

Abstract

Science data products for the James Webb Space Telescope (JWST) will be generated within the Data Management Subsystem (DMS) of the Science and Operations Center at the Space Telescope Science Institute. This paper describes the format of uncalibrated and calibrated FITS science image data products generated by the DMS Science Data Processing and Calibration components.

Data level definition

The JWST DMS data levels are illustrated in Figure 1. The blue box in Figure 1 indicates the data products covered in this document. These level 1 and level 2 data files contain pixel values of individual science instrument exposures taken through a single detector. Level 1b through level 3 files are provided to the proposer. All files are saved in the JWST archive.

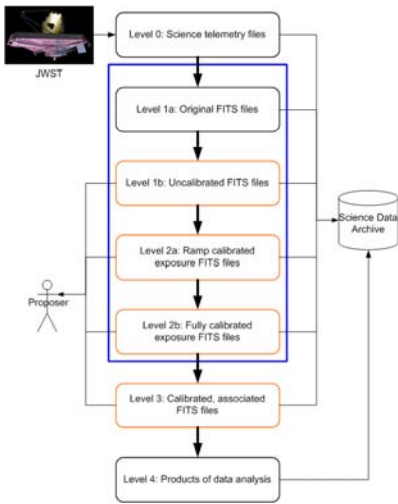


Figure 1 – JWST data product level definition

FITS file structure

Science data from all of the JWST science instruments will be captured in FITS format files. During the initial stages of data processing, each FITS file will contain pixel values from a single exposure taken with a single detector. These exposure-level FITS files consist of a Primary Header Data Unit that contains keywords that apply to all subsequent extensions. Uncalibrated, level 1, data files have extensions for the on-board science pixel values, reference pixel values, and group information as shown on the left in Figure 2. Calibrated, level 2, data files have extensions for calibrated pixel values, calibrated reference pixel values, data quality flags, and errors as shown on the right in Figure 2.

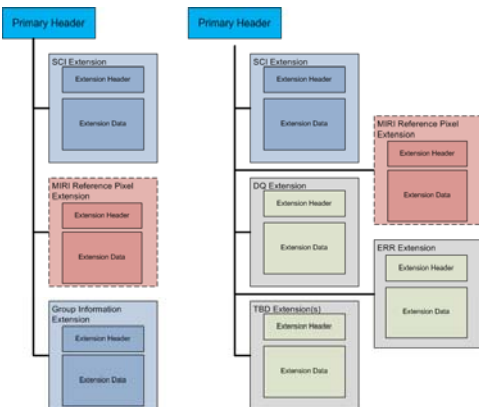


Figure 2 – FITS file structure for uncalibrated and calibrated data

Data cube

The image data array structure should be in Figure 3. The image arrays are formatted as four-dimensional data cubes with axes for image columns and rows, as well as stacked images for each group within an integration and each integration within an exposure. Multiple groups and integrations result from up-the-ramp exposure data collection. For the level 2a, it remains to be determined whether each integration within the exposure generates a separate count rate image with multiple count rate images in the science data extension, or all integrations are folded into a single count rate image.

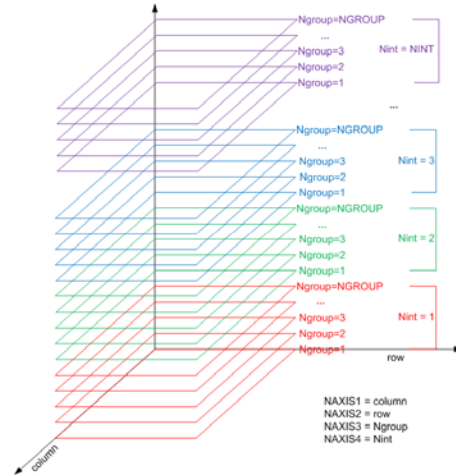


Figure 3 – Science exposure data cube

As shown in Figure 4, the origin of the image data array is chosen to ensure a consistent parity and orientation for pixel data between instruments and detectors.

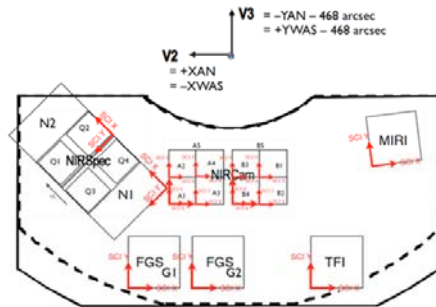


Figure 4 - Science image frame orientations with respect to V-frame as seen looking through the optics toward the sky

Header keywords

The FITS header keyword values are populated from multiple sources as files progress through data processing pipelines as shown in Figure 5.

The level 0 science data files from the spacecraft supply information about the on-board data capture. Observatory Status files, which provide exposure start and end times through on-board event messages, are used to partition the detector readouts into exposures. Standard FITS keywords describe the data format. The level 1a FITS files contain just the standard FITS keywords and on-board science image metadata.

Generation of the level 1b data involves supplying detailed header information. Proposal information is obtained from the Proposal, Planning and Scheduling database. Engineering parameters are obtained from a calibrated engineering database. A spacecraft ephemeris is used along

with a telescope pointing model to determine the specific World Coordinate System parameters for each exposure. Since JWST will be in a solar orbit, barycentric and heliocentric time corrections are determined.

Calibration processing generates the level 2 data. Calibration reference files are determined through the Calibration Reference Data System. The data cube is collapsed into a count rate image by determining the ramp slopes. The level 2a intermediate data product is saved from this compute intensive task. Further instrument specific calibration generates the level 2b data product of a calibrated exposure.

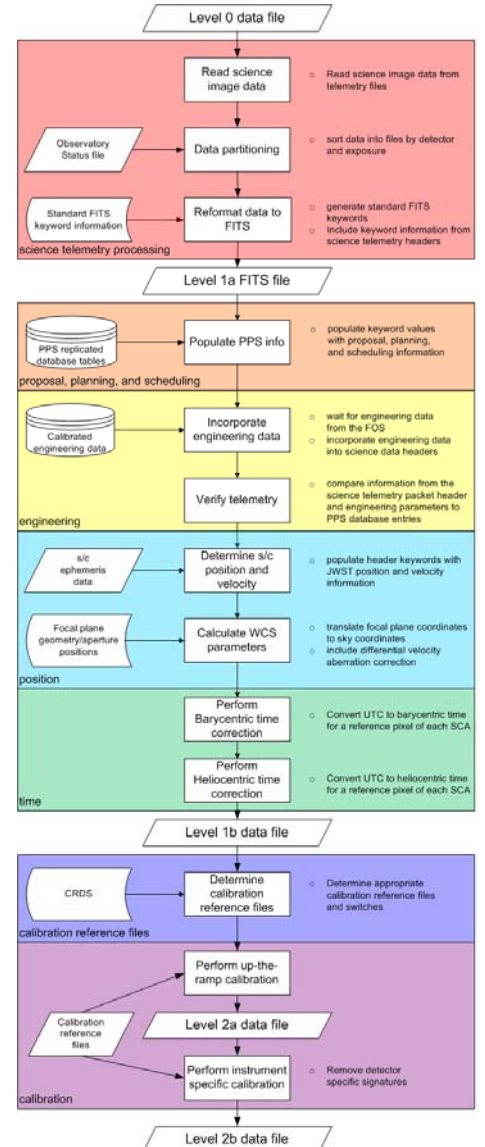


Figure 5 - Schematic representation of exposure data processing and header keyword population

Additional level 3 processing will generate combined exposures, for example for dithered or mosaiced images.

Future design

A number of design issues remain to be determined for exposure data from JWST. These issues include:

- the data array scheme for spectral data,
- specifics of the FITS WCS keywords, and
- the exact definition of exposure time for up-the-ramp data.