# Final Report for the Advanced Camera for Surveys (ACS) from Ball Aerospace & Technologies Corp. BATC.

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|---|---|
| ACS Contract Number | NAS5-32864 |
| Contract type | CPIF |
| Awarded Price | $28.2 M |
| Final negotiated price | $68.3 M |
| Added scope | $35.1 M |
| Cost overrun | $ 6.0 M |
| Original Delivery Schedule | Aug. 1998 |
| Final Negotiated Delivery Schedule | June 2000 |

ACS was launched aboard the Space Shuttle Columbia just before dawn on March 1, 2002. After successfully docking with HST, several components were replaced. One of the components was the Advanced Camera for Surveys built by Ball Aerospace & Technologies Corp. (BATC) in Boulder, Colorado. Over the life of the HST contract at BATC hundreds of employees had the pleasure of working on the concept, design, fabrication, assembly and test of ACS. Those employees thank NASA – Goddard Space Flight Center and the science team at Johns Hopkins University (JHU) for the opportunity to participate in building a great science instrument for HST.

After installation in HST a mini-functional test was performed and later a complete functional test. ACS performed well and has continued performing well since then. One of the greatest rewards for the BATC employees is a satisfied science team. Following is an excerpt from the JHU final report " The foremost promise of ACS was to increase Hubble's capability for surveys in the near infrared by a factor of 10. That promise was kept. "

## Delivery Schedule

NASA initially changed the delivery schedule from August 1998 to December 1998 to accommodate changes in their fiscal year budget profile. NASA changed the delivery date again to June 2000 to accommodate an additional launch delay and technical issues with the CCD detectors.

## Cost Growth

The cost growth includes $35.1 M of added scope and $6.0 M overrun. The scope increases included the addition of a coronagraphic capability, schedule extensions driven by the customer's fiscal year budget profiles, re-engineering the ACS to accommodate the rising temperatures in the HST's instrument bay, the requirement for additional charged coupled devices focal planes, mission and joint integrated simulation support and two launch delays. The overrun was caused primarily by technical difficulties experienced by the CCD vendor, the additional efforts required to modify

designs and fabricate and test new hardware when the hardware from earlier projects included in the baseline proved to be incompatible with the final ACS requirements, and indirect rate changes.

Design Information

ACS was designed to be an axial replacement instrument for the Hubble Space Telescope and to provide an improvement in discovery efficiency over the current HST camera. ACS discovery efficiency was designed to be a factor of ten improvement – in fact ACS exceeded performance expectations during ground testing and on orbit evaluation. Performance data will be presented in a later section.

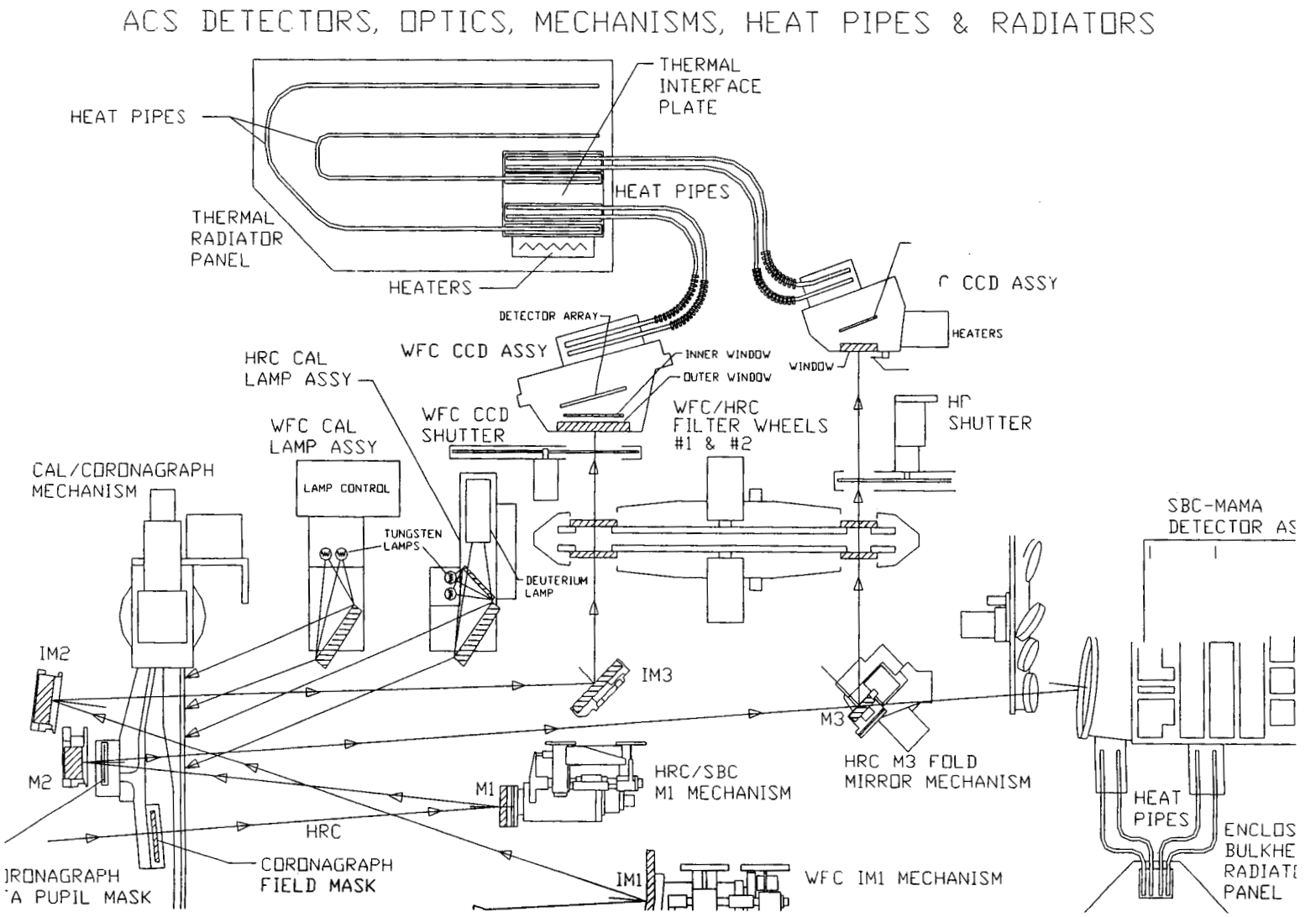
The ACS design included three cameras in one package.

1) A wide field, high throughput visible camera optimized for 800 nm (WFC)
2) A high resolution, critically sampled camera optimized for the blue spectrum (HRC)
3) A high throughput far UV camera

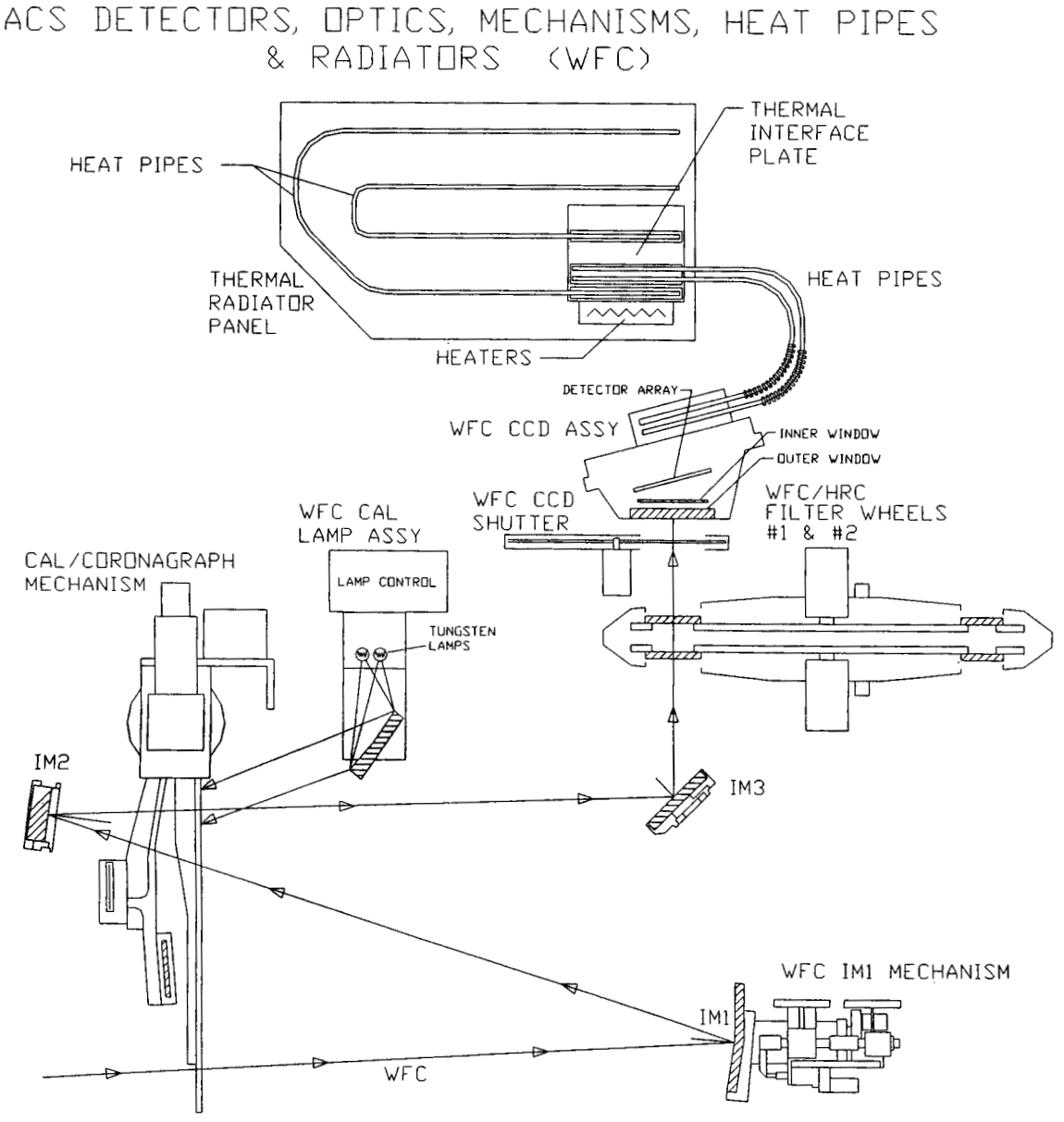
Key characteristics are listed below.

| **Features** | **WFC** | **HRC** | **SBC** |
|---|---|---|---|
| **Maximum throughput** | 49% @ 600 nm | 25% @ 600 nm | 6.1% @ 121.6 nm |
| | 36% @ 800 nm | 17% @ 800 nm | 5.3% @ 130 nm |
| | 24% @ 400 nm | 17% @ 400 nm | 4.2% @ 140 nm |
| | | 11% @ 250 nm | 2.9% @ 150 nm |
| | | | 1.7% @ 160 nm |
| **Field of View** | 200" x 204" | 26"x 29" | 26"x 29" |

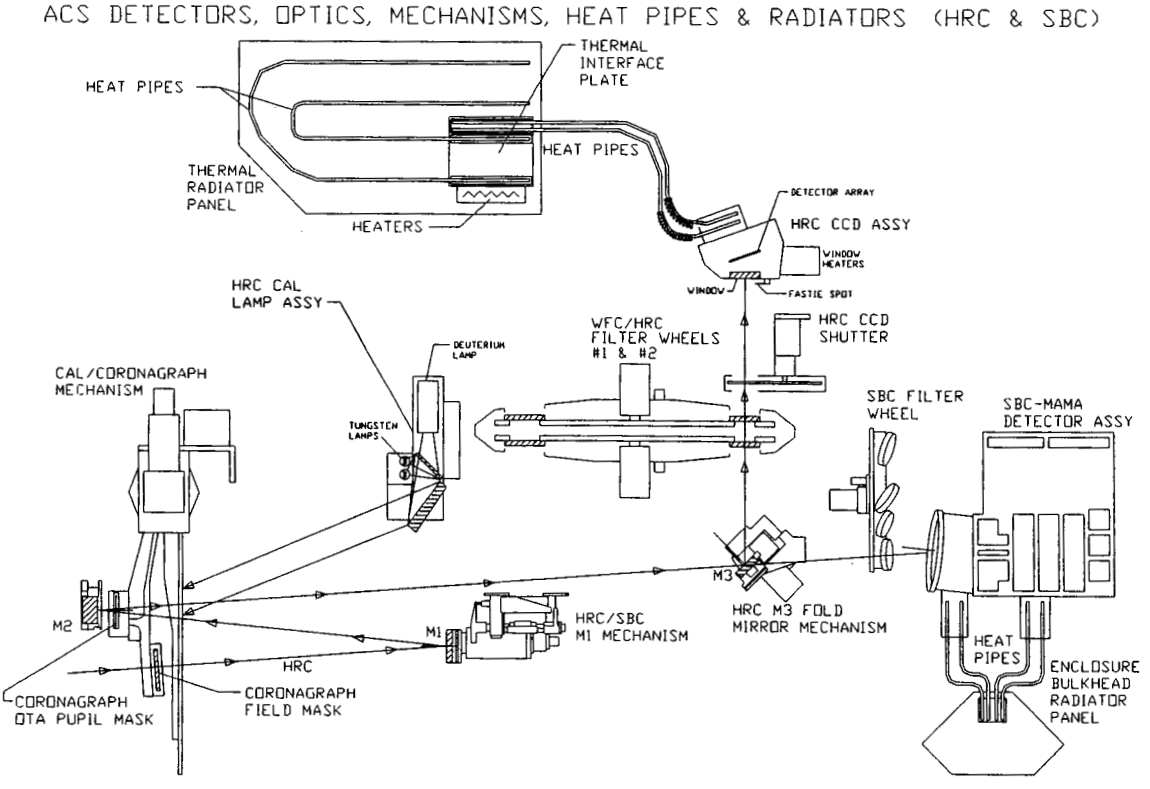
Below is a block diagram of the ACS instrument. On the following two pages are diagrams that have one optical channel each.



This block diagram shows the light coming in from the lower left, through imaging optics, through two filter wheels, past a shutter mechanism and into the WFC detector assembly. Inside the WFC housing are two 2000 x 4000 detector chips mounted together to make a 4000 x 4000 imaging array. The detector array is cooled with a Thermal Electric Cooler – heat is rejected through heat pipes to the thermal radiator. During the next servicing mission NASA will attach heat pipes to the thermal interface plate so heat will be able to be rejected outside the instrument bay. The end result will be lower operating temperatures within ACS and extended life.

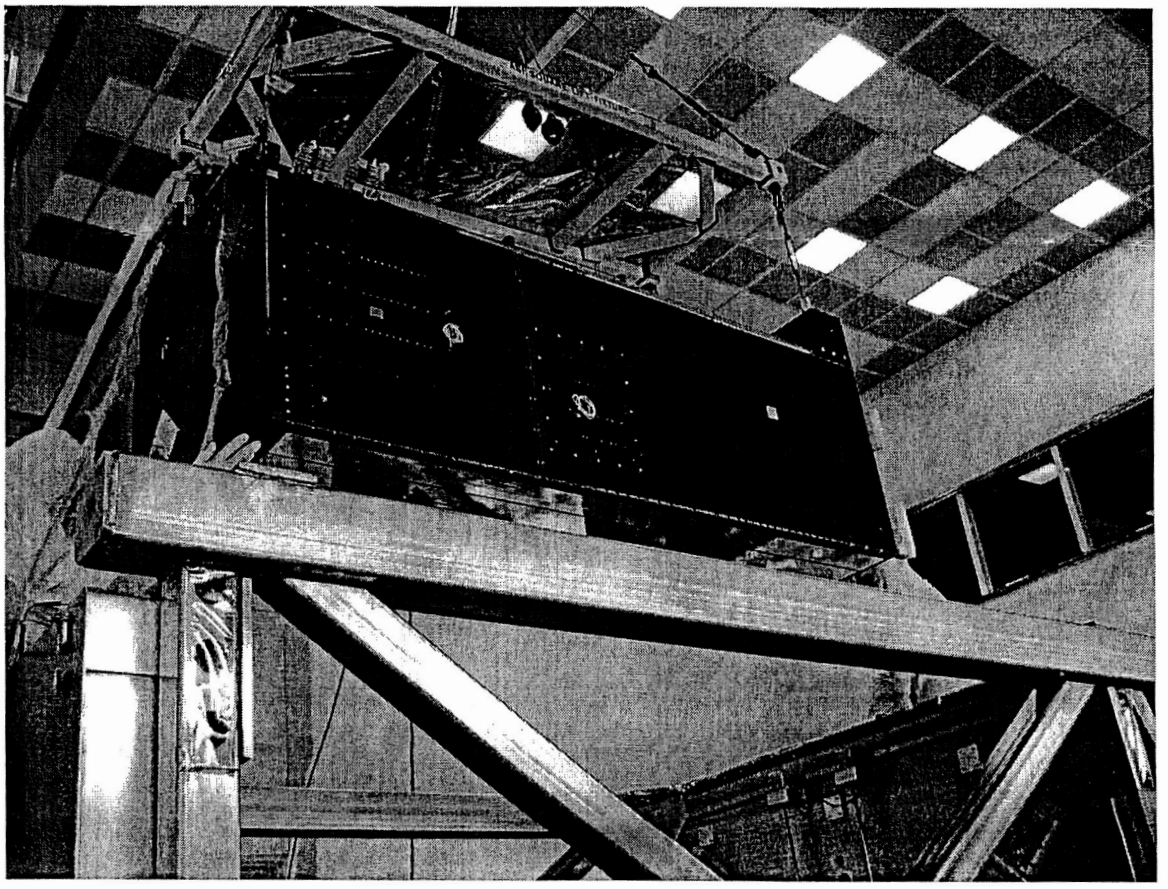


Below is the HRC / SBC block diagram. Again, detector heat is carried away from the detectors with heat pipes. A fold mirror directs light to the detector of choice for High Resolution images.



ACS Final Optical Verification at BATC

Below is a picture of ACS as it is lowered into the Hubble Optical Mechanical Simulator (HOMS) at BATC. While in HOMS ACS was supplied light from the Refractive Aberration Simulator (RAS) to verify proper alignment and optical performance with the spherical aberration of HST's primary mirror.



Discovery Efficiency Calculations

Discovery efficiency was used to determine incentive fee. Estimates were made on the ground by combining detector and optic efficiencies. Three categories were predetermined and the accompanying discovery efficiency factors are below.

| Performance requirement | WFC Discovery Efficiency | |
|---|---|---|
| Minimum 17200 - 22899 | | |
| Exceeds 22900 - 23899 | 22931 on ground | |
| Exceptional ≥ 23900 | 24766 on orbit | Exceptional |

| Performance requirement | HRC Discovery Efficiency | |
|---|---|---|
| Minimum 30 - 60 | | |
| Exceeds 61 - 133 | 135 on ground | |
| Exceptional ≥ 134 | 139 on orbit | Exceptional |

| Performance requirement | WFC Discovery Efficiency | |
|---|---|---|
| Minimum 65 - 84 | | |
| Exceeds 85 - 109 | 101 on ground | |
| Exceptional ≥ 110 | 101 on orbit | Exceeds |

Additional information on ACS design, schedules, and other technical data can be found in the ACS monthly review packages, the preliminary design review (PDR), critical design review (CDR), and pre-ship review documents submitted to GSFC by BATC.