OSIRIS

Optical, Spectroscopic, and Infrared Remote Imaging System

OSIRIS Experiment Data Record and Software Interface Specification (EDR/SIS) for JPEG Thumbnails

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Document Change Record

Iss./Rev.	Date	Pages affected	Description
1/-	16/12/2016	All	First version
1/a	21/12/2016	All	Use of OSIRIS as an acronym is now consistent Cleaned up some formatting errors Added Acronyms and Instrument Overview sections Updated File Naming Convention Generation of the JPEG thumbnail images changed to Product Generation, to include information on how base data is generated before JPEG generation Added Coordinate Systems
1/b	31/03/2017	All	Updated Reference Documents Added section “Detached PDS Label”

Table of contents

1 General aspects

1.1 Scope

This document describes in detail the OSIRIS data product JPEG thumbnail images.

1.2 Introduction

The purpose of this Data Product Software Interface Specification (SIS) is to provide consumers of OSIRIS Camera Experiment Data Record (EDR, uncalibrated images) and Reduced Data Record (RDR, calibrated images) data products with a detailed description of the products. How the data products are generated, including data sources and destinations, can be found in "Rosetta-OSIRIS To Planetary Science Archive Interface Control Document". The SIS is intended for the planetary science scientific community who will analyse the data.

1.3 Reference Documents

no.	document name	document number, Iss./Rev.
RD1	OSIRIS calibration pipeline OsiCalliope	RO-RIS-MPAE-MA-007, 1/a
RD2	OSIRIS Experiment Data Record and Software Interface Specification (EDR/SIS)	RO-RIS-MPAE-ID-018, 4/d
RD3	Rosetta-OSIRIS To Planetary Science Archive Interface Control Document	RO-RIS-MPAE-ID-015, 4/a

2 Acronyms

ASCII	American Standard Code for Information Interchange
ADC	Analog Digital Converter
CRB	CCD Readout Board
CCD	Charge Coupled Device
DDS	Data Distribution System
DPU	Data Processing Unit
DSP	Digital Signal Processor
EDR	Experiment Data Record
ESA	European Space Agency
HK	House Keeping data
IAA	Instituto de Astrofísica de Andalucía
IDA	Institut für Datentechnik und Kommunikationsnetze
INTA	Instituto Nacional de Técnica Aeroespacial
JPEG	Joint Photographic Experts Group (compressed image format)
LAM	Laboratoire d'Astrophysique de Marseille
MCB	Motor Controller Board
MLI	Multi-Layer Insulation
MPS	Max Planck Institut für Sonnensystemforschung
NAC	Narrow Angle Camera
ODL	Object Description Language
OIOR	Orbiter Instrument Operational Request
OSIRIS	Optical, Spectroscopic, and Infrared Remote Imaging System
PCM	Power Converter Module
PDS	Planetary Data Systems
RDR	Reduced Data Record
RSSD	Research and Scientific Support Department (ESA)
RO	Rosetta Orbiter
PSA	Planetary Science Archive
SPICE	Spacecraft, Planet, Instrument, C-matrix, Event kernels
SIS	Software Interface Specification
SPIHT	Set Partitioning in Hierarchical Trees (Wavelet compression algorithm)
SSMM	Solid State Mass Memory (Rosetta spacecraft storage device)

TBC	To Be Considered
TBD	To Be Determined
TMI	TeleMetry Image
UPD	Università di Padova
UPM	Universidad Politécnica de Madrid
WAC	Wide Angle Camera

3 Instrument Overview

The OSIRIS instrument was provided by the OSIRIS consortium led by the principal investigator Dr. Horst Uwe Keller at the Max Planck Institut für Sonnensystemforschung.

The OSIRIS camera system consists of a Narrow Angle Camera (NAC) and a Wide Angle Camera (WAC).

3.1 The Narrow Angle Camera (NAC)

The NAC uses an off axis three mirror optical design. The off axis design was selected in order to minimize the straylight reaching the CCD (the NAC has a proven stray light attenuation of better than 10^{-9}). The optical beam is reflected by the three mirrors (M1, M2 and M3) before passing through a double filter wheel, a mechanical shutter mechanism and an anti-radiation plate (ARP) before reaching the CCD.

Figure 1: (Left) The OSIRIS NAC flight unit in the lab. (Right) The NAC optical path

3.2 The Wide Angle Camera (WAC)

The WAC uses an off axis two mirror optical design. The off axis design was selected in order to minimize the stray light reaching the CCD (the WAC has a proven stray light attenuation of better than 10^{-8}).

The optical beam is reflected by the two mirrors (M1 & M2) before passing through a double filter wheel, a mechanical shutter mechanism, and an anti-radiation plate (ARP) before reaching the CCD.

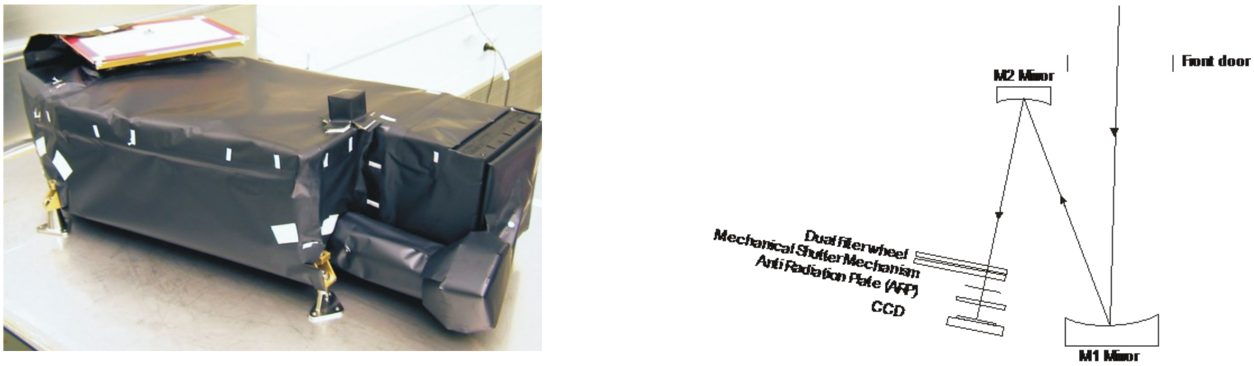

Figure 2: (Left) The OSIRIS WAC flight unit in the lab. (Right) The WAC optical path

More detailed information about the design of the cameras, the filter wheels, the mechanical shutter mechanism and the CCD can be found in:

Keller, H. U. et al. OSIRIS -- The Scientific Camera System Onboard Rosetta, *Space Science Reviews*, 2007, **128**, 433-506.

4 File Naming Convention

4.1 The OSIRIS archive filename convention

The OSIRIS image files as archived in the project internal archive (please note NOT the PDS archive) use the following filename convention:

CCC_YYYY-MM-DDTHH.MM.SS.UUUZ_FFLI_NNNNNNNNNN_FAB.JPG

Field	Description
CCC	Either: NAC (Narrow Angle Camera) **OR** WAC (Wide Angle Camera)
YYYY	The year of acquisition
MM	The month of acquisition
DD	The day of acquisition
T	The letter T (stands for "Time")
HH	The hour of acquisition
MM	The minute of acquisition
SS	The second of acquisition
UUU	The millisecond of acquisition
Z	The letter Z
FF	The image file type: ID: Image Data (normal images) TH: Thumbnail version PA: Amplifier A pre pixels (calibration data) PB: Amplifier B pre pixels (calibration data) OL: Overclocked lines (calibration data)
L	The OSIRIS processing level of the image
I	The instance id if the image (multiple transmissions of an image will be reflected in this number incrementing)
NNNNNNNNNN	A ten digit user defined image ID number (specified by the user when writing the command timeline)
F	The letter F (stands for "Filter")
A	The position index of the filter wheel #1
B	The position index of the filter wheel #2
.JPG	The file extension

Table 1: OSIRIS PDS data file filename elements

Example:

NAC_2003-10-16T13.50.05.012Z_ID12_0000000001_F82.JPG

A NAC image acquired at 2003-10-16T13:50:05.012 UTC. The file contains CCD image data (image type ID) with raw image data (level 1) and the image represents the 3rd transmission of the image data. The image was acquired using the filter combination (8, 2). The processing level is 1 (project internal, not CODMAC). The time is the approximate start time of the exposure.

Note! The filename contains an approximate time of acquisition. This time value is only used to uniquely identify the image and should not be used for any calculation needing high precision. The time value in the filename has not been corrected for on-board clock drift and leap seconds.

4.2 The PDS archive filename convention

The OSIRIS image files as archived in the PDS use the following filename convention:

CYYYYMMDDTHHMMSSUUUFFLIFAB.JPG

Field	Description
C	Either: N (Narrow Angle Camera) **OR** W (Wide Angle Camera)
YYYY	The year of acquisition
MM	The month of acquisition
DD	The day of acquisition
T	The letter T (stands for "Time")
HH	The hour of acquisition
MM	The minute of acquisition
SS	The second of acquisition
UUU	The millisecond of acquisition
FF	The image file type: ID: Image Data (normal images) TH: Thumbnail version PA: Amplifier A pre pixels (calibration data) PB: Amplifier B pre pixels (calibration data) OL: Overclocked lines (calibration data)
L	The CODMAC processing level of the image
I	The instance id if the image (multiple transmissions of an image will be reflected in this number incrementing)
F	The letter F (stands for "Filter")
A	The position index of the filter wheel #1
B	The position index of the filter wheel #2
.JPG	The file extension

Table 2: OSIRIS JPEG filename elements

Example:

W20040923T071606570ID12F12.JPG

A WAC image acquired at 2004-09-23 at 07:16:06.657 UTC. The file contains CCD image data (image type ID) with raw image data (level 1) and the image represents the 3rd transmission of the image data. The image was acquired using the filter combination (1, 2).

Note! The filename contains an approximate time of acquisition. This time value is only used to uniquely identify the image and should not be used for any calculation needing high precision.

5 Coordinate Systems

There are a number of coordinate systems relevant to the interpretation of OSIRIS data. These coordinate systems can be separated into two groups: (a) pixel coordinate systems referring directly to the CCD and (b) inertial coordinate systems referring to the spacecraft and viewing geometry.

5.1 CCD Coordinate Frames

In the CCD coordinate frame, pixel (0, 0) is always the closest pixel to amplifier A, independently from which amplifier is used (see Figure 3).

The first pixel to be read-out is the closest to the used amplifier. The on board software re-arranges each line as if the CCD would have been read out through amplifier A. In this way, the first pixel in the image corresponds always to pixel (0, 0).

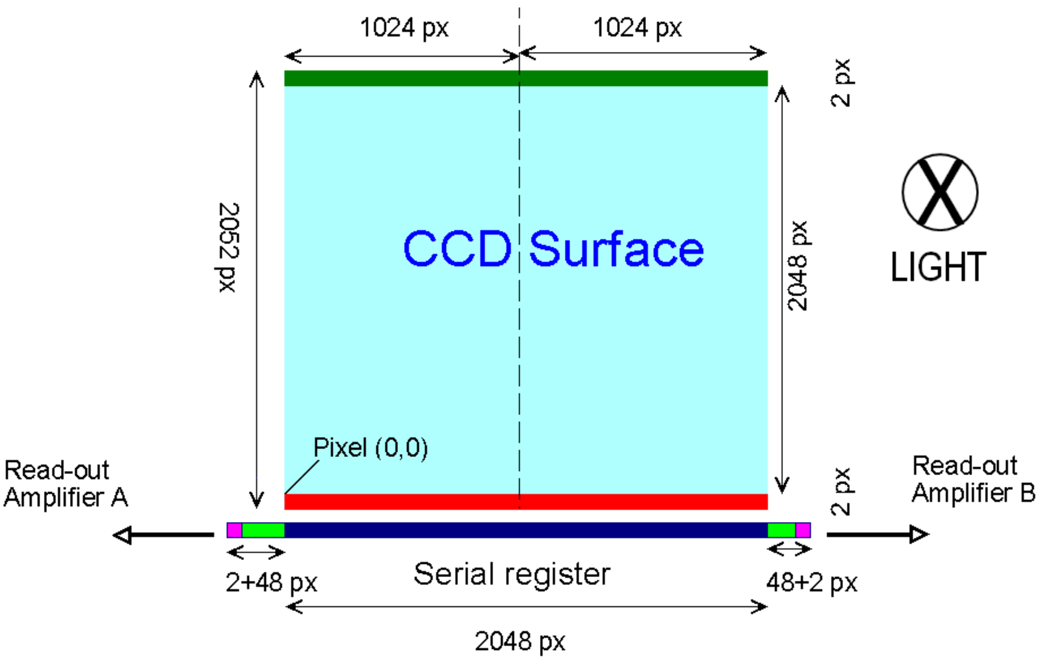

Figure 3: CCD array as seen by the science beam. CCD and S/C coordinate systems are shown

Lines are parallel to the serial register. *The line numbers* increase with distance from the serial register. Samples are perpendicular to the serial register. *The sample numbers* increase with distance from the edge of the CCD that contains read-out amplifier A.

5.2 Inertial Coordinate Frames

5.2.1 Standard Rosetta orientation

To display the images in the "standard Rosetta orientation" as most of the Rosetta products and tools (NAVCAM, 3DTool, MAPPS):

- WAC images have pixel (0,0) in the bottom right corner, the line number increases from bottom to top and the sample number increases from right to left (Figure 4, left).
- NAC images have pixel (0,0) in the bottom left corner, the line number increases from bottom to top and the sample number increases from left to right (Figure 4, right).

The direction in which the line number and the sample number increases in stored in the PDS header keywords SAMPLE_DISPLAY_DIRECTION and LINE_DISPLAY_DIRECTION, respectively. To display the images in the standard Rosetta orientation, an additional 180° rotation has to be applied to both NAC and WAC images.

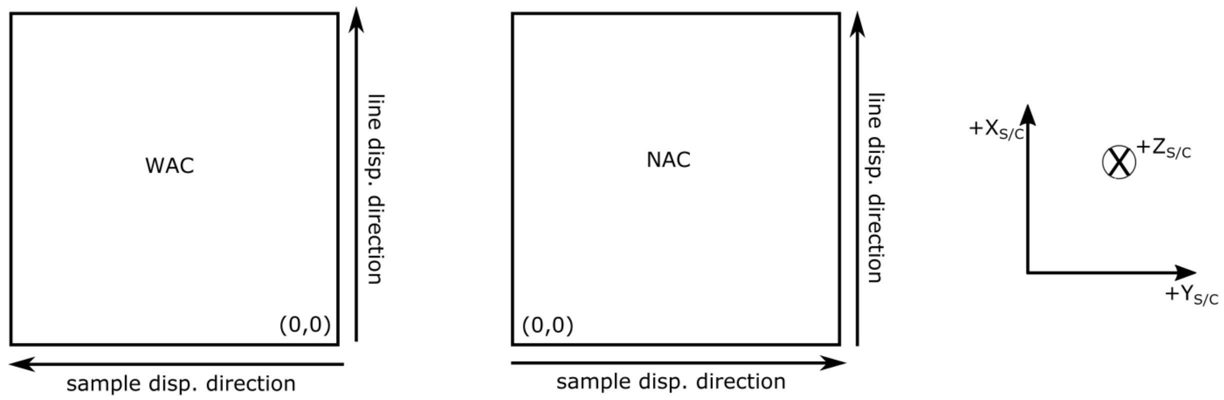

Figure 4: WAC and NAC images in camera frame

In this orientation, the spacecraft +X axis is up and the spacecraft +Y axis to the right, meaning that the Sun is up in most images.

5.2.2 Rosetta spacecraft coordinate frame

The Rosetta spacecraft coordinate frame (S/C-COORDS) is defined with the +Z axis which is the nominal pointing of remote sensing instruments (orthogonal to the payload plane). The +Y axis is oriented along the solar panels and the +X is orthogonal to the high gain antenna mounting panel. The Rosetta spacecraft coordinate frame can be addressed in the SPICE system using the coordinate frame alias “ROS_SPACECRAFT”.

The OSIRIS cameras are mounted on the –X panel, looking nearly parallel along the +Z axis.

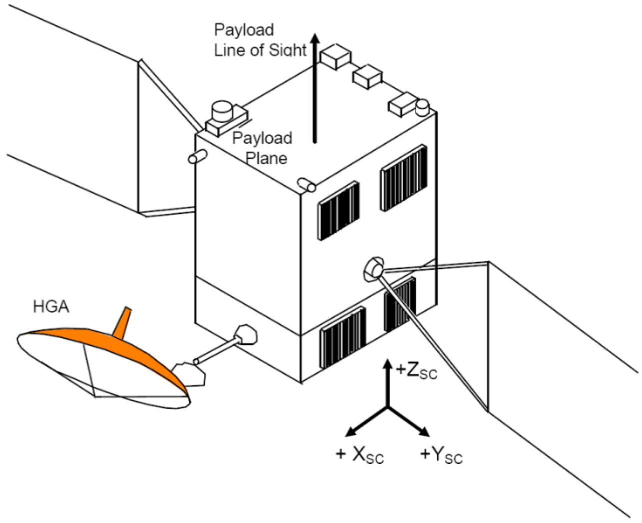

Figure 5: The Rosetta spacecraft coordinate frame (S/C-COORDS) definition

6 Product Generation

Products are generated following the process which is described in “Science Archive Interface Control Document” [RD2].

6.1 OSIRIS Level 1 (EDR)

OSIRIS Level 1 (EDR or CODMAC Level 2) data is generated from the telemetry data, by OsiTrap, following the generation of engineering data. Level 1 data includes raw image data, and a calibrated header. Pre-pixel and overclocked lines data, if they were present in the raw telemetry data, are also written into separate IMAGE objects.

6.2 OSIRIS Level 2 (RDR)

OSIRIS Level 2 (RDR or CODMAC Level 3) data is generated by OsiCalliope, taking the level 1 data, calibrating the image data, following the steps in the table below:

1.	IMAGE data is copied.
2.	Convert IMAGE data to “double” format.
3.	Correction of the tandem ADC offset and gain.
4.	Subtraction of bias.
5.	High spatial frequency flat fielding.
6.	Removal of bad pixels and bad columns.
7.	Low spatial frequency flat fielding.
8.	Normalization to exposure time.
9.	Conversion to radiometric units (absolute calibration).
10.	Generate sigma map and quality map.

Table 3: Steps performed during calibration of Level 2 (RDR) data products

6.3 Conversion to JPEG Format

6.3.1 Level of images created

The thumbnail images are created for OSIRIS Level 1, 2, and 3, directly from the corresponding Level 1, 2, and 3 PDS images (i.e. from the IMG files).

6.3.2 Scaling

The intensity scaling of the images is done using a ±2.5 sigma clipping on the full image around the average of the pixel intensity of an image, excluding values below zero. If M is the arithmetic average of all pixels and σ the standard deviation of the distribution around the average, the image is linearly scaled from M - 2.5σ (translated into JPEG grey value 0) to M + 2.5σ (translated into JPEG grey value 255). If M - 2.5σ is smaller than zero, the image will be linearly scaled from 0 to M + 2.5σ.

6.3.3 Orientation

The images are stored in the “standard Rosetta orientation” as most of the Rosetta products and tools (NAVCAM, 3DTool, MAPPS).

6.3.4 Resizing

Thumbnail images are resized from the original 2048 x 2048 pixels to 64 x 64 pixels with bilinear resampling. For images with original size differing from 2048 x 2048 pixels, the images are resized with the longest dimension being set to 64 pixels. (e.g., an image of 1024 x 512 pixels is resized to 64 x 32 pixels.)

6.3.5 Compression

Standard JPEG compression with quality factor 75.

6.3.6 Header

There is no header associated with the JPEG thumbnail images.

6.4 Detached PDS Label

In order to provide a PDS compatible delivery, every thumbnail image delivered to PSA has a detached PDS label, containing some extra information defined in [RD3].