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# ROSETTA-MIDAS
# Science User Guide

## Issue 1.0
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# 1. Introduction

The following provides a basic guide to using MIDAS specific data products in the archive. More details of each product can be found in the MIDAS EAICD or in individual documents per product. Section 2.5 of the EAICD also gives an overview of MIDAS data products in the archive.

# 2. List of Standard MIDAS Archive Data Products

The standard MIDAS archive products are PDS Level 3 data sets produced per cometary phase, which are named as follows:

RO-{target ID}-MIDAS-{level}-{phase}-{description}-V{version}

{target ID} : target identifier {A=Asteroid, CAL=calibration, C=comet, D=dust, X=cruise}

{level} : PDS processing level [3, 5]

{phase} : mission phase [GRND, CVP, CR1, …]

{description} : free character string

{version} : data set version number in the form X.Y

*e.g. RO-C-MIDAS-3-ESC1-SAMPLES-V3.0 (for details see MIDAS EAICD section 4.2.1)*

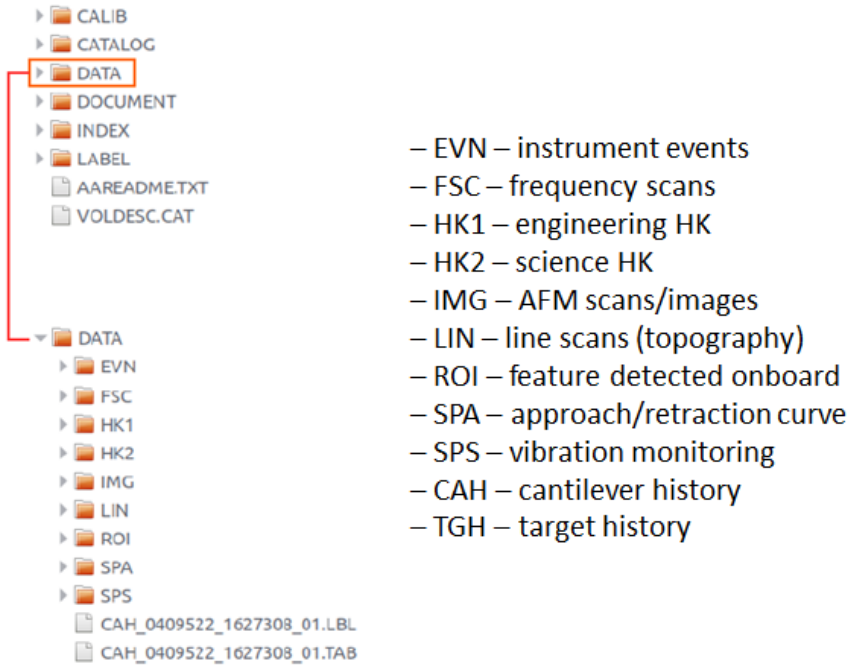


Figure 1 - List of standard MIDAS data products found in the DATA directory of a data set

The actual data set version of the standard MIDAS archive products is 3.0. Below is a short summary of the version history:

Version 3.0 is based on the Enhanced Archiving Science Reviews held in Oct 2017 and contains the updates as agreed in the MIDAS Enhanced Archive Data Delivery contract work packages 101, 102 and 103 (see section 3). This version supersedes version 2.0 and contains the following improvements:

- General: Updated contact names and addresses (VOLDESC.CAT)
  Updated dataset content description (AAREADME.TXT)
- Documentation: Updated DOCINFO.TXT, MID_EAICD.ASC|PDF (/DOCUMENT)
  Added image scan table MID_IMG_CATALOG.TAB|LBL
  Added tip mapping table MID_TIP_CATALOG.TAB|LBL
  Added enhanced calibration report MID_CALIBRATION.PDF
  Added reconstructed images report MID_REC_IMAGES.PDF
  Added tip image catalogue MID_TIP_IMAGES.PDF
  Added MIDAS analysts notebook MID_ANALYSTS_NBOOK.PDF
- Data files: Recalibrated images in X/Y/Z based on the evaluation of the results from the calibration target scans
  Complemented dataset with reconstructed images
  Added particle mask image files (DATA/IMG/*_MK.IMG)
  Added document links to detached label files
  Added browse images for PSA (/BROWSE/PRV_*_ZS.JPG)
  Fixed HORIZONTAL/VERTICAL_PIXEL_SCALE calculation
  Fixed xlength/ylength calculation in image files
  Fixed number of columns in ROI and SPA data products
- Catalogue files: Updated to latest versions (/DOCUMENT/CATALOG)
  Marked reconstructed and mask images in image list (DATASET.CAT)

Version 2.0 supersedes version 1.0 and includes several updates made in response to the Comet Science Reviews held in February 2016 and October 2017. Updates have been made to:

- Documentation: MID_EAICD.ASC|PDF, MID_COOR.ASC|PDF (/DOCUMENT)
- Data browser: Updated ReadPDS library to V4.9 (/DOCUMENT/CODE)
- Label files: Added X/Y scaling factor for images (/DATA/IMG/*.LBL)
- Data files: Enhanced history files (/DATA/CAH*.TAB|TGH*.TAB)
- Catalogue files: Updated to latest versions (/DOCUMENT/CATALOG)
  Improved image list facilitates data file referencing (DATASET.CAT)

Version 1.0 of each Level 3 data set has been released three months after the end of the respective mission phase. A detailed list of the ROSETTA mission phases is provided in section 4.2.1 of the MIDAS EAICD.

# 3. Enhanced Archiving Products

| Description | Location/Dataset | Files and Contents |
|---|---|---|
| MIDAS Particle Catalogue | RO-C-MIDAS-5-PRL-TO-EXT3-V1.0 | DATA: MID_PARTICLE_TABLE.tab<br>DOCUMENTS:<br>MIDAS_PARTICLE_CATALOG.pdf (this is the user guide for the particle catalogue).<br>DATA/IMG:<br>_ZS MIDAS images containing particles<br>*_MK particle mask*<br>BROWSE: Browse images of MIDAS scans containing particles (_ZS), their location on the MIDAS target (_SP), and the particle masks (_MK). |
| Updated Calibration Report | MID_CALIBRATION.pdf<br>V3.0 Level 3 Datasets DOCUMENTS directory | V3.0 MIDAS images are recalibrated in the X,Y and height dimensions. This report describes the updated calibration. |
| Reconstructed Images | MID_REC_IMAGES.pdf<br>V3.0 Level 3 Datasets DOCUMENTS directory | Several MIDAS images were recovered from failed data packets and added to the later datasets. These images are listed here. |
| MIDAS Tip Images | V3.0 Level 3 Datasets DOCUMENTS directory | MID_TIP_IMAGES.pdf:<br>List of MIDAS tip images and the image.<br>MID_TIP_CATALOG.TAB:<br>Catalogue of MIDAS tip images.<br>MID_IMG_CATALOG.TAB:<br>Catalogue of all MIDAS images and their closest tip image before and after scanning. |
| Flight Spare Datasets | e.g.<br>RO-CAL-MIDAS-3-GRND-REF-2008-V1.0 | The MIDAS flight spare was fitted with a set of reference materials and was used extensively to learn more about the operation of MIDAS. These datasets, in the same format as the flight model data, can be found here. |
| Description of Targets on the Flight Spare | e.g.<br>RO-CAL-MIDAS-3-GRND-REF-2008-V1.0<br>DOCUMENTS directory | MID_FS_SUMMARY.pdf:<br>A description of the targets on the flight spare and images of the cantilevers before and after use. |

| | | |
|---|---|---|
| Analysts Notebook | DOCUMENTS directory of the datasets. | Description of MIDAS operations.<br>Contents:<br>Typical MIDAS scan sequence.<br>Use of tips.<br>Reducing tip wear.<br>Temperature effects.<br>Choice of operating modes.<br>Tip shape deconvolution.<br>Tip Resonance.<br>Cantilever positioning.<br>Other key operational findings.<br>Summary of operations carried out. |

Table 1 - List of MIDAS Enhanced Archiving Products

# 4. Archive Browser Tool

The archive browser tool allows a user to browse MIDAS science products and housekeeping data. The tool can be run in IDL (licence required) and the source code is available in the DOCUMENT/CODE folder of the MIDAS datasets.

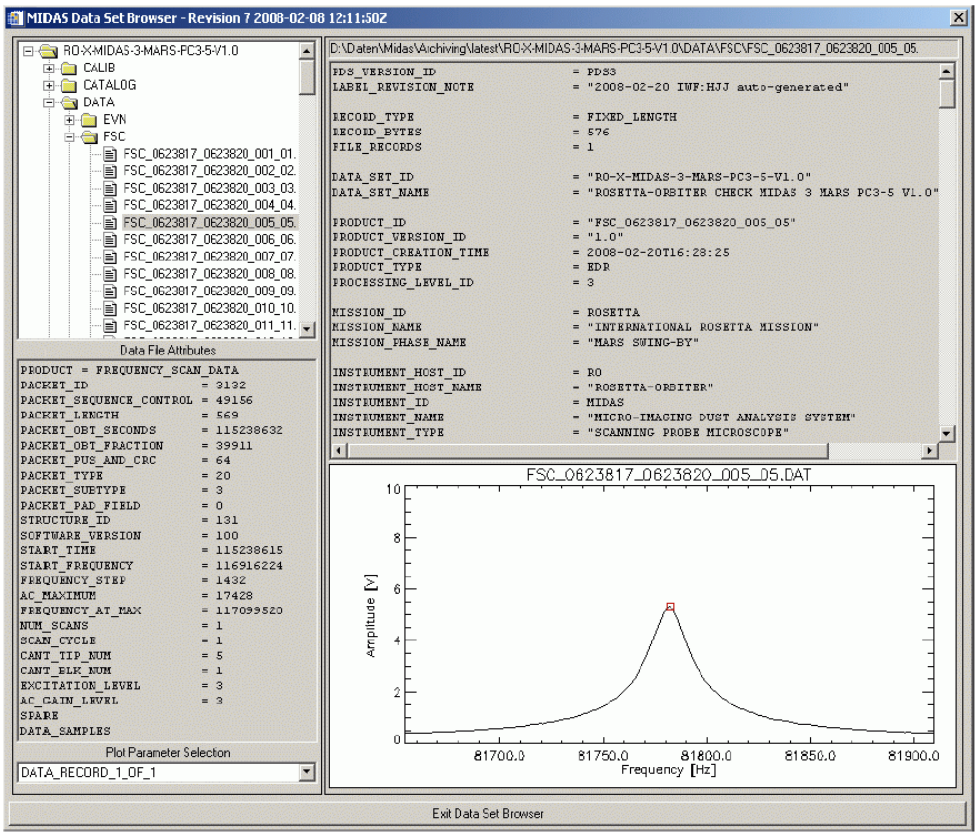


Figure 2 - Screen shot of IDL browser tool used to view MIDAS products

# 5. MIDAS Images

The key MIDAS data product is the MIDAS images, found in the DATA directory of the MIDAS datasets: DATA/IMG/IMG*ZS.[*LBL/IMG*].

The .IMG file is a BCR (standard AFM format) file that can be opened with free/open source tools, the LBL files contain the metadata and description.

The data are rectangular height fields (see EAICD) and 2D plots can be made with any PDS3 viewer (e.g. NASAView). The open source AFM toolkit Gwyddion is an easy way to view and manipulate MIDAS images (http:/gwyddion.net), which can straightforwardly open all MIDAS image files (_ZS, _MK, _PH, _S1 files, see EAICD). Python scripting is also available in Gwyddion.

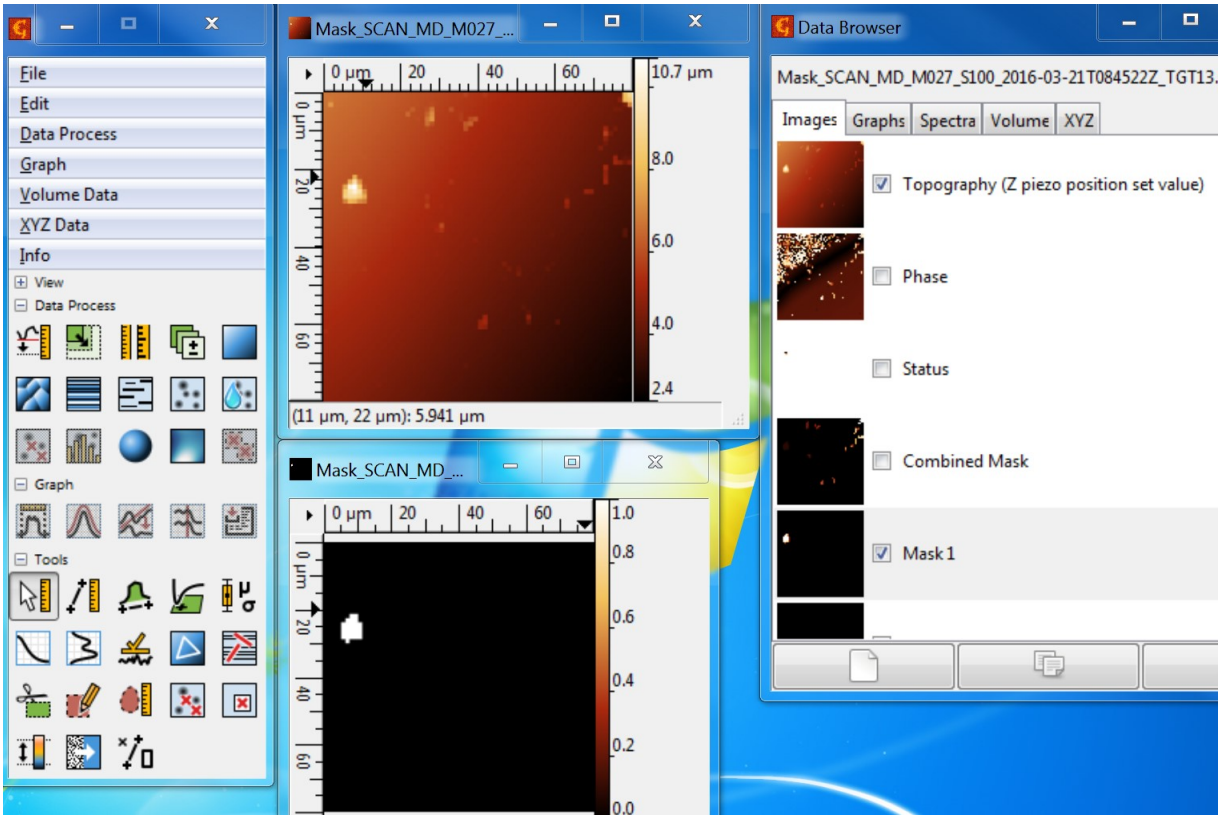


Figure 3 - Example of an edited MIDAS scan viewed in the open source software Gwyddion

# 6. Browse Images

Preview images of all MIDAS scans are available in the BROWSE directory of the data sets. These images are displayed on the ROSETTA Archive web interface when browsing the MIDAS images situated in the DATA/IMG directory.

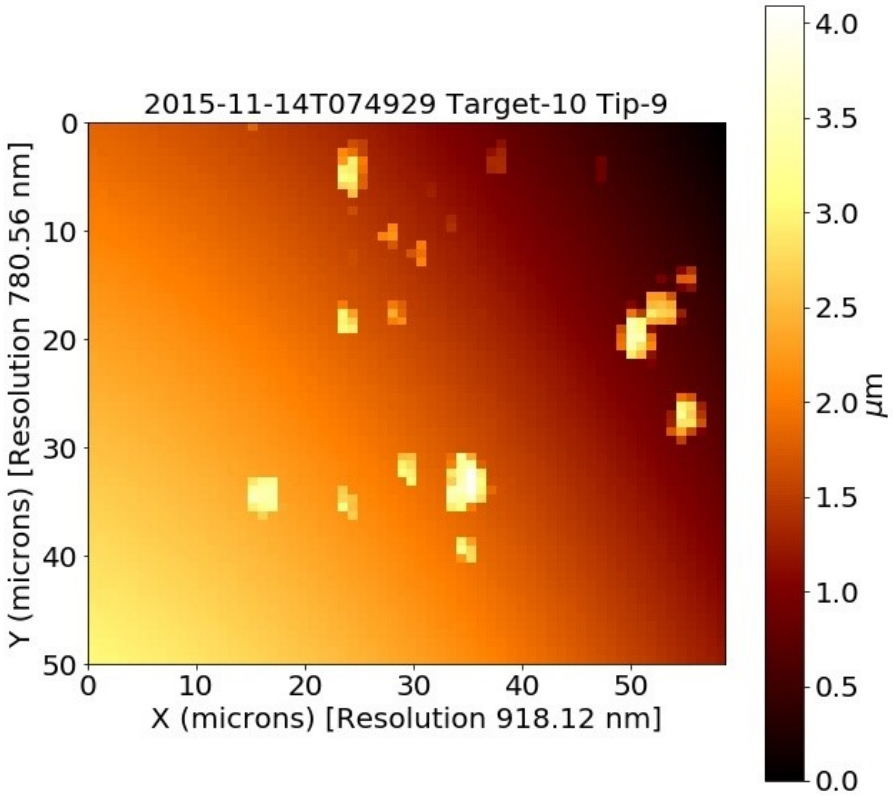


Figure 4 - Example of a browse image as shown on the ROSETTA Archive web interface

The enhanced MIDAS Level 5 data set additionally contains preview files of the particle masks and the location of the image scans on the selected target.

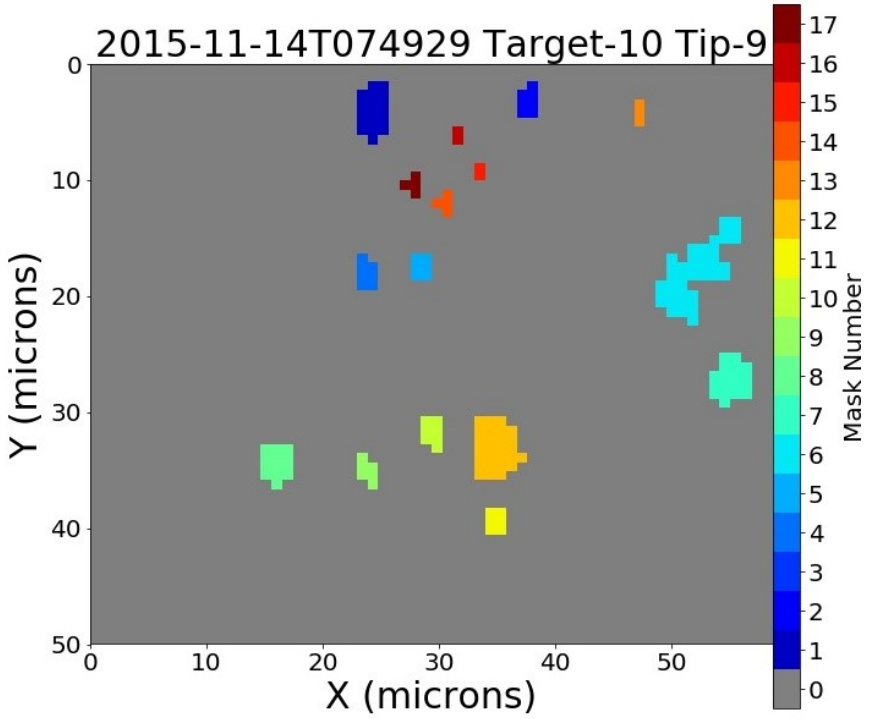


Figure 5 - Example of a particle mask browse image

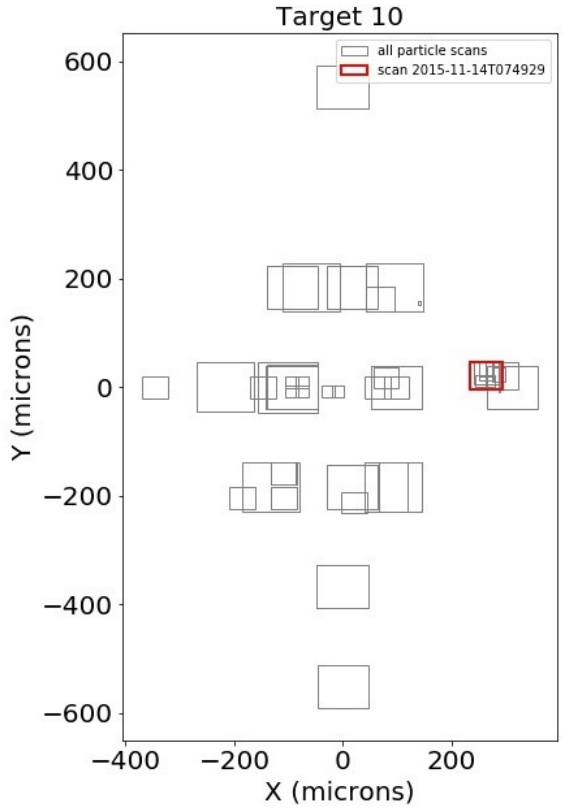


Figure 6 - Example of a scan position browse image

# 7. Cantilever and Target Histories

Two types of histories are tabulated:

TGT: timestamped target history

CAH: timestamped cantilever history

# 8. Events and Housekeeping

MIDAS instrument events are found in the EVN directory.

| OBT | UTC | count | ID | name |
|---|---|---|---|---|
| 394343624.644 | 2015-07-01 03:55:01.316000 | 15060 | 42552 | EV_SHUT_CLOS_STARTED |
| 394343638.356 | 2015-07-01 03:55:15.028000 | 15061 | 42554 | EV_SHUT_CLOSED |
| 394343924.616 | 2015-07-01 04:00:01.288000 | 15069 | 42674 | EV_ABS_APPR_STARTED |
| 394343941.839 | 2015-07-01 04:00:18.511000 | 15071 | 42624 | EV_ABS_APP_POS_REACHED |
| 394344104.658 | 2015-07-01 04:03:01.330000 | 15075 | 42661 | EV_BACK_APP_STARTED |
| 394344121.796 | 2015-07-01 04:03:18.468000 | 15076 | 42768 | EV_APP_LVDT_ON_MIN_POS |
| 394344164.669 | 2015-07-01 04:04:01.341000 | 15079 | 42652 | EV_LIN_TO_ABS_STARTED |
| 394344195.213 | 2015-07-01 04:04:31.885000 | 15080 | 42631 | EV_LIN_POS_REACHED |
| 394344346.461 | 2015-07-01 04:07:03.133000 | 15085 | 42591 | EV_SEARCH_FOR_REF_PULSE |
| 394344362.788 | 2015-07-01 04:07:19.460000 | 15086 | 42587 | EV_SAVING_TABLE |
| 394344363.014 | 2015-07-01 04:07:19.686000 | 15087 | 42592 | EV_SEGMENT_FOUND |
| 394344523.742 | 2015-07-01 04:10:00.414000 | 15091 | 42641 | EV_F_SCAN_STARTED |
| 394344524.77 | 2015-07-01 04:10:01.442000 | 15092 | 42642 | EV_F_SCAN_CYCLE_STARTED |
| 394344542.532 | 2015-07-01 04:10:19.204000 | 15094 | 42643 | EV_F_SCAN_CYCLE_FINSHED |

Figure 7 - Example EVN ASCII table of MIDAS instrument events

There are two types of housekeeping packets (any parameter can be plotted by the archive tool):

HK1 – basic engineering parameters

HK2 – extended parameters

Further information in the MIDAS EAICD.

# 9. Where to find other useful information

MIDAS EAICD (MID_EAICD) and instrument user manual (MID_USER.pdf) in MIDAS datasets DOCUMENT directory.

Description of MIDAS operations: MID_ANALYSTS_NOTEBOOK (see table 1 above).

The MIDAS instrument paper can be found in the DOCUMENTS directory of MIDAS datasets as MID_SSRV.pdf.

MIDAS publications also give a good introduction to the MIDAS data:

MIDAS: Lessons learned from the first spaceborne atomic force microscope: Bentley, M. S., Arends, H., Butler, B., et al. 2016a, Acta Astronautica, 125, 11.

Aggregate dust particles at comet 67P/Churyumov–Gerasimenko: Bentley, M. S., Schmied, R., Mannel, T., et al. 2016b, Nature, 537, 73.

Fractal cometary dust- a window into the early Solar System: Mannel, T., Bentley, M. S., Schmied, R., et al. 2016, MNRAS, 462, S304.