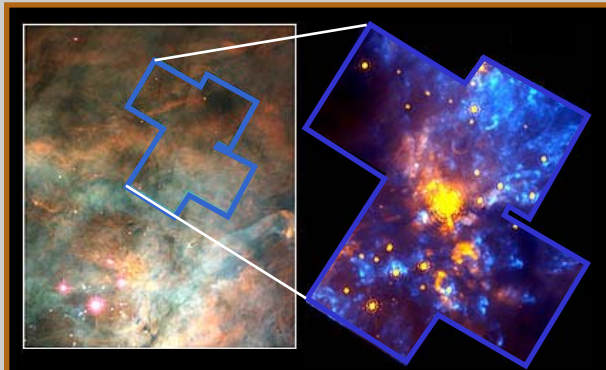
with the experimental **cryogenic** system, NASA hopes to re-cool its detectors to -334°F (-203°C or 70 K) and revive its infrared vision.

Infrared vision allows NICMOS to see through clouds of interstellar dust. This dust obscures visible and **ultraviolet** light, but some infrared light can pass through it. With NICMOS revived, we will once again be able to see through thick hazes to study the evolution of galaxies, stars, and planets that lie hidden within.

NICMOS "busts the dust"

See how NICMOS "busts the dust" that obscures our view of star birth in the Orion Nebula and star death in the Egg Nebula.

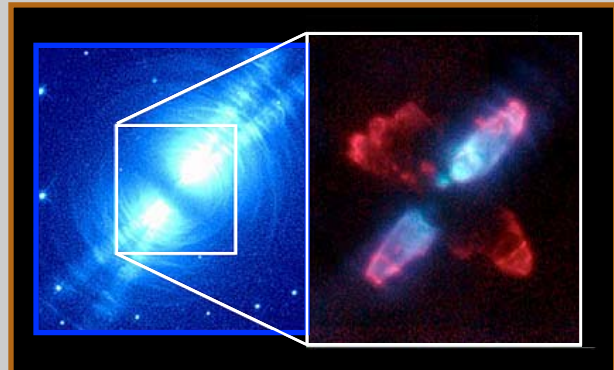
Example 1:
Star birth at the heart of Orion



Visible light
image

NICMOS's
infrared view

Example 2:
Star death in the Egg Nebula



Visible light
image

NICMOS's
infrared view

J

Solar Array 3 (SA3) Installation

Once the telescope is in the shuttle's cargo bay, the astronauts can begin replacing **instruments** and equipment. They will accomplish their tasks while at least one of them is attached to the shuttle arm. The arm serves as a dolly, allowing the astronaut to move conveniently from one location to another.

The first parts of the telescope to be replaced are the four large, flexible solar arrays, which have powered Hubble for over 8 years. **Radiation** and debris take their toll on the sensitive electronics in the panels, which makes the solar arrays unreliable. To ensure an uninterrupted supply of energy for the remainder of the mission, new solar arrays are being installed. Although these arrays are one-third smaller, they take advantage of current technology and produce slightly more power than the old arrays. Since they don't roll up, the arrays are rigid and less susceptible to extreme temperatures, and their smaller size will reduce the effects of atmospheric drag on the spacecraft.

Once removed, the old solar arrays will be stored in the shuttle's cargo bay and returned to Earth, as will all the replaced instruments and equipment.

New rigid solar arrays



Solar array in cleanroom





<http://amazing-space.stsci.edu>

“Mission Mastermind” Glossary Words

Acronym (n.) – A word formed from the initial letters of a name or compound term, such as ‘**WAC**’ for **W**omen’s **A**rmy **C**orps or ‘**radar**’ for **r**adio **d**etecting **a**nd **r**anging.

Altitude (n.) – The distance between an object and the earth's surface.

Cleanroom (n.) – A room housing sensitive equipment, such as delicate optics and precision electronics, that cannot be contaminated with dust. Cleanrooms are 10,000 times cleaner than a hospital operating room. Such cleanliness is incredibly hard to achieve and maintain. Huge air filtration systems completely change the air in cleanrooms about 10 times per minute. People working in cleanrooms must wear special dust-free clothing.

Cryocooler (n.) – A miniature refrigerator designed to cool spacecraft instruments to very low temperatures. The system’s coolant is often a super-cooled gas, such as liquid nitrogen or liquid helium.

Cryogenic (adj.) – Of or relating to the production of very low temperatures.

Electromagnetic spectrum (n.) – The entire range of wavelengths of the electromagnetic radiation, from radio waves, to infrared, visible and ultraviolet light, to X-rays and gamma rays.

Field of view (n.) – The amount of sky visible through a telescope.

Infrared (IR) light (n.) – A region of the electromagnetic spectrum not visible to the human eye. This spectral region is analogous to sounds that are too low for the human ear to hear. Waves of IR light are slightly longer in length and slightly lower in frequency than those of visible light. IR light can be detected as the heat from a fire or light bulb.

Instrument (n.) – Any device that measures and records energy from astronomical objects.

Manifest (n.) – A list of activities to be accomplished, which are sometimes ranked in order of priority.

Nebula (n.) – A general term used in astronomy to indicate any light or dark patch of the night sky that is “fuzzy,” or not sharply defined, as a star or planet would be.

Orbit (n.) – The path a satellite takes around a celestial body.

Radiation (n.) – All wavelengths of the electromagnetic spectrum, including radio, infrared, visible, ultraviolet, X-rays, and gamma rays.

Retrofit (v.) – To provide with new equipment or parts that were unavailable at the time of original manufacture or construction.

Spectrometer (n.) – An instrument that divides light into its array of colors and records the information.

Switch-out (n.) – The process of replacing an old, outdated instrument or piece of equipment with an updated version.

Ultraviolet (UV) light (n.) – Situated beyond the visible region of the electromagnetic spectrum. Its location on the spectrum is analogous to sounds that are too high for the human ear to hear. Waves of UV light are slightly shorter in length and slightly higher in frequency than those of visible light. On Earth, too much UV light causes sunburns.