Operated for NASA by AURA

Instrument Science Report ACS 2001-10

ACS software tool development

W.B. Sparks, W.J. Hack, M. Clampin
December 12, 2001

ABSTRACT

We describe the anticipated software tool development requirements for ACS for the period November 2001 to mid-2002, a period which is expected to include the installation of ACS on HST. The highest priority is to complete the present phase of development and ensure correct functionality of calacs and PyDrizzle as applied to ACS data. New tools to support ACS include: those needed for provision of calibration reference files; astrometric utilities for image registration; and flux calibration of ramp filter observations. As experience is gained with real ACS data, we envision upgrades to the handling of data quality information and cosmic ray flagging. Iterative requirements for PyDrizzle in stand-alone mode will also be helpful. Given the uncertainties of a new instrument, contingency time is crucial.

Software Tools Overview

Software tools are required in support of an HST instrument in order to (i) simulate observations with the instrument (ii) access, visualize and manipulate data arrays (iii) provide calibration reference files in support of the calibration pipeline for the instrument (iv) provide the calibration of the instrument, i.e. removal of the instrument specific signatures from the data, through the calibration pipeline itself and in stand-alone mode for more complex operations (v) provide analysis tools that enhance the scientific usefulness of the data and allow scientific measurements to be made. Here we outline software development plans for ACS, building on the work described in ACS ISRs 01-4 and 00-3 (Sparks et al). The ACS pipeline operations are described in ACS ISRs 99-03 (Hack), 99-04 (Mutchler et al) and 99-08 (Hack).

PyDrizzle and calacs

We expect OPUS 13.4 to be the launch version of OPUS. Currently, OPUS 13.3 is in test; OPUS 13.4 is expected to be available by February 2002.

PyDrizzle

ACS has severe distortions in mapping of positions in pixel coordinates to a rectified grid, of order 15% in terms of pixel area projected onto sky. WFC3 will have a similar level of distortion, which is much larger than for existing instruments. There are consequences for pointing control, astrometry and photometry.

The major development effort of the last year has been implementation of “drizzle” for ACS by means of PyDrizzle, and a supporting framework to describe the instrument geometry by means of an “IDCTAB” (ACS ISR 01-08, Hack & Cox 2001).

The most recent revision is to allow for image shifts, as recorded in the association table which drives PyDrizzle.

Support utilities apart from PyDrizzle itself include an equivalent to the WFPC2 *metric* task which provides pixel to sky transformations using the World Coordinate System of the image plus knowledge of the instrument distortion, and a task to build an exposure time image from the context image provided by *drizzle*. A task to build association tables from a set of data initially not associated is necessary in order to use PyDrizzle to combine multiple images of the same field. An early version of this has been written. Image registration tools using object catalogues and astrometric support tools will enable much more accurate combination of non-associated images.

Item: complete initial implementation of PyDrizzle with capabilities as described in ACS ISR 01-04 (Sparks, Hack & Hook 2001) requiring OPUS 13.4 version. Priority 1.

Item: complete related software particularly “metric” (or xytosky, skytoxy), pixel area mapping. Priority 1.

Item: complete supporting utilities needed for using drizzle products (exposure time; BuilAsn; registration using catalogues). Priority 2.

Item: investigate other image registration options such as cross-correlation. Priority 4.

Calacs

Item: complete fixes and modifications made to calacs currently under test and requiring OPUS 13.4. Priority 1.

This includes fixes to exposure time keywords, use of additional OBSTYPE to enable coronagraphic calibration, implementation of synphot photometry keyword calculation, revised CCDTAB reference file format to include bias defaults for each amplifier and a fix to subarray processing.

Following launch of ACS, unanticipated issues are likely to arise. Contingency time for these plus calacs maintenance is essential. Priority 1.

Upgrade Path for calacs and PyDrizzle

The initial implementation of *calacs* with *PyDrizzle* uses no iterative methods and a conservative set of parameter settings. In particular, if a dithered sequence does not use CR-SPLIT (i.e. multiple images at each pointing) then *calacs* cannot identify cosmic rays in the data. In cases where it does CR-SPLIT, the cosmic ray identification is not currently recorded in the raw image data quality array. We wish to investigate the utility of single image cosmic ray identification. We also wish to compare current processing methods (use CR-SPLIT combined images as input to *PyDrizzle*) with using individual input images together with data quality information generated by the processing of the CR-SPLIT set.
Item: investigate data quality procedures and single image cosmic ray identification. Priority 3.

In the medium term, additional tasks from the stsdas dither package that focus on iterative use of drizzle are likely to prove useful.
Item: implement individual output images per input image to offer greater flexibility in eliminating cosmic rays and other defects, and in registration of images. Priority 2.
Item: Implement equivalent of "blot" to transform a processed image back onto the raw image in order to facilitate identification of cosmic rays and image defects. Priority 2.

Longer term, PyDrizzle in principle may be used to combine very different images provided an association table is generated to identify and characterize the input set. Currently in test, individual images can have their own IDCTAB, and their own image shift and rotation with respect to a reference image. With allowance for different background levels and sensitivity (i.e. filter choice) it should be possible to combine images which use different filters, which were taken at very different times, or even with different instruments. The algorithm options for scaling images with different flux calibrations require investigation.
Item: Allow additional image parameters in the association table to offer enhanced capabilities for image combination. Priority 4.

Reference File Generation Tools and CTE Analysis

Maintenance of tools needed to generate stable reference files such as flat-fields given on-orbit data is likely to require some resources.
It is expected that ACS will require time-dependent reference file generation. In particular, bad pixels will come and go, as for other CCDs on HST. Development of tools to generate appropriate reference files as automatically as possible is desirable, following an initiative by the STIS group to do this.
Degradation of CTE is another area which may lead to time dependent reference files. The observed CTE degradation of WFPC2 and STIS together with the large format of the ACS

CCDs has given rise to great concern over the rate of CTE decline in ACS, particularly the WFC. Hence, CTE monitoring will form an important part of the ACS calibration plan. Analysis tools to facilitate that monitoring will be helpful once the program is under way. There are currently two options: (i) Mike Jones has designed an engineering program first pixel response (FPR) test to estimate CTE (ii) Also, Riess WFPC2 ISR 99-04 describes a technique to measure CTE from cosmic rays in dark frames. The ACS group will utilize these techniques to monitor CTE and, if possible, automate the measurement process given experience with on-orbit data. Such a process may become straightforward with an application tool.
Item: support of reference file generation. Priority 1.
Item: automatic reference file generation tools. Priority 2.
Item: stand alone CTE tools. Priority 3.

Ramp filter calibration

Conceptually, the process of calibrating ramp filter observations may be envisaged as a two-stage one in which firstly, the data are flat-fielded in such a way as to enable continuum subtraction to be carried out, and secondly, the resulting monochromatic data are flux-calibrated to correct for the changing transmission, or sensitivity, around the field of view, knowing (or assuming) the wavelength of the monochromatic data. These tools have not been implemented for WFPC2, however there the ramp filter field of view is so small that a point-source approach is tractable. ACS ramp filter observations cover about 80x40 arcsec, by contrast, and hence tools to correct and manipulate the full area of an ACS ramp filter observation are desirable for the data analysis stage.

Ramp filter flat-fielding

Ramp filter P-flats (pixel to pixel changes) were constructed using nearest-filter full field flat fields. Given L-flat sensitivity changes across the field of view, a utility to scale the continuum emission according to the known sensitivity curves may be needed. Investigation with on-orbit data is required to determine whether automatic scaling is sufficiently accurate.
Item: ramp filter L-flat scaling tool. Priority 4.

Flux calibration of ramp filter data

An extended monochromatic source image is the expected result of a typical ramp filter observation following continuum subtraction. Continuum subtraction can be a rather specialized operation, so we do not envisage including it in the pipeline. Hence, we cannot include the subsequent step of flux calibration in the pipeline over an extended area. We do expect to provide flux calibration keywords that will be valid for the specified wavelength of the observation, A stand-alone utility interfacing with the *synphot* library of transmission curves will in addition enable an areal flux calibration to be carried out.

Item: generate inverse sensitivity maps for ramp filter observations for (i) fixed wavelength (ii) default central wavelength (iii) an input wavelength map. Note that (ii) is very similar to L-flat correction, above. Priority 3.

Tools for coronagraphic analysis

ACS has a powerful coronagraphic capability that will allow faint source to be seen very close to bright stars and quasars. In order to process data of this form, we will require techniques to determine azimuthal profiles using a variety of methods (mean, median, mode for example), plus construction of model profiles utilizing the azimuthal averaging information. Priority 4.

Existing software maintenance and contingency

Contingency time must be allowed for, since with a new instrument, it is almost always the case that unforeseen developments lead to new, unanticipated requirements in the area of software support. Hands-on experience with real data is likely to change priorities and introduce new needs, potentially at short notice and potentially as a matter of urgency.
Item: instrument anomaly contingency time. Priority 1.

With the advent of actual ACS data, tasks that have already been completed will potentially be tested much more rigorously by external users. Debugging and maintenance of such tasks may be anticipated as part of the contingency allowance. These tasks include: ACS quick display, ACS pdf products.
Item: maintenance for ACS quick display and pdf products. Priority 2.

Other ACS software utilities

Synphot

Ensure accurate and complete functionality of ACS *synphot* software which is needed by both calacs and the exposure time calculator. The ETC will transition to the APT version during this year.

PSF modelling

Validate the Tiny Tim implementation for ACS; Krist.

Extracted spectra for grisms

ST-ECF have developed grism spectra analysis tools, and have assumed formal responsibility for support of the software they provide. Some discussion of incorporating this in the ACS pipeline has taken place. SSG support will be needed to assist ST-ECF in installing and integrating the software they are to provide within STScI systems, and eventually the ACS pipeline.

Item: STScI contribution to grism support, primarily an ST-ECF responsibility. Assistance with installation of software and integration within STScI systems. Priority 3.

Summary

Item	Timescale	Priority	Pipeline
initial implementation of drizzle - in the pipeline - stand alone	feb 2002	1	yes
xytosky, skytoxy ("metric") convert x,y to RA,Dec; pixel area map	cycle 11	2	no
drizzle support utilities (exposure time map; BuildAsn; registration tools)	cycle 11	2	yes
image registration using cross-correlation	fall 2002	4	no
Complete fixes and modifications to calacs for OPUS 13.4	feb 2002	1	yes
calacs maintenance post-launch		1	yes
data quality procedures and cosmic rays for calacs	fall 2002	3	no
individual image output for pydrizzle	cycle 11	2	maybe
"blot" equivalent for image defect location	mid 2002	2	maybe
additional parameters in Association tables	fall 2002	4	no
reference file generation tools	mid 2002	1,2	yes
CTE analysis tools	mid 2002	3	no
Ramp filter L-flat field interpolation	fall 2002	4	maybe
Ramp filter flux calibration	fall 2002	3	no
coronagraphic analysis		4	no
Contingency time for instrument anomaly		1	
ACS quick display		2	
Quick-look PDF products		2	
ACS ETC / APT / synphot			
PSF modelling			Krist
Extracted spectra for grisms		3	STECF