INAF-Padova 3DPD SUM
CaSSIS DTMs Generations and Repository v3

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Contents

1 Introduction 4

1.1 Scope 4

1.2 Applicable documents 4

1.3 Reference Documents 4

1.4 Acronyms 4

1.5 Document description 5

2 Definitions and assumptions 6

2.1 Workstation 6

2.2 Network access 6

2.3 Repository 6

3 System Update 8

3.1 Download new images 8

3.1.1 Archive structure 9

3.1.2 Manual method 9

3.1.3 Automatic script 10

3.2 Update of the Spice Kernels 11

3.3 UI_batchall (mosaicing) 12

3.4 Repository Archive Updates 12

3.4.1 TOOL_Repository_ImagesList (enumerating of stereo pairs) 12

3.4.2 TOOL_Repository_ThumsImages_withM (generating Repository images) 13

3.4.3 TOOL_ShapeFileUpdate (generating shape files) 13

4 CaSSIS_Reader (generating stereo projects) 15

4.1 Generate Stereo Images 16

4.2 Export Stereo Project 18

4.3 TOOL_Tie_automatic_detection 19

5 3DPD (DTM generation) 20

5.1 Upload on the Repository 22

1 Introduction

The Team at the Observatory of Padova (INAF) developed a stereo 3d reconstruction pipeline [RD 1] for the planetary images, by taking advantage of its know-how from the design, realization and calibration of the stereo camera STC [RD 2] on board the BepiColombo mission. The stereo cameras STC and CaSSIS are different in terms of optical design and stereo strategy, but they both apply the push-frame acquisition mode. In this context, an ad-hoc DTM generation software, called 3DPD, has been developed.

1.1 Scope

This document describes the nowadays procedures for the internal use of the 3DPD software and the associated MATLAB tools finalized to:
- update of the CaSSIS images and spice kernels
- Read CaSSIS images data and projection matrices assembly
- generate the stereo pair mosaic projects
- generate the 3D models (DTMs)
- update the OAPD Archive (https://cassis.oapd.inaf.it/archive/)

All these procedures can be performed only by OAPD Workstations.
Changes in the procedures will be documented in the next issues of this report.

The software development was supported by the Italian Space Agency (ASI) (ASI-INAF agreement no.I/018/12/0)

1.2 Applicable documents

There are no applicable documents.

1.3 Reference Documents

[RD 1] Simioni, E., Re, C., Mudric, T., Pommerol, A., Thomas, N., Cremonese, G. (2017). A Photogrammetric Pipeline for the 3D Reconstruction of CaSSIS images on board ExoMars TGO. The International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences, 42, 133-139.10.5194/isprs-archives-XLII-3-W1-133-2017

[RD 2] *Cremonese, G., Capaccioni, F., Capria, M. T., Doressoundiram, A., Palumbo, P., Vincendon, , ... & Amoroso, M. (2020). SIMBIO-SYS: Scientific Cameras and Spectrometer for the BepiColombo Mission. Space Science Reviews, 216(5), 1-78.* 10.1007/s11214-020-00704-8

1.4 Acronyms

3DPD three-Dimensional reconstruction of Planetary Data
ASI Italian Space Agency

CaSSIS	Colour and Stereo Surface Imaging System
DTM	Digital Terrain Model
ESA	European Space Agency
FOV	Field Of View
GUI	Graphical User Interface
MTP	Mid Term Planning
OAPD	Padua Astronomical Observatory
SK	Spice Kernels
STP	Short Term Planning
STC	STereo Channel
TGO	ExoMars Trace Gas Orbiter
UniBe	Bern University (Space Research & Planetary Sciences)
WS	WorkStation

1.5 Document description

After the two introductory sections the document has the following structure:

1. System Update: describes the Padua Observatory archive update for the SK and framelets data (starting from the Halimede Bern server). In the same section the process for the update of the Repository data (Padova observatory webtool described in 2.3) with the newly uploaded framelets and shape file is described
2. Project Generation: describes the process for selecting a set of framelets and of mosaicking the images for the generation of the stereo pair project to be processed by 3DPD software
3. 3DPD DTM generation: describes the 3DPD software and the procedure to generate a DTM starting from a stereo-pair project (defined by previous procedure)

A diagram of the different phases could be seen in Figure 1

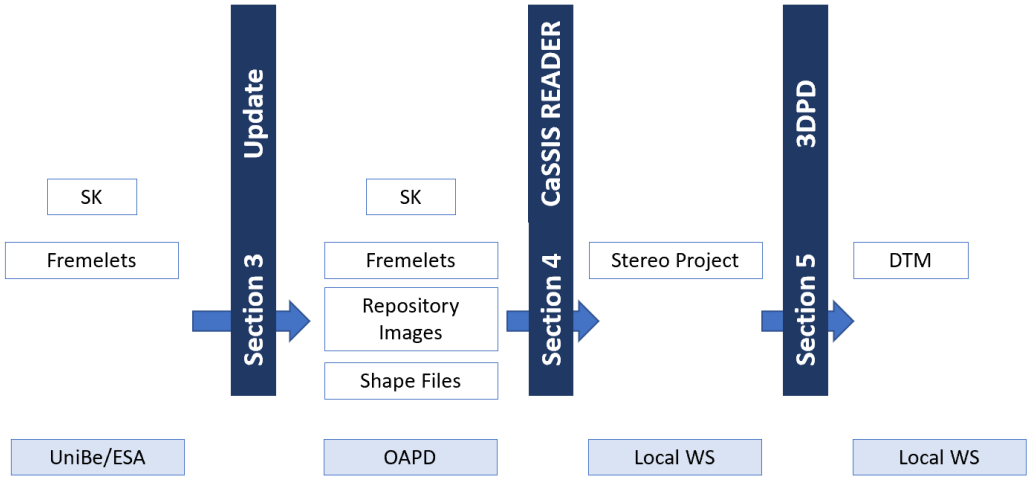


Figure 1 Complete pipeline : the three phases described in the previous paragraph (and the associated Sections of this Manual) are represented with their input/output dataset. Section 3 hallows the mirroring of the SK and Framelets from external servers to the local ones; the Cassis_reader hallows to define a project in the local Workstation for the 3d reconstruction; the final step is the 3DPD which performs the generation of the DTM.

Note that only 3DPD (Section 5) can be applied on a local WorkStation while other process needs to be connected to OAPD net or UniBern server.

2 Definitions and assumptions

In this section the main physical and technical terms are defined.

2.1 Workstation

The DTM Reconstruction is processed on two local Workstations:
-ICARUS (password “Icarus”)
-DTM-PC (no password is needed)

Both the WorkStations mount a Microsoft Windows 10 Version 1809 (2018). The software is tested until Matlab Version 2019b. The pipeline needs a set of Libraries reported in Table 1.

Library	Scope	Release
MathNet.Numerics	linear algebra	3.13.0
Emgu.CV	image processing	3.1.0
GDAL	geospatial data	2.3.3
Graphics.WPF	rendering of graphics	1.0.5242.30810
ZedGraph	user control, and web control for .net	5.1.7

Table 1 Libraries needed to the correct development of the OAPD pipelines with the last tested Release Version.

These or other workstations must be connected to the OAPD Network (named CaSSIS) during the mosaicking phase of the stereo images.

2.2 Network access

All software lean on a network folder called CASSIS.

Path: \\st1.oapd.inaf.it\cassis
Login: cassis@oapd.inaf.it

Please check if you can access. All Spice Kernels used and calibrated CaSSIS data are archived at this location.

2.3 Repository

The Repository WebPage (a Dynamic Interface for the management of the requests of DTMs reconstruction and the delivery of the stereo products) is the way to manage the booked reconstruction and upload the generated DTMs.
According to the agreement within the CaSSIS science team the system has three authorization levels:

- CI: Co-I Team. Each Co-I have a user. A CI can upload or delete the DTMs he uploaded. It is possible for one institute to have different Co-I. Any Co-I can download any DTM of the repository.
- ST: Science Team, it can download any DTMs.
- After 12 months from the upload the products become public (without any need of user identification).

Each Co-I member has his personal access.

3 System Update

An update of the CaSSIS archive at OAPD is performed monthly.
All the tools described in this report are based on the use of the OAPD archive data which are a mirror of the CaSSIS one. This means that monthly the local archive should be updated to be in line with the CaSSIS ones.
The archive contains:

- CaSSIS images : images (composed by a file with the data with extension .dat and a descriptor of the data format in the file with extension .xml) are divided in MTP and STP following the path \\st1.oapd.inaf.it\cassis\Halimede2\data\. This folder contains the MTP (i.r. M01) and each MTP folder contains the STP ones (i.e. 180414_mtp000_stp004_boot2). Each STP folder should contains one folder "level1c" containing the data acquired. More details on data archive structure are reported in Section 3.1.1.
- Spice kernels: updated SK are archived in \\st1.oapd.inaf.it\cassis\SpiceKernels
- Mosaicked images: mosaicked images are archived in the 'jpg_mosaic' folder contained in the STP one
- the list of the stereo pairs and the thumbnail images used in the repository: both the datasets are archived in \\st1.oapd.inaf.it\cassis\Repository Archive.

The update consists of the following:

- Download of new images
- Spice Kernels update
- Tiff images and thumbnails generation

In Table 1 the scripts for the archive update are listed according to the order in which they are used. The same table reports the script scope, the packets which include them and a hyperlink to the section which describe the script in detail.

SCRIPT NAME	SCOPE	Packet	SECTION
CASSIS_SFTP_initialize.m	Define STP to be updated	SFTP_UPDATE_HALIMEDE	3.1.3
CASSIS_SFTP_download_batch.m	Download STPs	SFTP_UPDATE_HALIMEDE	3.1.3
TOOL_BatchNewMXX	Mosaic MTP	CaSSIS Reader\Tools	3.3
TOOL_Repository_ImagesList	Generate Stereo images list	CaSSIS Reader\Tools	3.4.1
TOOL_ThumbsImages	Generate Repository Archive	CaSSIS Reader\Tools	3.4.2

Table 2 Main scripts described in Section 3.

3.1 Download new images

Once an STP is radiometrically calibrated by CaSSIS Team it is archived on the **remote UniBe server** sftp://halimede.unibe.ch in the corresponding MTP folder. A mirroring of the framelets should be performed in **OAPD local server** \\st1.oapd.inaf.it\cassis to guarantee a correct mosaicking.
In this section we describe the Archive structure (3.1.1) and two possible methods for the update:

- manual method (obsolete) (see 3.1.2)
- automatic script (see 3.1.3)

3.1.1 Archive structure

The images are stored in the OAPD local server in the 'data' folder.
Each folder MXX refers to a MTP (Mid Term Planning) (XX indicates the number of a planning term). An MTP lasts 4 weeks. Each MTP is comprised of several STP (Short Term Planning). A STP covers one week.
Each MXX folder contains several folders in the form 'YYMMDD_stpAAA_bootB' and several folders of the form 'stpAAA' as the following name convention:

- YY-year,
- MM-month,
- DD-day,
- AAA-number of the short term plan,
- boot=software boot,
- B-number of the boot (usually one boot is one day) .

Each folder YYMMDD_stpAAA_bootB contains a folder 'level1c' in which contains all the framelets files. Folder stpAAA contains the images separated according to the orbits.

The folders YYMMDD_stpAAA_bootB and stpAAA should be downloaded by the UniBe archive.
In this way we create our own mirror of the UniBe archive of the CaSSIS images. The folder YYMMDD_stpAAA_bootB is read by the CaSSIS Reader and the mosaics of the images are produced in it.
Folder YYMMDD_stpAAA_bootB is defined as AA in the following sections, and folder stpAAA as folder BB.

3.1.2 Manual method

Steps to download the new images:

1) Start FileZilla Client and insert as host sftp://halimede.unibe.ch and as local folder: \\st1.oapd.inaf.it\cassis\Halimede2\data\.
2) Enter in the last MXX folder in our archive and enter in the same folder on the UniBe archive
3) Check in all our AA folders if there is a folder level1c. If it is missing somewhere you have to download it from the same AA folder in the UniBe archive. Place yourself in the same AA folder in our (left side) and UniBe (right side) archives. Right click on the level1c folder in the UniBe archive, and then click on Download.

4) Now if there is a new MXX folder in the UniBe archive, create the same folder in our archive Halimede2/data/
5) Enter in the last created MXX folder in our archive and enter in the same folder created in the UniBe archive.
6) For each AA folder in the UniBe archive create the same folder in our archive. Then enter in the specific AA folder in our and in the UniBe archive. Download the level1c folder from the UniBe archive into our archive.
7) Download each BB folder from the UniBe archive into our archive: right click on each BB folder in the UniBe archive and then click on Download.

3.1.3 Automatic script

Two Matlab scripts (tested until 2019b release) allow to define automatically if the net folder "\\st1.oapd.inaf.it\cassis\Halimede2\data" is aligned with "halimede.unibe.ch".

- CASSIS_SFTP_initialize (3.1.3.1)
- CASSIS_SFTP_download_batch (3.1.3.2)

The first checks if there are new STP in the remote server not present in the local one and generate a set of .bat files containing the list of files to be downloaded, the second download the selected data.

3.1.3.1 Inizialize

To perform the initialization, run CASSIS_SFTP_inizialize script and answer yes to question "Connecting to Halimede, Continue?(Y/N)":
The script will ask to SFTP server all the STP present in the folder "data" and will compare the results with OAPD server.
At the end of the execution a list of STPs (NOT in alphabetic order) is provided with the text note "no action" if the stp is synchronized with OAPD or "TO UPDATE" at the contrary.
The list of the STP to be updated is reported in the bat files used in by script CASSIS_SFTP_download_batch to perform the download of the selected STP.

An example of the log output provide is here showed:

```
_____________________________________
_______MTP/STP_____________|__ACTION__
M14\190504_stp055_boot8 | no action
M22\191214_stp087_boot4 | no action
M22\191221_stp088_boot7 | TO UPDATE
M22\191130_stp085_boot3 | no action
M22\191221_stp088_boot6 | no action
M22\191221_stp088_boot8 | TO UPDATE
M22\191221_stp088_boot4 | no action
Number of stps           469
Number of stps to update 2
Generating STP_dw_folders_scripts\M22_191221_stp088_boot7.bat
```

```
Generating STP_dw_folders_scripts\M22_191221_stp088_boot8.bat
```

In this case in a set of 469 STPs present in Halimede 2 STPs should be updated. The .bat script to download these STPs are generated in the internal folder STP_dw_folders_scripts.

3.1.3.2 Download

After the initialization all the .bat files reporting the files to be downloaded are ready for the download. Run the script (CASSIS_SFTP_download_batch) and answer yes to question "Connecting to Halimede, for update of the N STPs ?(Y/N)[Y]:"
The scripts will read the .bat files generated by previous script and will start the download from each MTP/STP/level1c folder of Halimede to each MTP/STP/level1c of OAPD.

3.2 Update of the Spice Kernels

- Go in \\st1.oapd.inaf.it\cassis\SpiceKernels
  The folder with the spice kernels that is used by CaSSIS reader has the format kernelsYYMMDD, where YY is the year, MM the month and DD the day.
- Make a copy of the folder 'kernelsYYMMDD' with the most recent date in its name. Change the name of the new folder to 'kernelsYYMMDD' so that YYMMDD is set to the actual date.
- Make a mirror by FileZilla download by the host: spiftp.esac.esa.int/data/SPICE/ ExoMars2016/kernels to Local site '\\st1.oapd.inaf.it\cassis\SpiceKernels\kernelsYYMMDD'Select
- Now connect with FileZilla with the following Host: sftp://halimede.unibe.ch/ spice/cassis_ck to download in the remote site the 'ck' kernels
- Go in the folder 'mk' and Make two copies of the newest .tm file, check the name of the file to understand which one is the newest. The copies must have the same name as the original plus the suffix '_win' one file and '_ios' the other.
  In each of the two files set the value of PATH_VALUES equal to the correct path. The path must correspond to the folder in which the folder 'mk' is located. So set it to '\\st1.oapd.inaf.it\cassis\SpiceKernels\kernelsYYMMDD' for the '_win' file and to '/Volumes//cassis/SpiceKernels/kernelsYYMMDD' for the '_ios' file, where kernelsYYMMDD is the newly created folder. BE CAREFUL THAT 'kernelsYYMMDD' IS THE CORRECT FOLDER, CHECK THE DATE YYMMDD.
- In the line where it is written '$KERNELS/ck/em16_tgo_cassis_ilp_tel_.....bc' change the predicted kernel with the one already downloaded. For example '$KERNELS/ck/em16_tgo_cassis_ilp_tel_20160312_20181231_s20180215_v01.bc' was replaced with '$KERNELS/ck/cassis_ck_p_160312_191231_190216.bc'. This has to be done in both the '_win' and '_ios' files.

3.3 UI_batchall (mosaicing)

The MATLAB script file 'UI_batchall' takes care of the generation of the mosaicked images of all the stereo pairs belonging to an MTP folder (and consequently its STPs).

Once Spice Kernels and Images are updated you have to open CaSSIS_Reader/UI_batchall.m MATLAB script and to select in the first command line the MTP folder you want to mosaic. For example:

```
nameM='\\st1.oapd.inaf.it\cassis\Halimede2\data\M23';
```

Press F5.
The process will ask from which STP the batching has to run i.e.:

```
MTP FOLDER \\st1.oapd.inaf.it\cassis\Halimede2\data\M23
FOLDER_NUMBER | FOLDER
       0001   | .
       0002   | ..
       0003   | 191228_stp089_boot1
       0004   | 191228_stp089_boot2
       0005   | 191228_stp089_boot3
    ….
       0033   | 200118_stp092_boot7
       0034   | 200118_stp092_boot8
       0035   | mat_files

Select starting folder [3]:
```

You have to select the first STP you want to batch (it should contain only the "level1c" folder).
That the process will make not available the Station until the end.

3.4 Repository Archive Updates

Repository Archive can be updated starting from the stereo images list and the thumbnail images. The second can be generated starting from the Stereo Image list (granted by the script described in 3.4.1).

3.4.1 TOOL_Repository_ImagesList (enumerating of stereo pairs)

The MATLAB script file 'TOOL_Repository_ImagesList.m' takes care of the generation of the repository text file that contains all the stereo pairs.
It creates a list of all the stereo couples based on the data contained in the MXX folder and YYMMDD_stpXXX_bootY subfolders. This list is saved in a text file which is used for the repository. The user has to select only the MXX folder, and all of its YYMMDD_stpXXX_bootY subfolders will be processed. An existing text file with the stereo couples can be updated, or a new one can be created. The steps to apply are the following:

- Select if you want or not to update an existing file [Yes/No]
- Select the folder MXX in which you want to identify all the stereo pair
- Write the name of the text file where all the stereo couples from the MXX folder and from the existing file selected for update (if selected so) will be written. Do not write the path for the file and the extension. The path is: '\\st1.oapd.inaf.it\cassis\Halimede2\data', and the extension is '.txt'.

3.4.2 TOOL_Repository_ThumsImages_withM (generating Repository images)

The MATLAB script file 'TOOL_Repository_ThumsImages_withM' takes care of the generation of the Repository images dataset starting from the image list file. It reads the list of all the stereo pairs from the image list file defined in Section 5.1 and generate a dataset of folders and image file which are read by the Repository dynamic pages. The script file creates a folder hierarchy based on the data contained in each MXX folder and each YYMMDD_stpXXX_bootY subfolders. The user has to select the source by browser and the folder name of the dataset in the first line of the script.

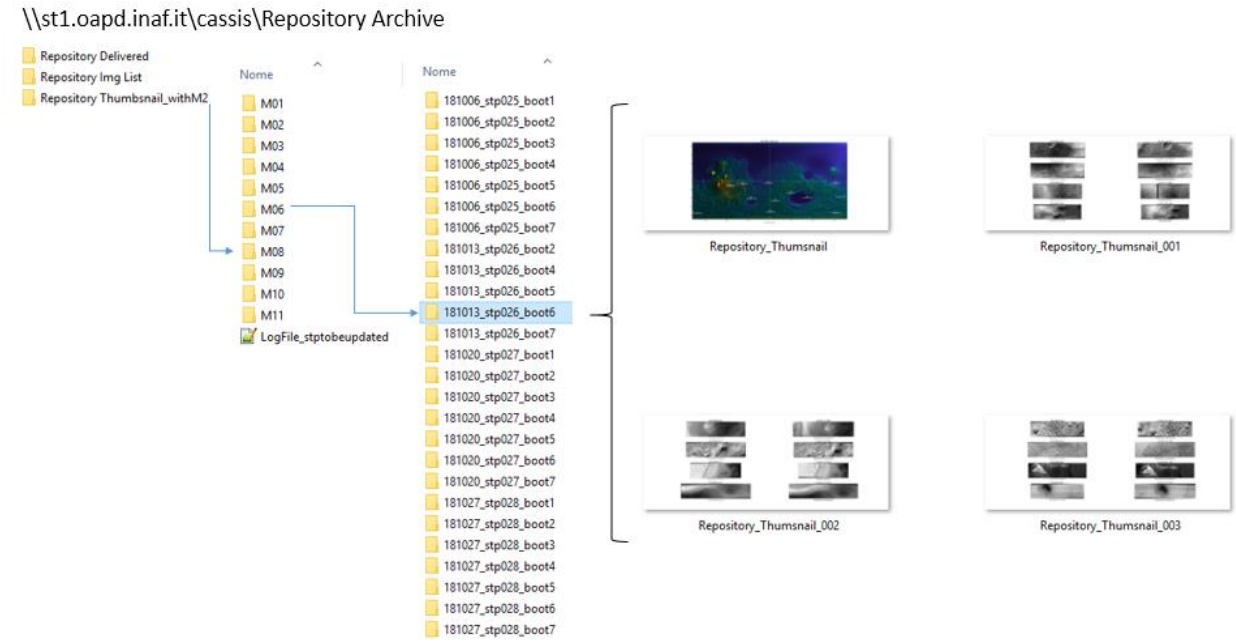


Figure 1 Hierarchal example of the images Thumbsnail dataset generated by the Tool.

At the end of the process a log is written on the command window.
NOTE: Remember that small txt files could be found in the data structure. Please delete them before send the data structure to A.

3.4.3 TOOL_ShapeFileUpdate (generating shape files)

The MATLAB script file 'TOOL_Repository_ThumsImages_withM' takes care of the Generation of the shape file containing the FOVs of the acquisitions. It is used to create a shape file containing the CaSSIS field of view of the various acquisitions (frames). The script can be used to produce a shape

file of all the acquisitions in one session (YYMMDD_stpXXX_bootY) or of all the acquisitions (frames) in the MXX folder (therefore, all the MXX subfolders with format 'YYMMDD_stpXXX_bootY'). Furthermore, it can be chosen to update an existing shape file. Then, the produced shape file will have the selected session/s and the field of views in the file selected for update. The field of view of the frames is always chosen to be equal to the nominal PAN filter and its length is between the first and last frame. This is an approximation since the other filters are slightly shifted between themselves because of the minimal difference of their boresight direction. However, it is enough to have an approximate overview of the areas acquired with different acquisitions. The shape file contains for each field of view some data relative to that acquisition, as the filters acquired, the time of acquisition, folder containing the image, and so on… At the end four files with the same name are saved. The extensions of the saved files are '.shp', '.shx', '.dbf' and '.prj'.

Steps for usage:

- Run the script and decide if you want to update an existing shape file (Yes/No) If you selected 'Yes' then select the shape file to be update
- If you want to read more sessions select 'Yes', one MXX folder must be selected and all its subfolders with the name format 'YYMMDD_stpXXX_bootY' will be read If you don't want to read more sessions but just one then select 'No', one folder with the format 'YYMMDD_stpXXX_bootY' must be selected.
- Write the name of the new shape file that will be saved. Do not write the file path and extension. The path where the file is saved is '\\st1.oapd.inaf.it\cassis\Halimede2\data'. Four files with the following extensions are saved: '.shp', '.shx', '.dbf' and '.prj'.

4 CaSSIS_Reader (generating stereo projects)

The MATLAB script file 'CaSSIS_Reader' takes care of the generation of the projects dataset to be used as input by the 3DPD pipeline. 3DPD software performs the 3D reconstruction from mosaicked images. Mosaicked stereo pairs are archived in Folder data called "Projects". The Project of a defined stereo pair can be generated by a MATLAB toolbox called "CASSIS_READER" installed in all the OAPD workstations.

After the generation of the project the pipeline does not need the Network access anymore.

CASSIS_READER project generation can be divided in 3 phases:

1. Selection and mosaicking (4.1)
2. Export Stereo Project(4.2)
3. Tie point alignment (4.3)

All this phases are performed by the UI_starter script which will launch the CASSIS Reader (CR) GUI buttons window. Please follow the following instructions:

1) From the CASSIS Reader (CR) interface press 'Mode: LOCAL' to change the mode in 'Mode: NET'. In this step Spice Kernels will be read.
2) Click on 'Select Framelet Folders' and select from net folder "Halimede2/data" the folder YYMMDD_stpXXX_bootZ that contains the folder 'level1c' with the images.
3) Select PAN filters (by answering 1 to question "Select Filter") and wait for MOLA figure (Figure 2).

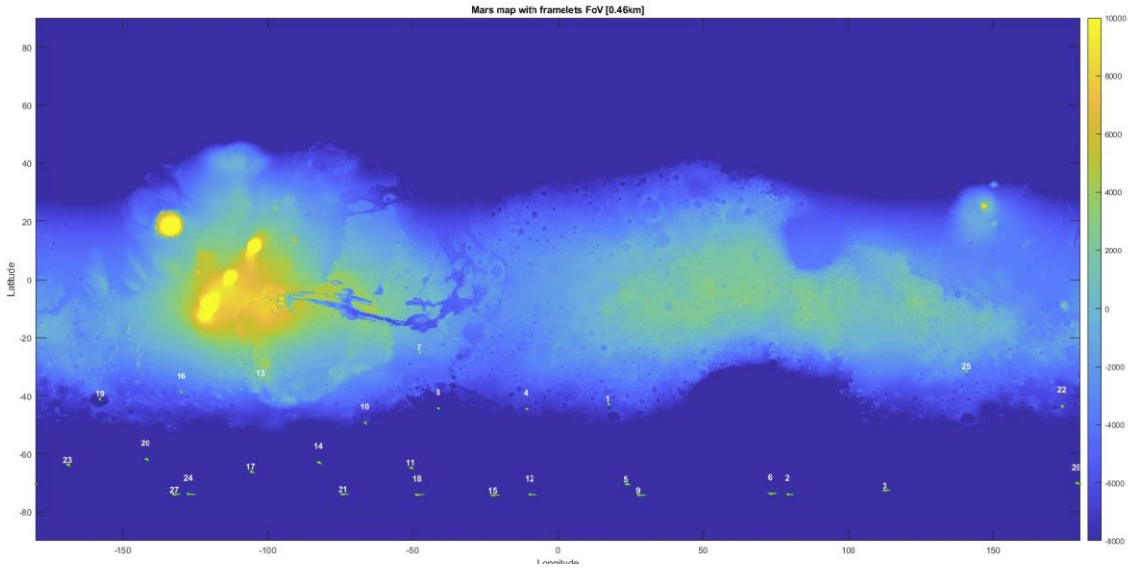


Figure 2 MOLA figure is a plot showing the MOLA height in equirectangular projection and all the CaSSIS images acquired in the STP selected at step 5. Stereo pairs are represented by an image with an ID number.

4.1 Generate Stereo Images

4) Click the 'Select Frame' button. Enter the number of the first frame of the stereo pair frames. If known it is possible to insert, instead of the number of the STP shown in **Figure 2**, the STEREO PAIR ID of the acquisition as reported by CASSIS repository website (see Figure 3).

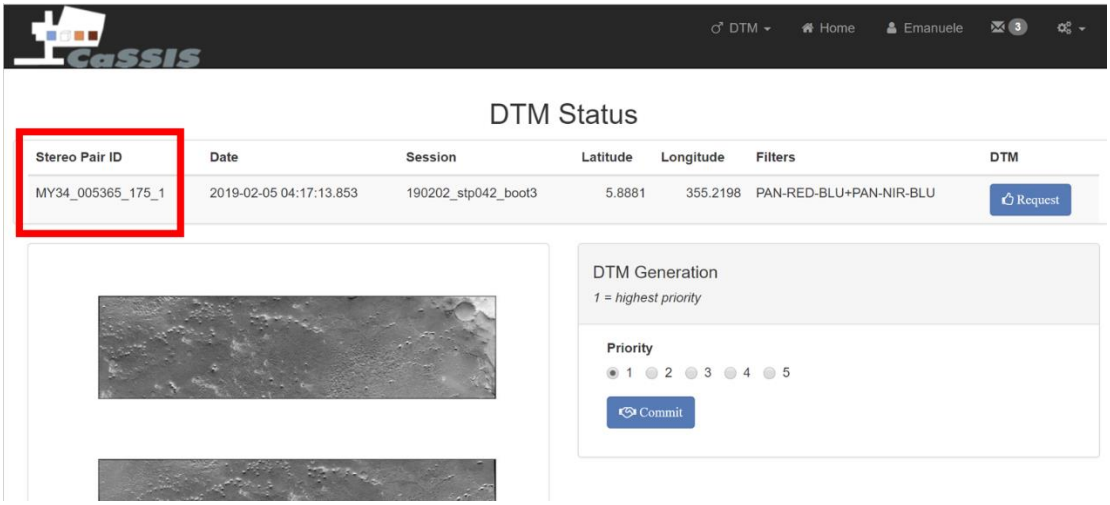


Figure 3 In red the location of the STEREO PAIR ID. In the example: "MY34_005365_175_1"

Set to 'Y' the field 'is stereo pair'. (The frame number must be the one referring to the all acquisitions). Click 'Ok'.

5) Answer 'No' to question 'Get ready for projection? (Y/N)'
6) Wait for the process to finish and other buttons to become available.
7) Click on 'Mosaic Images'.

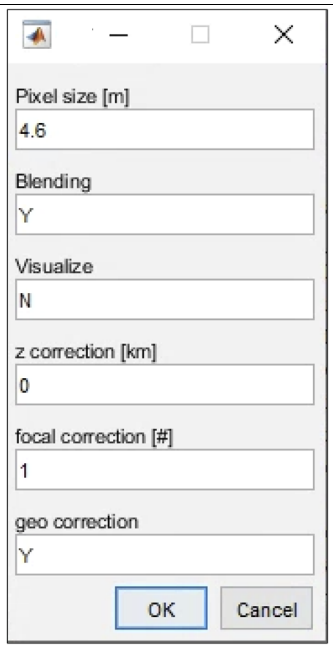


Figure 4 Mosaic mask for the definition of the mosaicking parameters

The Mosaic command opens a Parameter window showed in **Figure 4**. The parameters and the suggested (and default) values are reported din **Table 3**.

Parameter Name	Description	Default (nominal)
Pixel size	pixel size of the mosaicked images	4.6 (m)
Blending	if 'Y' applies the blending in the overlapping regions	'Y'
Visualize	If 'Y' visualizes the mosaicking image all the image added. Suggested Debugging mode	'N'
z correction	height of the mosaicking plane in km respect the Mola surface	0
focal correction	if '1' applies automatic bundle adjustment of the mosaicking plane	'1'
Geo correction	if 'Y' applies geometrical distortion	'Y'

Table 3 Parameters defined in the Mosaic window (see Figure 4)

8) Click on Mitigate PhP (Photoplane error). Answer 'Y' to question 'Mitigate on plane?'
9) Wait for the process to finish and close the resulting figure.
10) Click on 'Mosaic Images'. Parameters will be changed. Click 'OK'.

4.2 Export Stereo Project

11) Click on 'Export prj Auto'
12) Set the name of the folder that will contain the project. The name is composed by a prefix proposed followed by a "not funny" suffix. This should be a name of a crater/region/features of the surface , please see (https://www.uwingu.com/mars/ or http://muted.wwu.de/).Click 'OK'.
13) Decide if Clear sigma Outliers by writing in the command window Y or N. Clear sigma if x dispersion is greater than $\pm 2px$ or there are sparse points. If clearing sigma outliers select the factor for sigma clearing, default value of 2 is suggested.
14) Repeat the process if necessary. Select N when no more clearing will be performed.
15) For 'Change percentile threshold on histogram? (Y/N) [N]:' change it if saturation is present on the image, so look at the images. CaSSIS radiometric automatic pipeline nominally cut the 5% of the dynamic. To avoid possible lossy of information we allow the user to define a manual threshold. The image should have good contrast and no large areas or many points with over- and under- saturation. Oversaturation is present as bright (white) points and undersaturation as dark (black) points. It is recommended that the image should look like the mosaicked image present in the folder "jpg_mosaic", or the one shown in the thumbnails. You can change the default value as long as you are not satisfied with the image. Always check to avoid saturation or 0 values regions.

    Saturation or 0 values regions could generate holes in final 3D pd results!
16) Decide if you want to save a Project which consider as image a cropped part of the original images. We strongly advise to select 'Y'. If saving a section: write a suffix when asked to 'Add a suffix []:', that suffix will be added to the project name.

    We strongly advise to create 1 cropped stereo pair in case of the full overlapping region with suffix "entire".
    In case of cropping: on the left image select two points that will form opposite vertices of a quadrilateral that will determine the section region. Change the percentile threshold on histogram if necessary (i.e. if there is saturation present on the image).
17) If you need even a project with slow resolution. Select the factor of reduction of the image resolution. The default value of -1 do not generate any project (change the percentile threshold on histogram if necessary.)

After export TOOL_Tie_automatic_detection MUST be performed.

4.3 TOOL_Tie_automatic_detection

1) Click on 'TOOL_Tie_automatic_detection.
2) Select the project folder for which you want to apply the tool for automatic tie points detection, normally "entire" one (see point 17).
3) Set tiles dimension to the suggested value, press 'Enter'
4) Remove outliers interactively. Press 'Enter' ('Y') if you want to remove tie points from the disparity map in j direction. The left part of the figure shows the disparity in j from different views. Select the point/s to be removed from the bottom left figure. After selection the point will be removed and you will be prompted if you want to remove another point. After finishing point removal, write 'N' and press enter.
5) Now you can repeat the process for the disparity map in the i(vertical) coordinate. Select 'Y' for point removal and 'N' when you don't want to remove any other point.
6) Select 'Y' when prompted 'Continue and save? (Y/N) [Y]:'
7) Watch the images with the tie points and decide whether to add manual points or not.
8) If you like to add tie point manually select 'Y' when prompted to do so. Select 'N' when asked to reload an old tie point file, or else.
   If you selected to add tie points manually, select a point in the same area on both images (master and slave) and the figures will be enlarged, then try to select a tie point by selecting the same point on both images.
   You will be asked 'Save Point? (Y/N) [Y]:', if you are satisfied with the point selection select 'Y', otherwise select 'N'.
   Then you are prompted if you like to select other points so you can repeat the process until you are satisfied with the number of points selected. After that write 'N' when asked to select other points.
9) Now a file with the name XmYmXsYs.txt will be saved. It contains the x and y coordinates of the tie points on the master and slave images.

5 3DPD (DTM generation)

The c++ software is a GUI interface supported software which allows to generate DTMs with 3DPD software starting from a Project developed by the previous sections.

1) Run the 3DPD exe file.
2) Open a project created in the previous steps. File/Read Project -> select the project folder
3) Evaluate the disparity maps up to the NCC parabolic. WorkFlow/DP421p
4) WorkFlow/View Disps. Set the axes on the histograms of the Disparities and QMap in order to determine the points to be cleaned (removed). For the QMap the number of removed points should be below 30% of the image (The max value of the QMap minimum axes limit should be below 0.6). In case of greater percentile (normally due to the low quality of the images) this should be manually indicated in the xml file before the upload of the DTM in the Repository archive.
   A common solution to the definition of the limits is to define before the upper and lower limit of the image (disparity or qmap) considered by moving the mouse over the brighter and darker safe (not spiked) regions and read the value on the field Pixel Value (see Figure 1) .

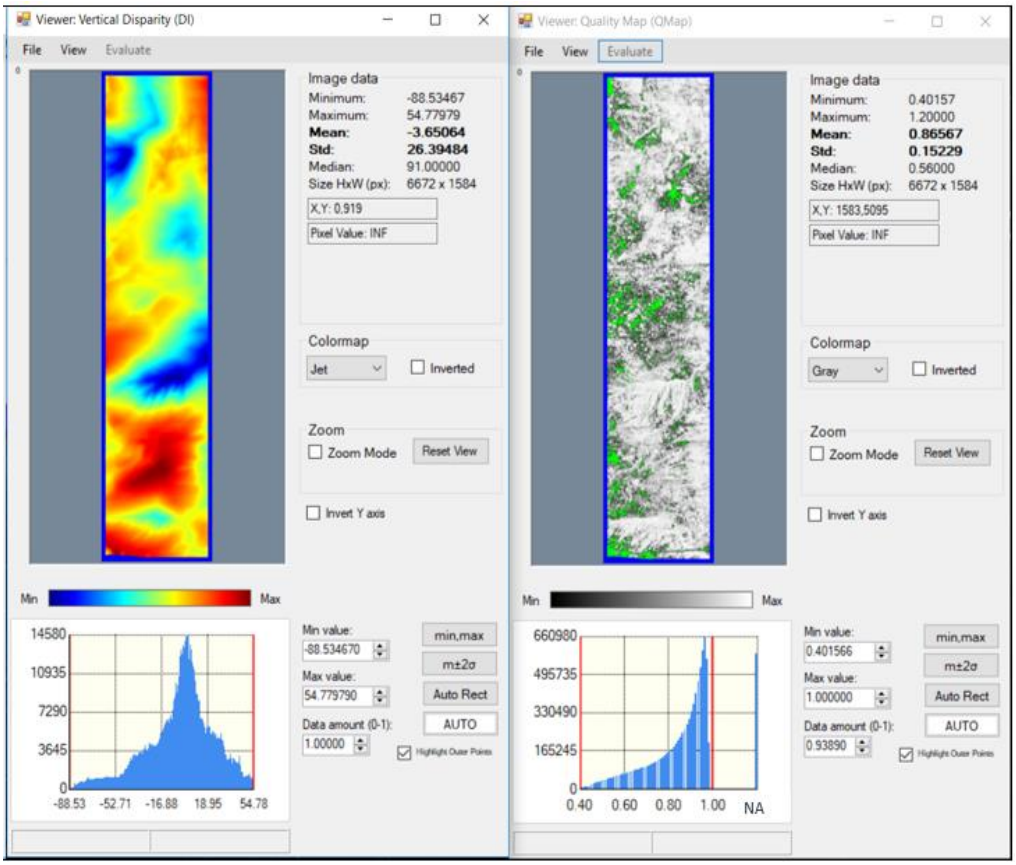


Figure 1 Common visualization of the Disparity (on left) and QMap on right.

The statistical distribution of the QMAP must follow the shape of the one shown in Figure 1 but limited to value 1. A Gaussian distribution around a mean of 0.5 means low information on the images (bad calibration/saturation/ …).

In case the system does not support this operation the only solution is to click on View/Disparities/Disp_i, set axes, close the Disp_i figure and click on PostProc/Cleaner/On Histogram Axes and repeat these steps for Disp_j and QMap. After this goto step 7.

5) Close the disparities.
6) WorkFlow/Cleaner/On Manual Axes
7) WorkFlow/FillOnList
8) WorkFlow/LSMLOG
9) Select the number of iterations and click on 'Start'.

(Now the disparities generation has been finished)
10) Apply again points 4-5-6-7
11) Save final internal file with Actual/Save bin , with name Z_final.bin

Saving products:

For fast save:
10) File/SaveDTM. Warning: if the software crashes do the following: (I) Run 3DPD, (II) reopen the last project with "File/Read Project/Last project", (III) save the products again "File/SaveDTM"

11) Maintain the configuration DTM/MolaAligned+OrthoPhoto+HeightTexturized
12) Click on 'Save'

The widget will generate in the folder NAMEPROJECT/REPOSITORY_FILES all the files to be updated in the repository website.

All the files could be checked. This means:
1) Open Orthopoto (jp2) and DTM (tif) with ARGIS/QVIEW checking position with THEMIS
2) Open DTM (tif) with ARGIS/QVIEW checking height profile with MOLA
3) Compare HMAP (jpg) and QMAP (jpg) with DTM and Orthophoto *(A simple measurement of the misalignment between THEMIS and ARGIS can be used to correct manually the position by correction the OrigReference_System.txt file.)*

5.1 Upload on the Repository

Go on the website of the repository (https://cassis.oapd.inaf.it/archive/). Logins are reported in Section 1.3.

1) Click on Log In and log in by using your account (see
2) Click on DTM/Upload DTM
3) Insert the DTM version
4) Now you should upload the files saved in the “RepositoryFiles” folder inside your project main folder
5) In the “DTM File*” field upload the “CAS-DTM-....tif” file
6) In the “XML File*” field upload the “CAS-XML-....xml” file
7) In the “HMap File*” field upload the “CAS-HMP-....jpg” file
8) In the “QMap File*” field upload the “CAS-QMP-....jpg” file
9) In the “ORImage 1*” field upload the “CAS-OTH-....jp2” file
10) Now click on “Upload” to upload your DTM and its products
11) If the process finished correctly your DTM is uploaded successfully, otherwise check for warning messages and repeat the steps for the upload