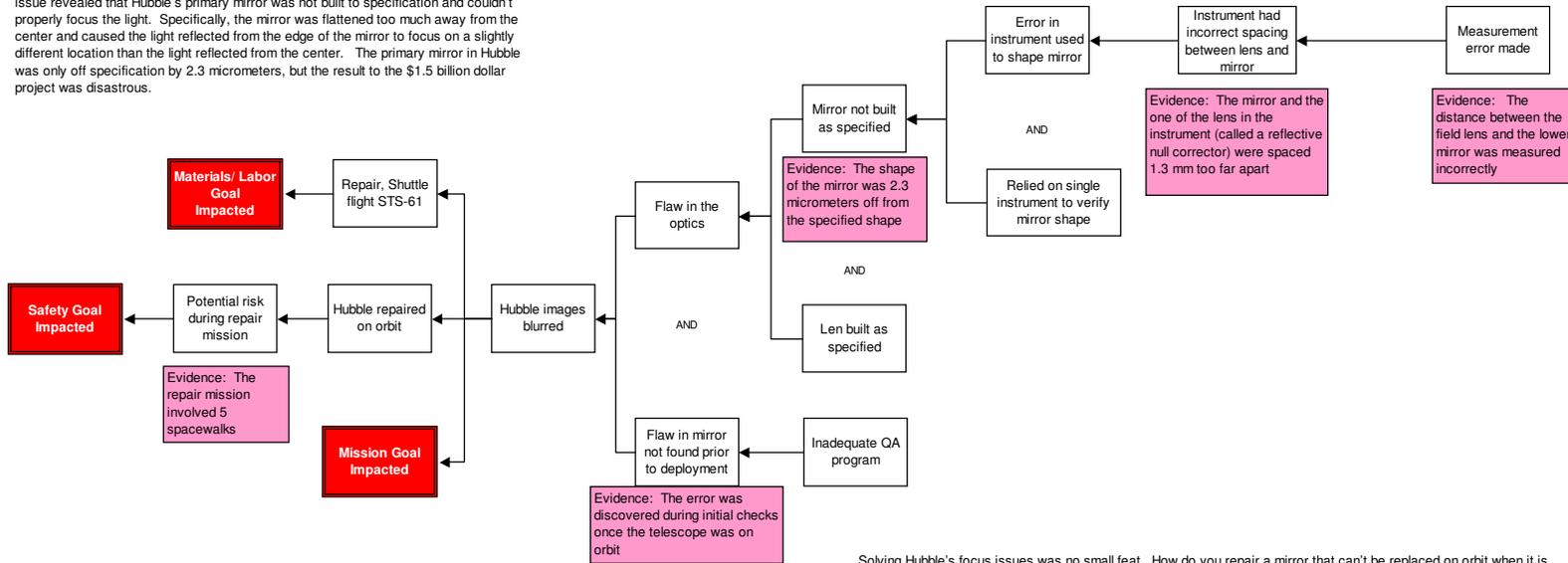


Hubble Focusing Issues
Orbit

April 25, 1990

A thorough root cause analysis built as a Cause Map can capture all of the causes in a simple, intuitive format that fits on one page.

The Hubble Space Telescope was launched on April 24, 1990. Once in orbit, it was quickly discovered that the images from Hubble were blurred. An investigation into the issue revealed that Hubble's primary mirror was not built to specification and couldn't properly focus the light. Specifically, the mirror was flattened too much away from the center and caused the light reflected from the edge of the mirror to focus on a slightly different location than the light reflected from the center. The primary mirror in Hubble was only off specification by 2.3 micrometers, but the result to the \$1.5 billion dollar project was disastrous.



Solving Hubble's focus issues was no small feat. How do you repair a mirror that can't be replaced on orbit when it is cost prohibitive to bring it back to earth for repair? The answer was to modify the lens (which met specifications) to work with the off specification mirror. COSTAR (Corrective Optics Space Telescope Axial Replacement) was added to Hubble during the first servicing mission in December 1993. COSTAR is essentially eyeglasses for Hubble, additional lens built with the same error as the mirror, but in the opposite direction so that the effects of the off specification mirror shape are canceled out. With the addition of COSTAR, Hubble met original design goals.

The primary mirror was constructed with a flaw because the tool, called a null corrector, used to create the template to guide the shaping of the mirror was itself flawed. Null correctors use precisely located mirrors and lens to determine the shape of a mirror. In order to assemble null correctors, reflected light is used to measure the distance between the mirror and the lens inside the tool. When the null corrector used to shape the Hubble's primary mirror was assembled a measurement error was made. A small amount of reflective coating had fallen off an internal piece of the instrument and the laser used to perform the measurement reflected off the wrong location, resulting in a lens being 1.3 mm too far from the mirror. Null correctors are extremely precise and do not change once assembled so the Hubble team used a single instrument to guide the mirror shape. A single flawed tool and inadequate quality controls resulted in a flawed mirror.

Cause Map
Intermediate Level



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