PRoViDE:

Planetary Robotics Vision Data Processing and Fusion

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(10) German Space Center, Berlin, D

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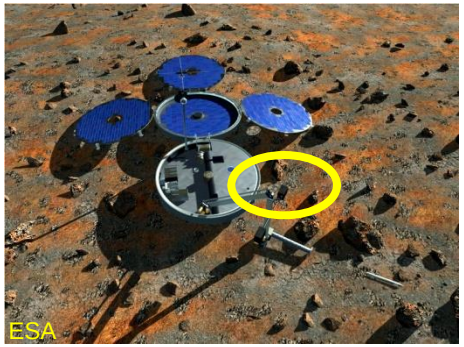
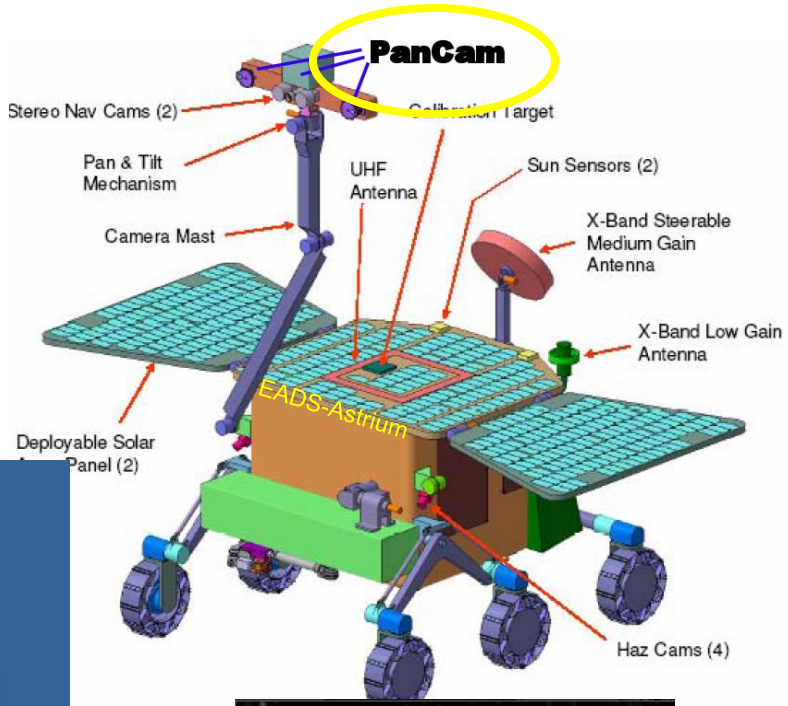
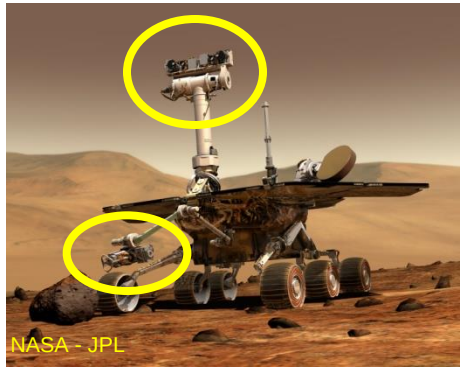
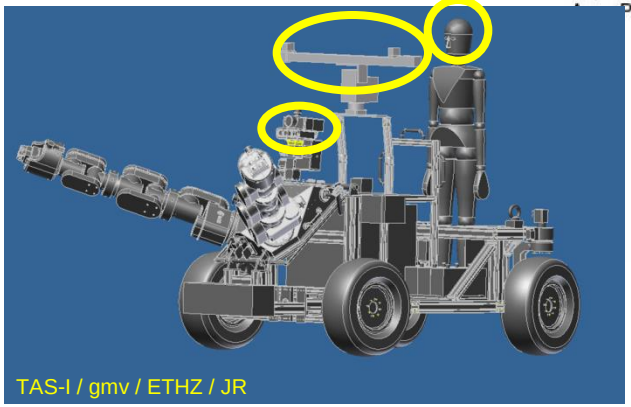
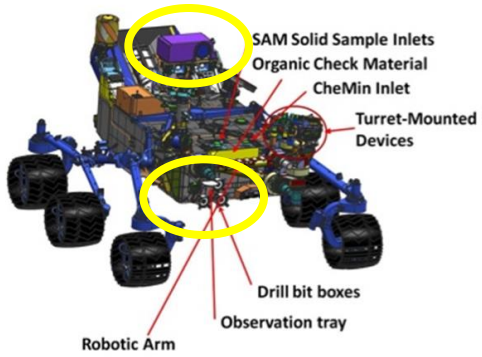
Dozens of Vision Sensors on Planets
Hundred Thousands of Images











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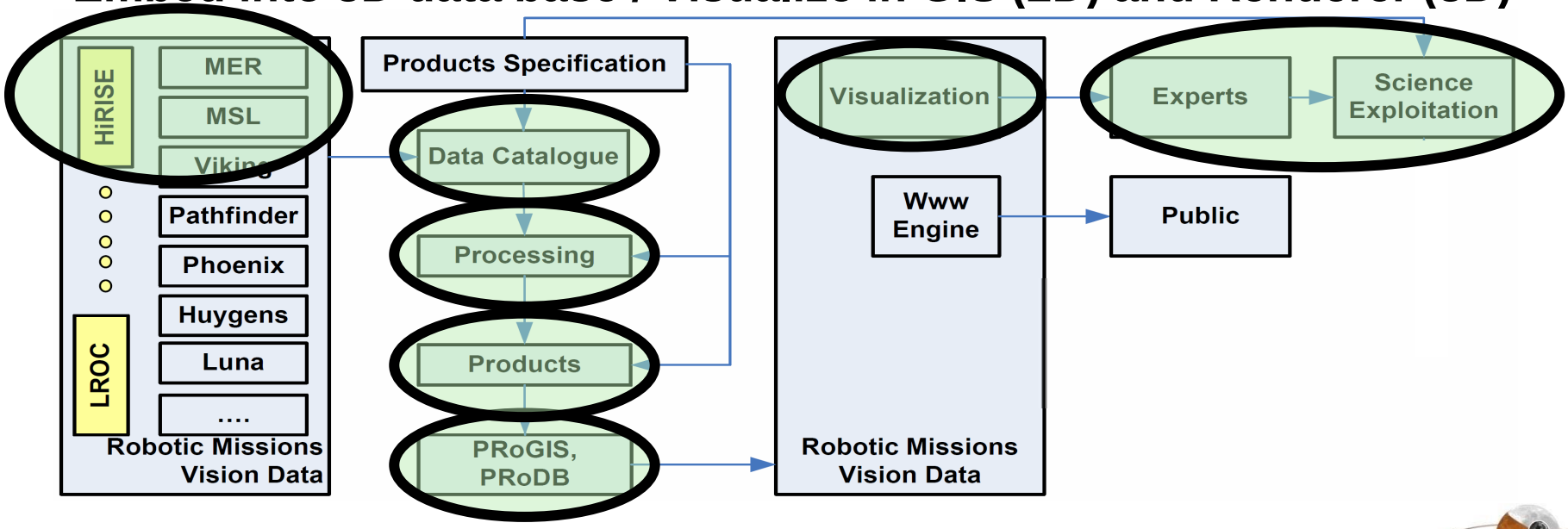
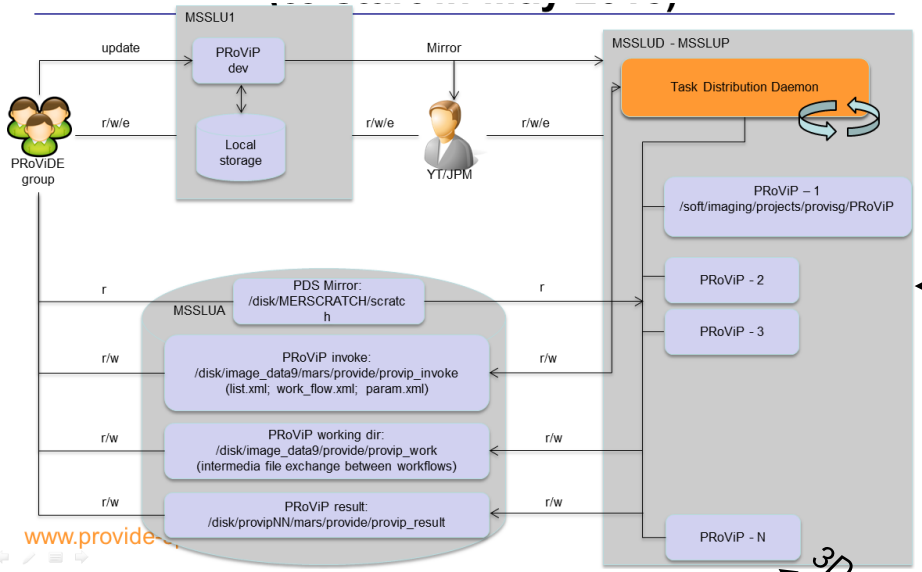
PRoViDE Objectives & Layout

- Many of the images were only processed under mission-pressure without further exploitation →
- Harvest literally all [available] Planetary surface-captured vision data
- Process in 3D Vision terms for further scientific exploitation
- Embed into 3D data base / Visualize in GIS (2D) and Renderer (3D)



Processing & Data Presentation Environment



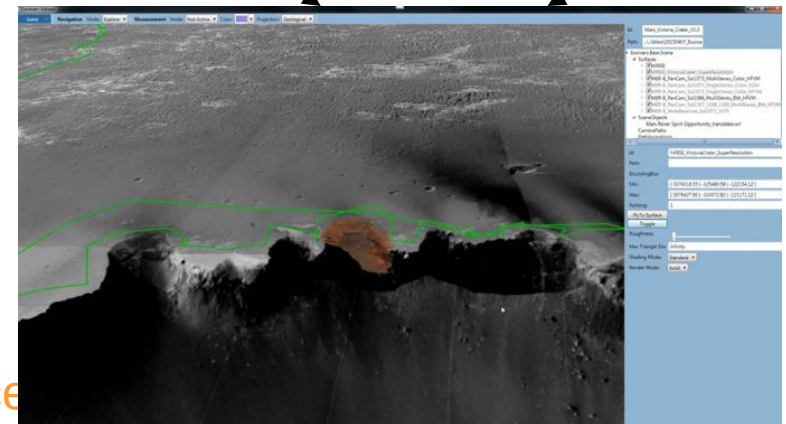
PRoViP: 3D Vision
Mass Production

Knowledge About 3D Products

PRoGIS (2D & Context)
Data Selection

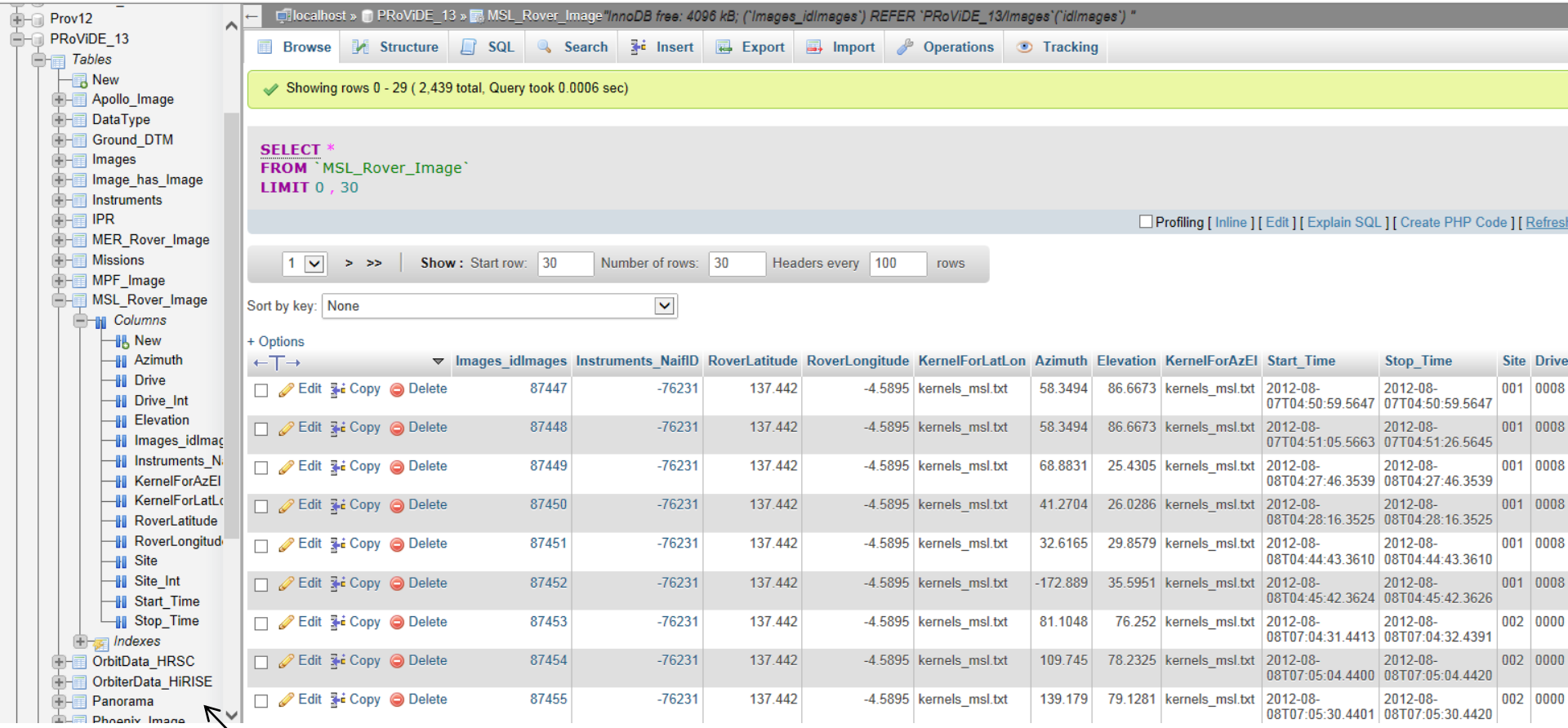
Select Products

3D Products



PRo3D (3D Geologic Assessment)

Data Base: Relevant Surface Images….



& Orbit Images

Poster Program / Attendance Tue, 29 Sep, 17:45–19:15 / Poster Area

P66 EPSC2015-291

A spatial planetary image database in the context of processing

K. Willner, E. Tasdelen and the PRoViDE project Team

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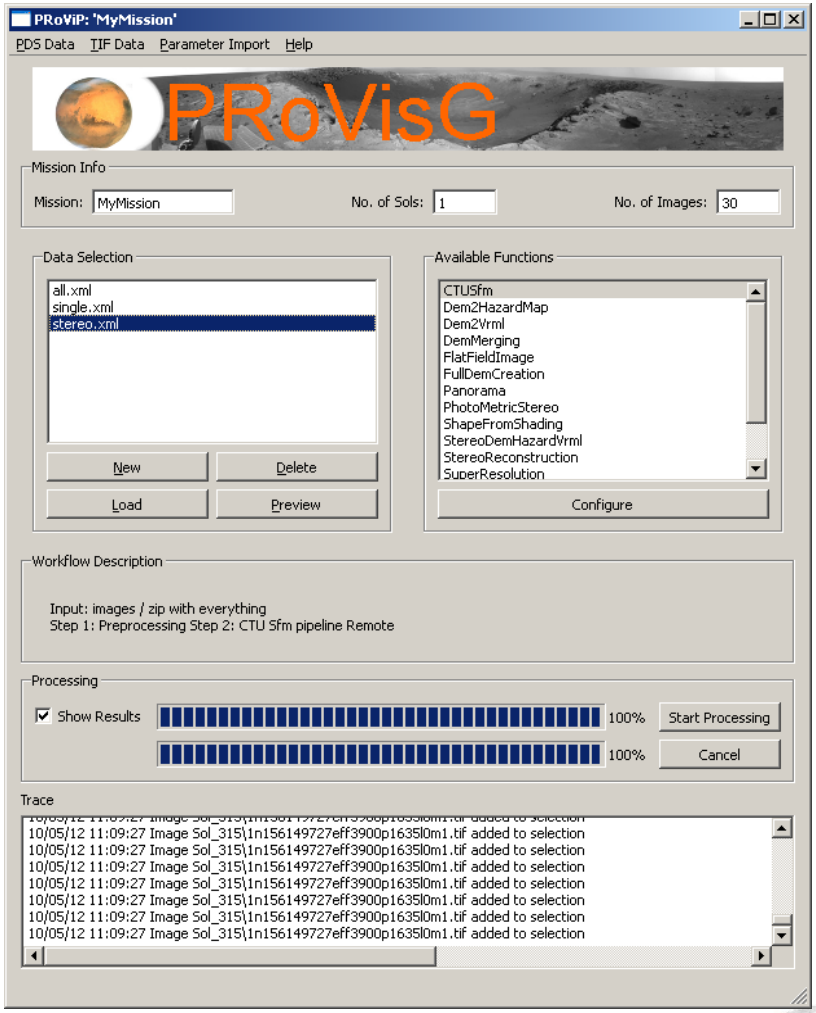
Processing Engine PRoViP

- **PRoViDE processing core**
(mainly developed during FP7-PRoVisG)
- **“Framework for planetary robotic vision processing”**

- **Integration of variety of 3D Vision algorithms (extendable)**
- **Modular processing chains (workflows / steps)**
- **Parallel processing**
- **PDS data processing / Spice kernel integrated**
- **Scheduler – based Processing directly from / to data base**

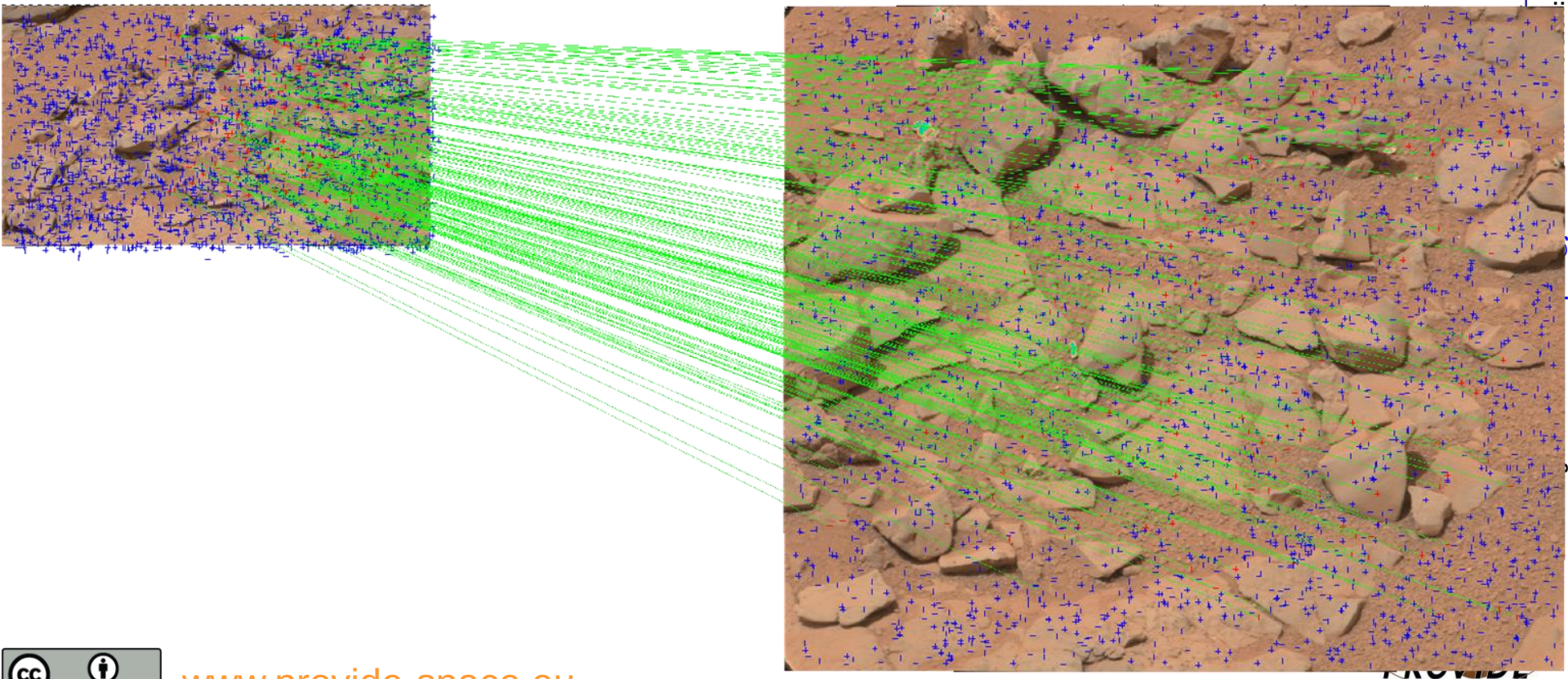


MSL Mastcam (close range) left and right Input Images Examples

- **Left**
  - **769x433 px**
- **Right**
  - **1402x1402 px**

Reconstruction Process pre-registration

- **Sparse point matching**

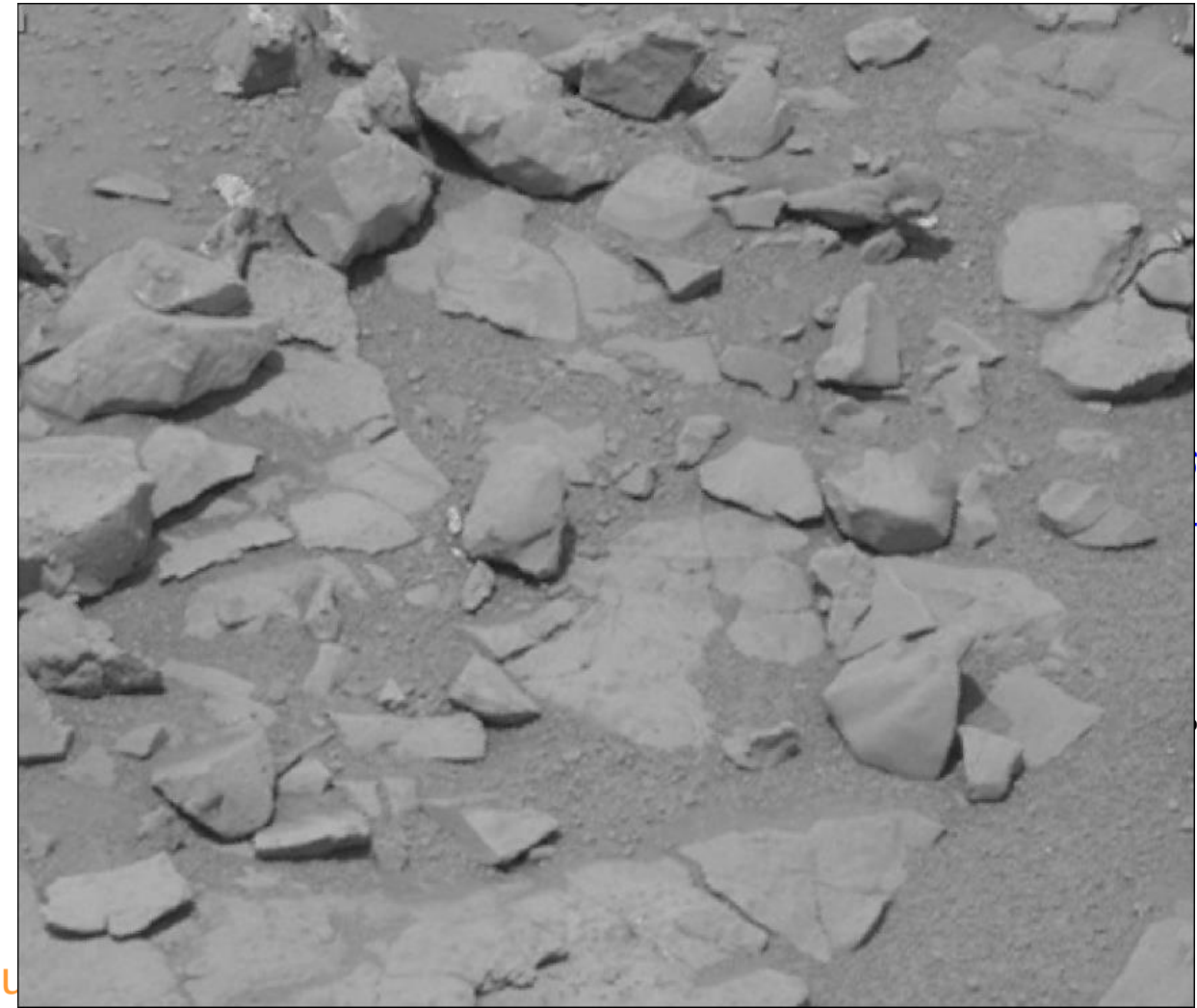


Reconstruction Process
Registration / up-scaling

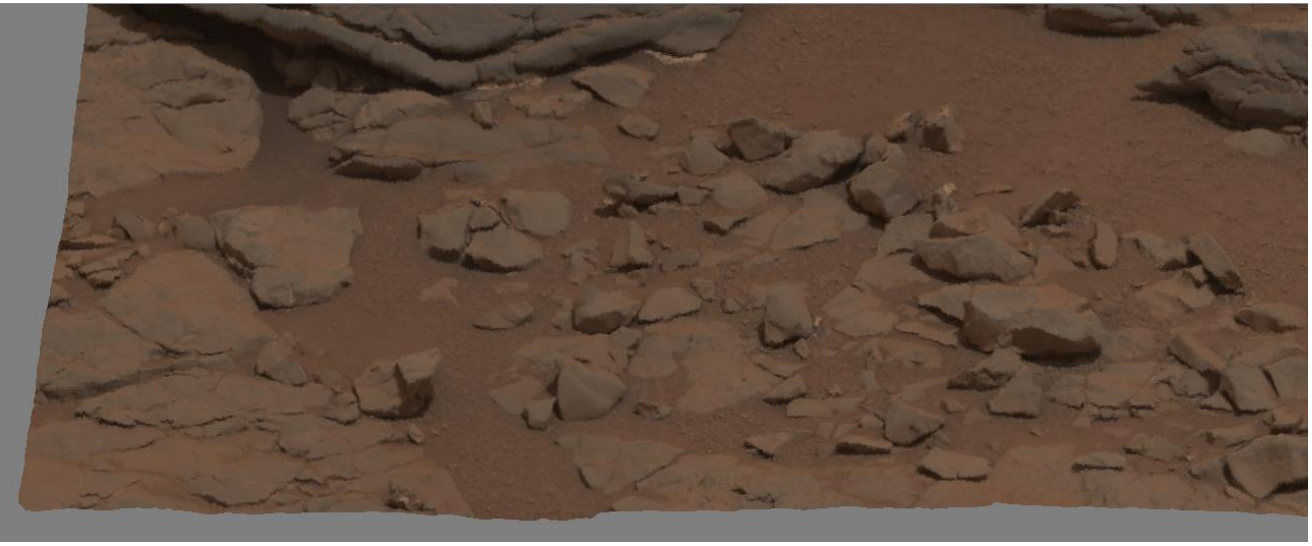
mastcam right (full image)

Reconstruction Process
Registration / up-scaling

registered mastcam left (image segment)

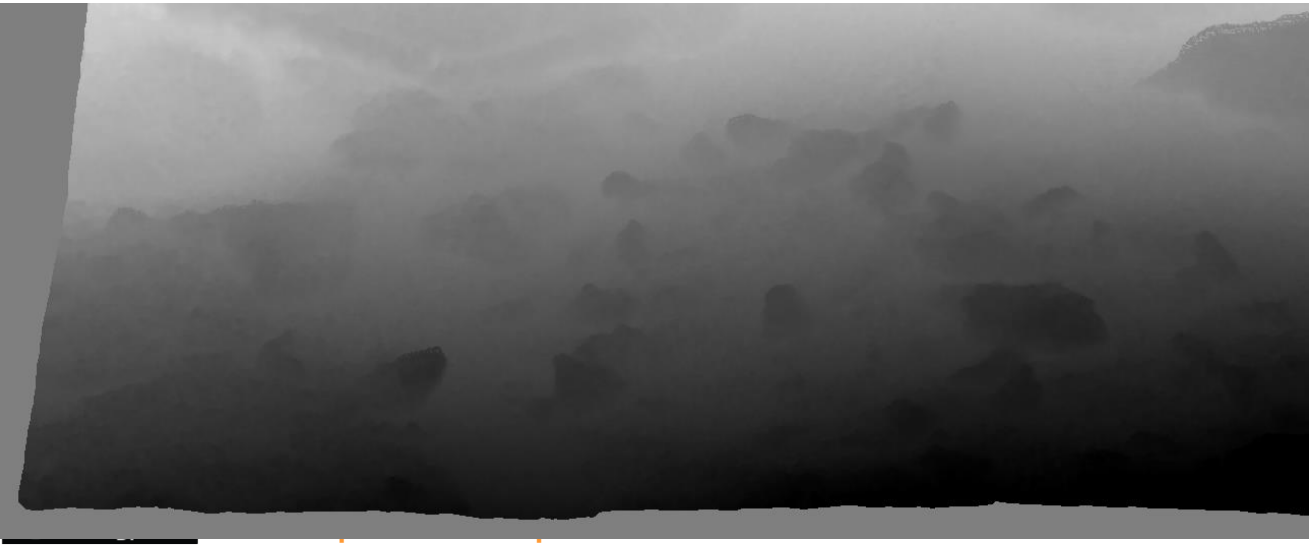


Reconstruction Process
Stereo reconstruction and mosaicking



Cutout of reconstruction

Ortho Image



DEM (Distance Map)

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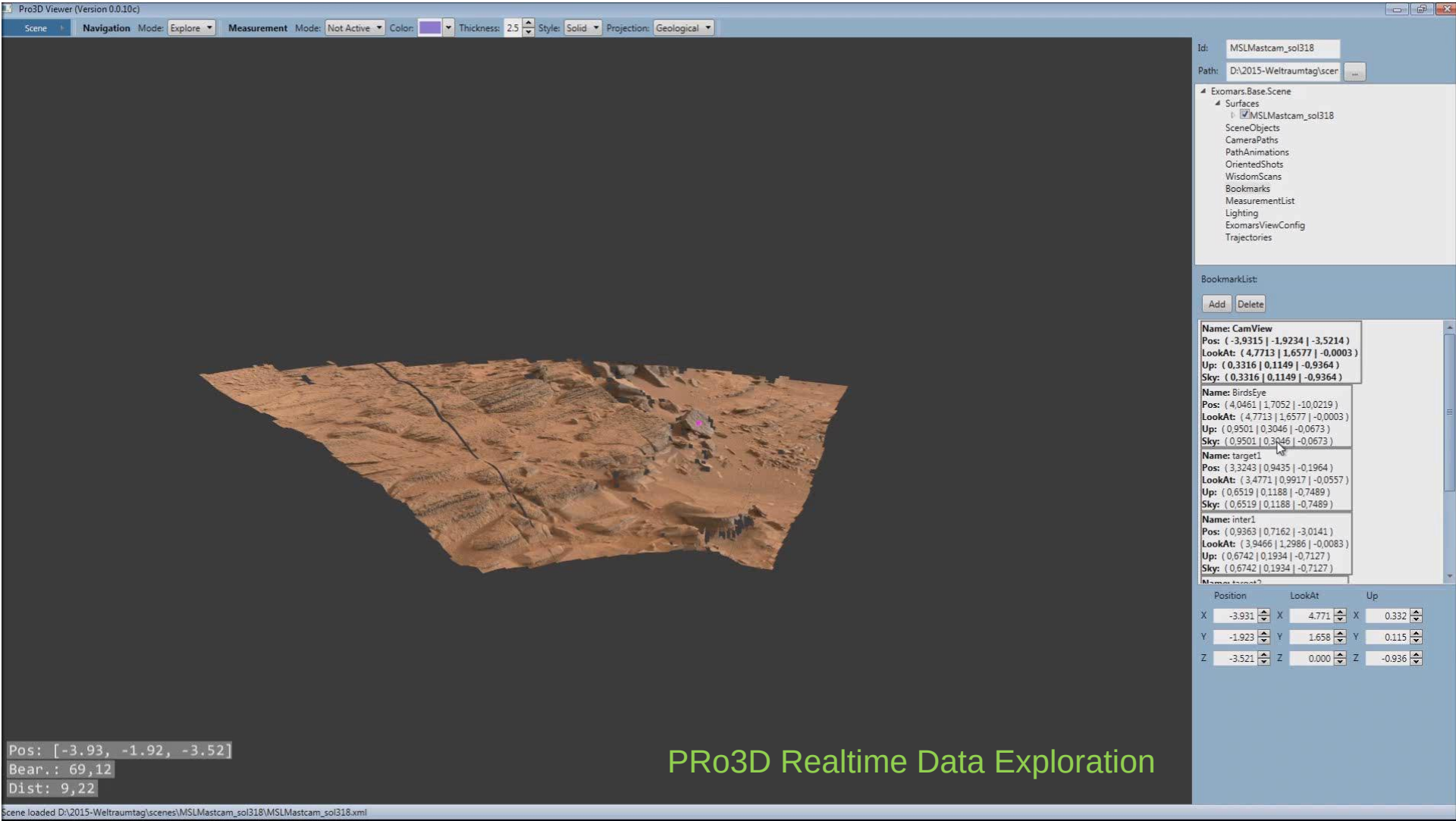
Version: 12.10.2015

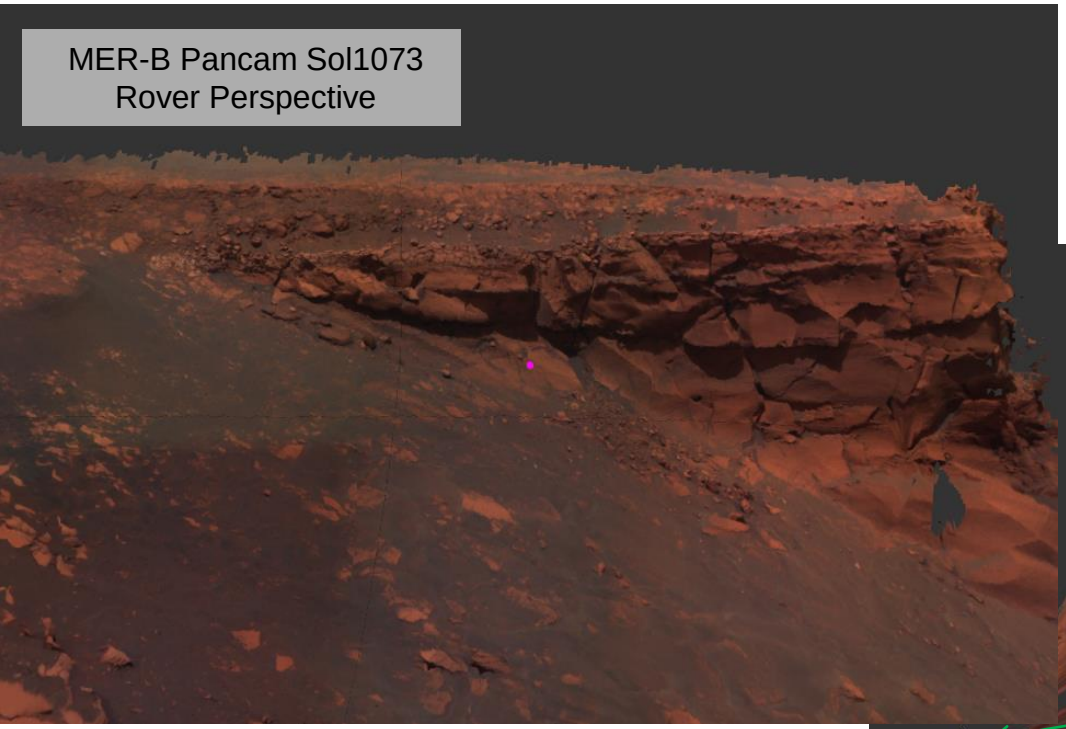
Combination of 99 Mastcam Pairs



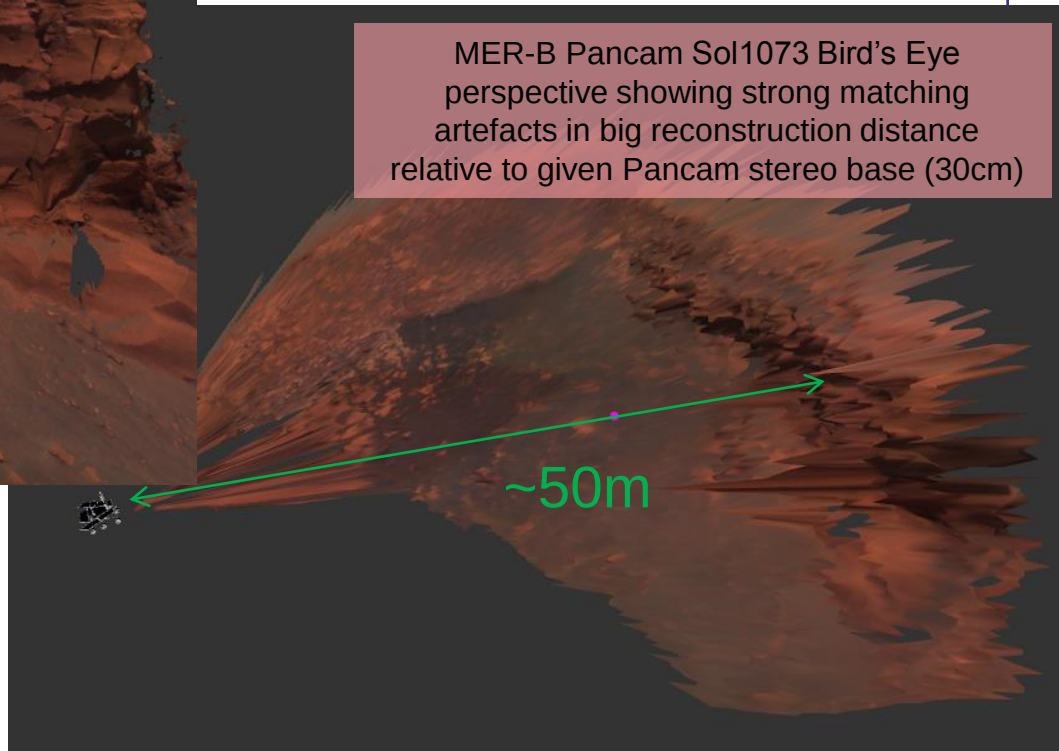
MER Pancam processing results

- Processing results using standard Pancam fixed baselength matching:
- Artefacts due to awkward stereo reconstruction geometry

MER-B Pancam Sol1073
Rover Perspective



MER-B Pancam Sol1073 Bird's Eye perspective showing strong matching artefacts in big reconstruction distance relative to given Pancam stereo base (30cm)



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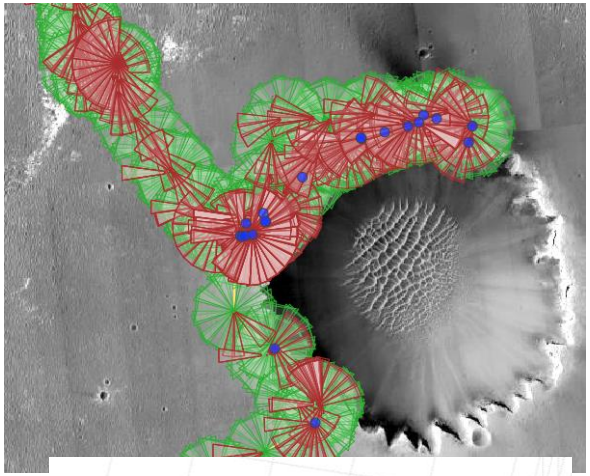
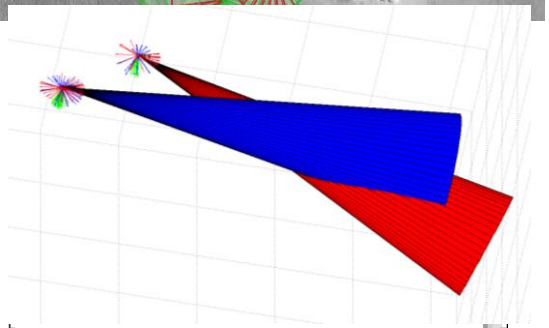
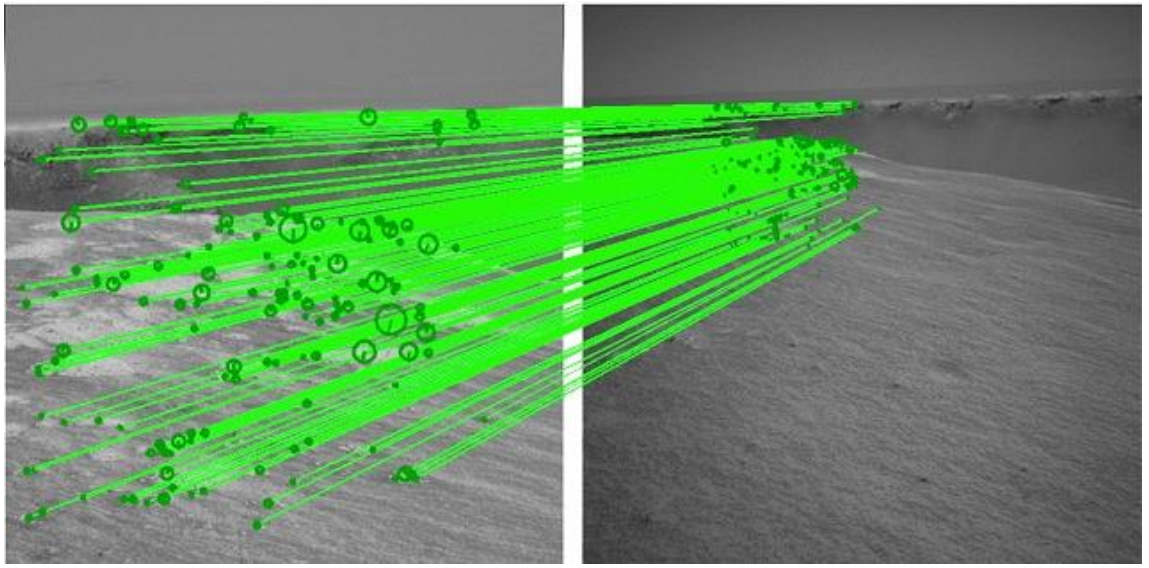
Serendipitous Stereo Pairs:
Victoria Crater – Matching overlapping views

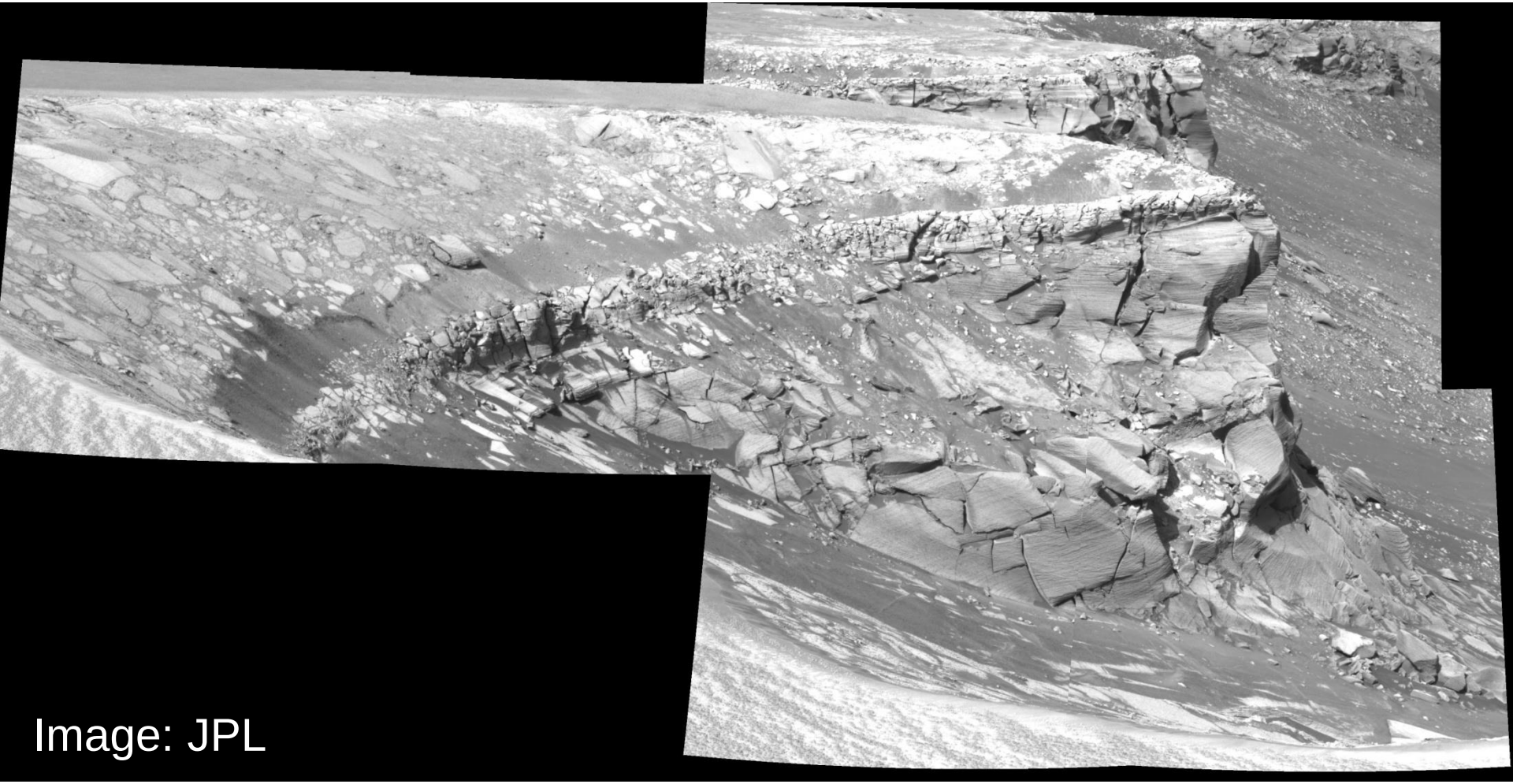




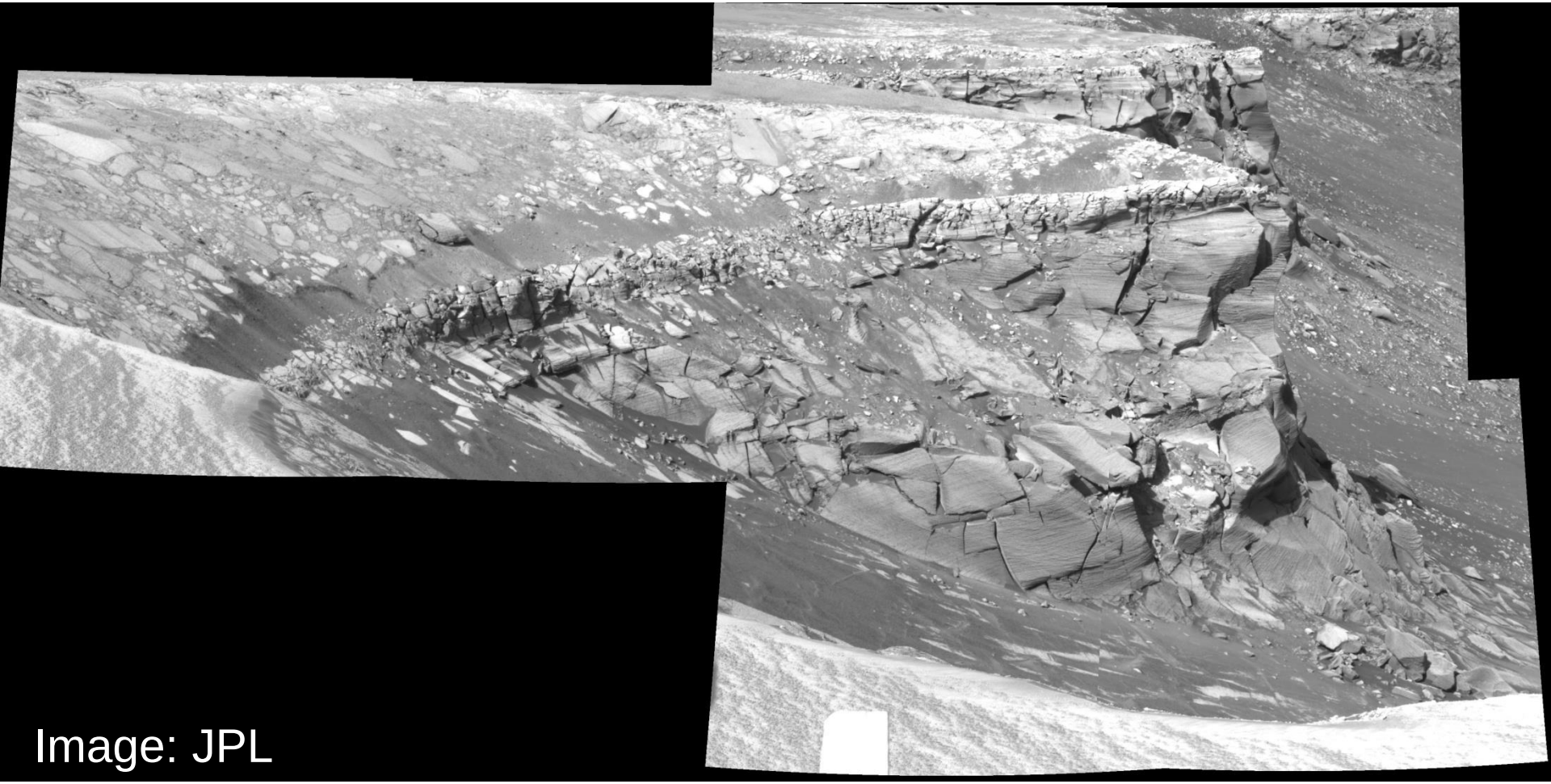


Two different data sets with a view overlap

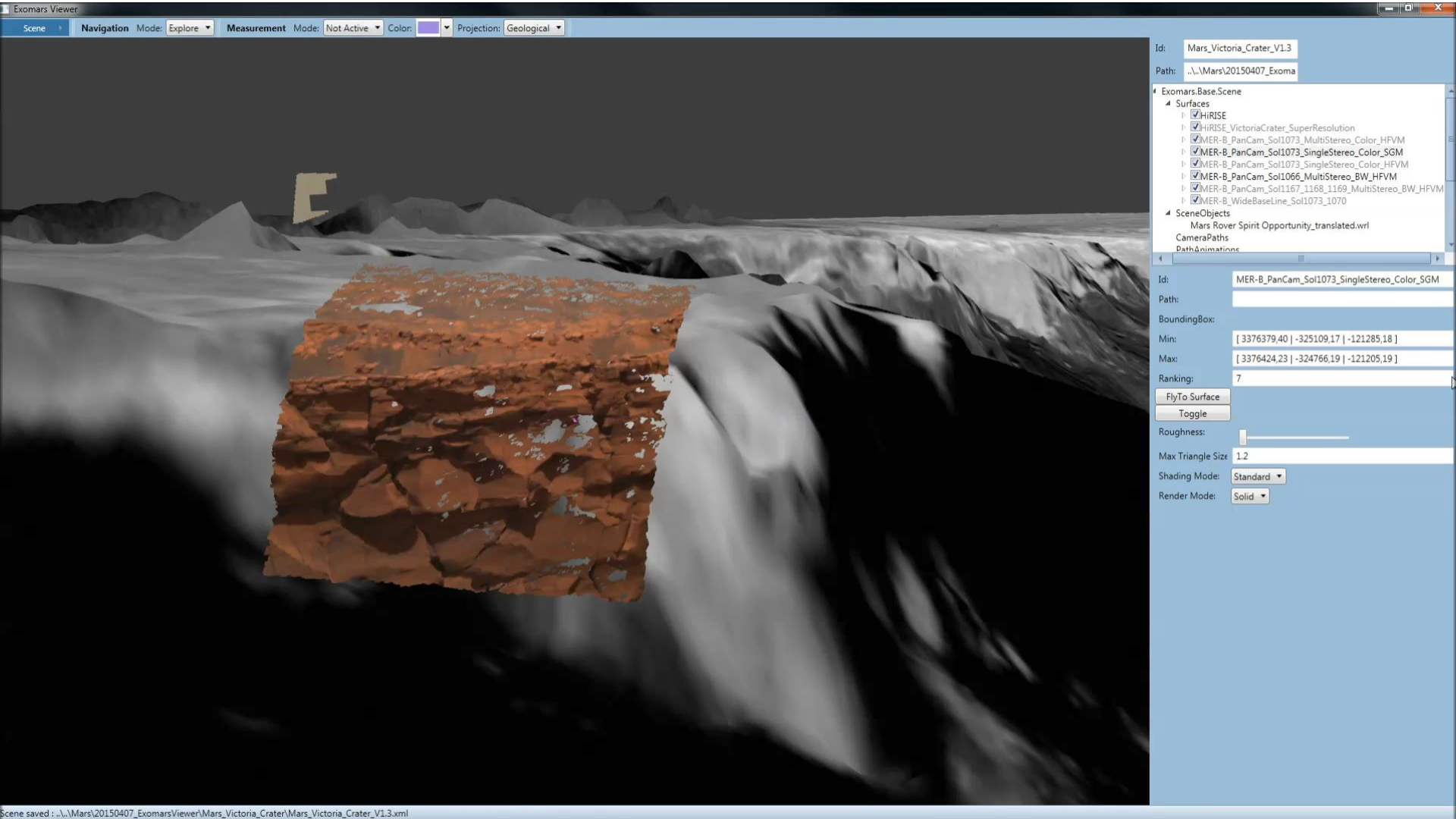
Enhancing far range quality by Wide Baselength Reconstruction:
1060/78/161 PanCam Sequence P2350



1061/78/196 PanCam Sequence P2351

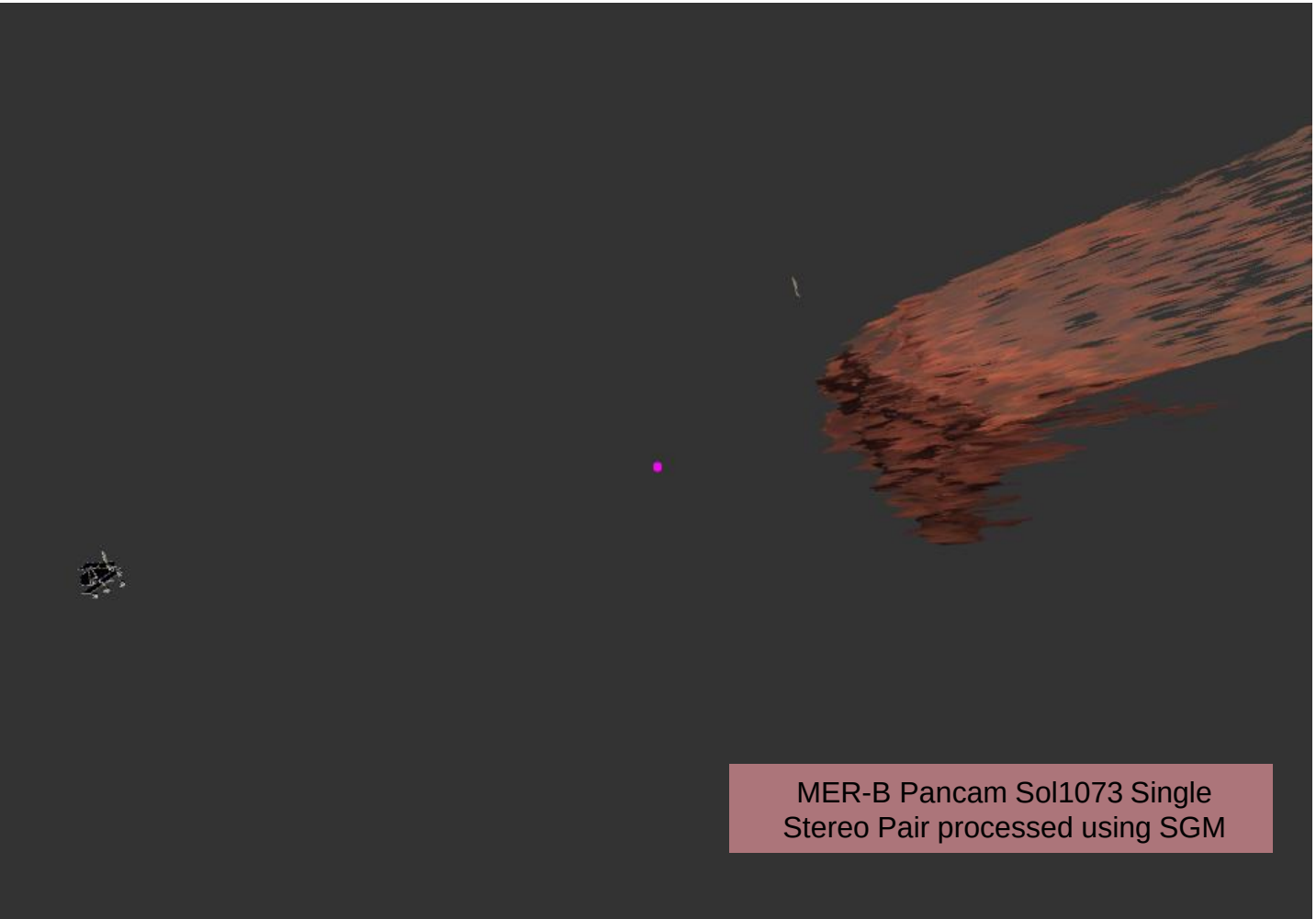


Showing Effect of Wide Baseline vs. Fixed: Changing viewpoint of fixed stereo 3D



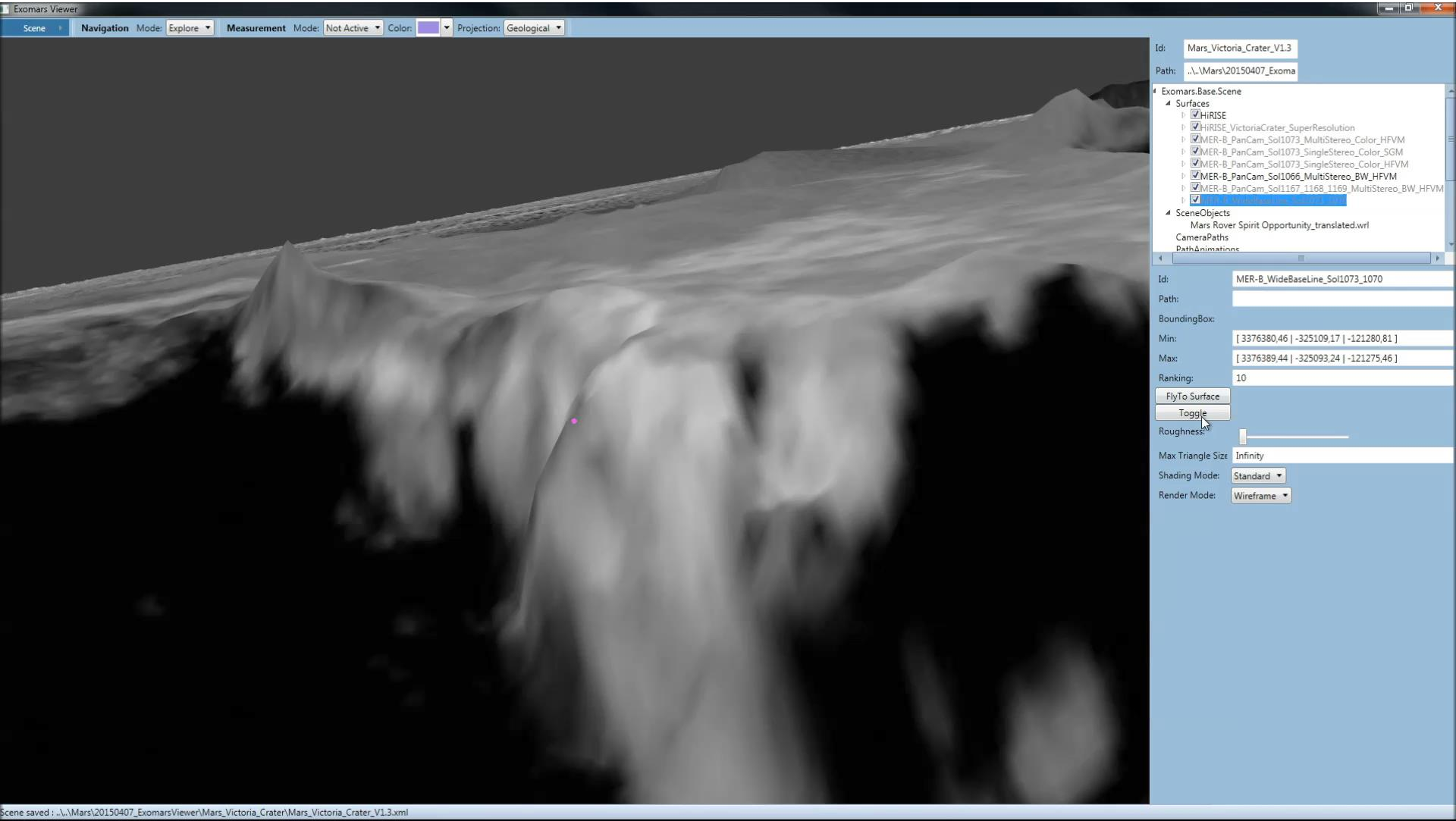
Why wide baselength ?
← MER Pancam processing results:

- Processing results using **HVFM** and **SGM** for matching



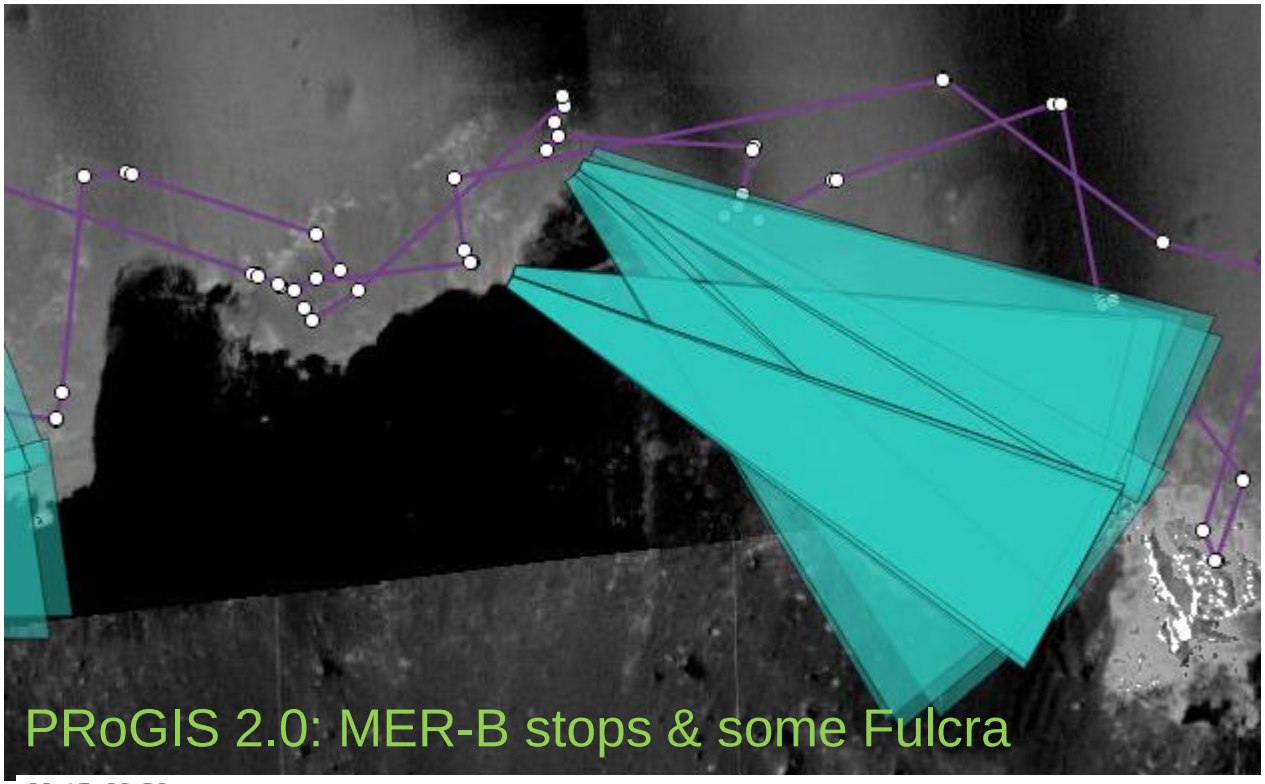
MER-B Pancam Sol1073 Single Stereo Pair processed using SGM

Wide Baseline: Usable for Geologic Assessment



Data Fusion: HiRISE / MER

- **HiRISE registered into unique MarsExpress HRSC Geometry**
- **MER Positions brought into same Context**



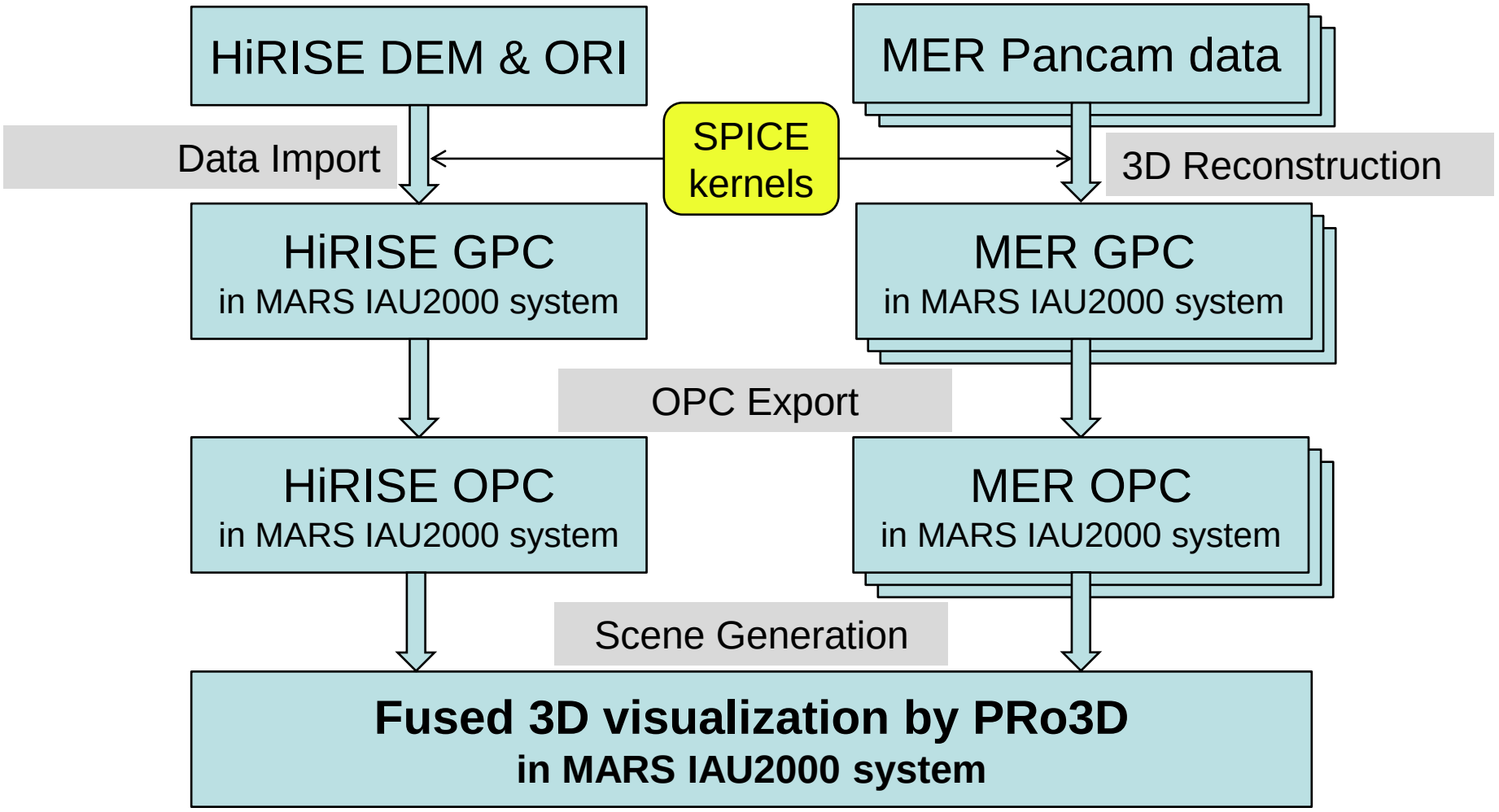
UCL: Muller & Tao

09:15–09:30 09:45–10:00 EPSC2015-359

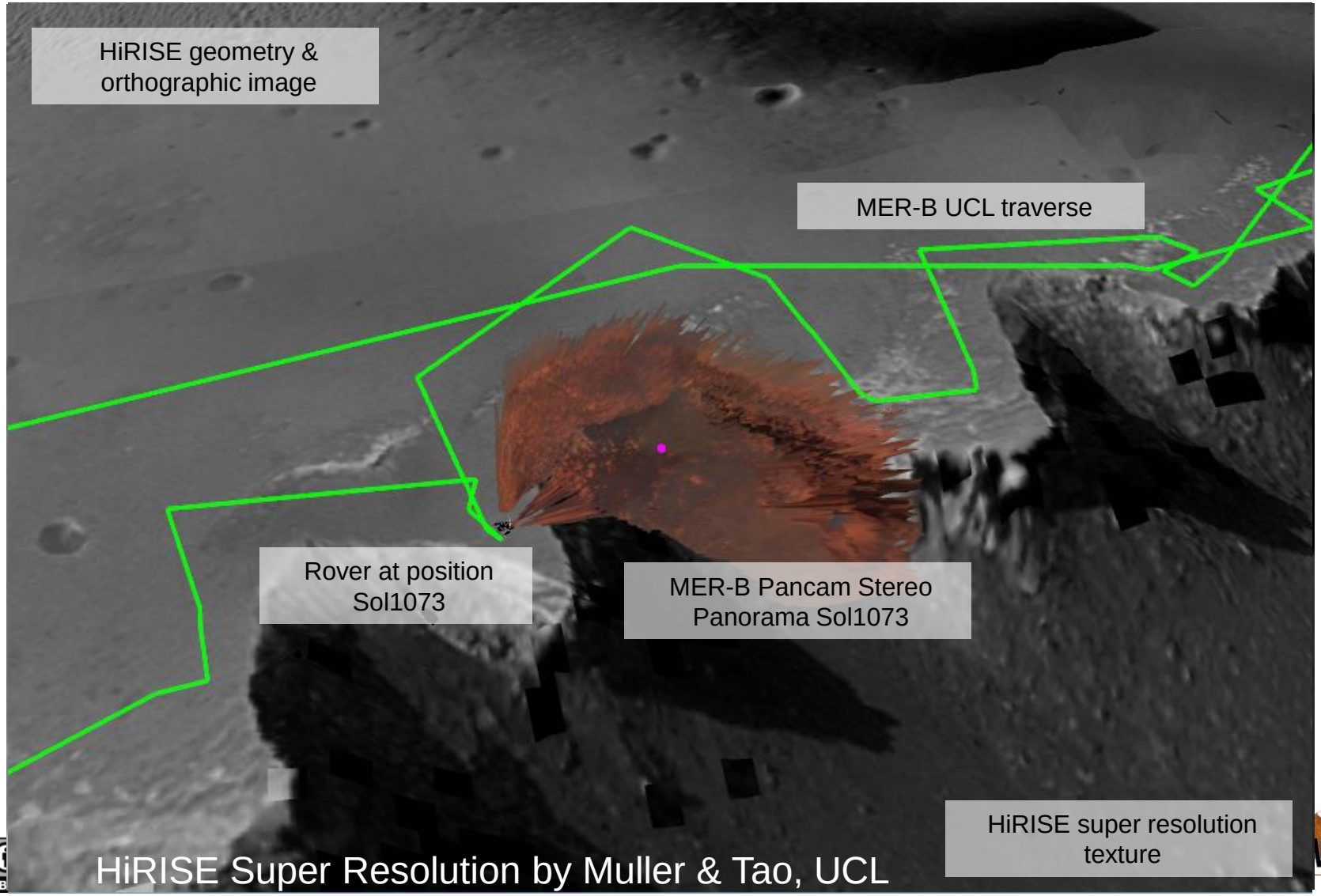
Towards a better understanding of Martian surface processes: zooming in for a quantitative assessment of key geomorphological features from super-resolution HiRISE images in comparison to overlapping rover Navcam image

Y. Tao and J.-P. Muller

Overall Workflow of fusion



Coregistration & Fusion result



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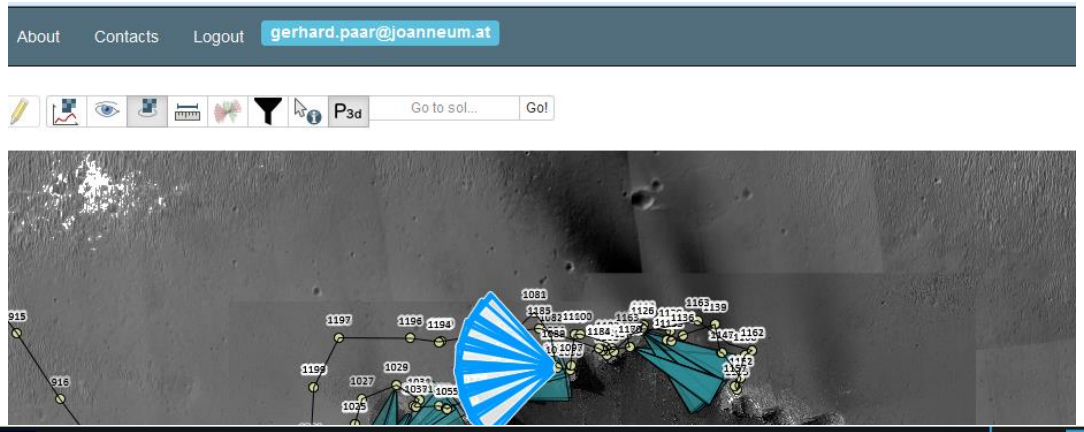
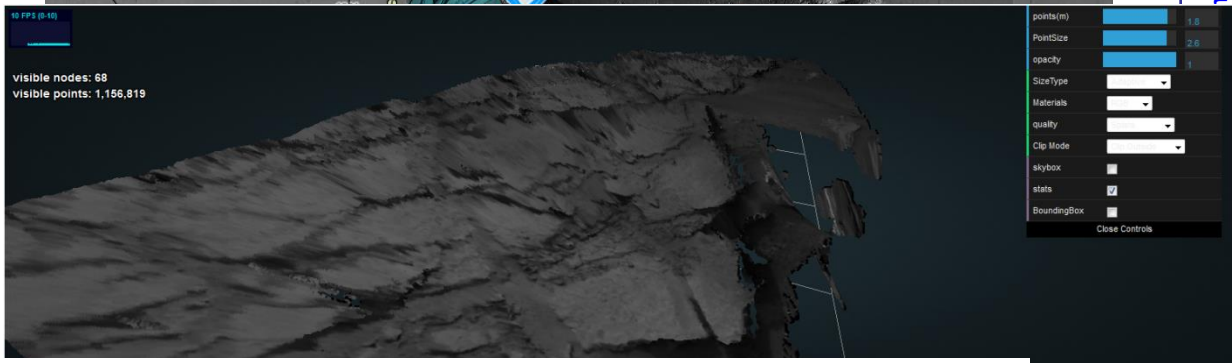
The PRoViDE Workflow

- Select 3D Vision Data Product from PRoGIS
- Visualize / Analyse in PRoGIS
- Open PRo3D Viewer via Remote Rendering (Ortner 11:30)
- Perform Geological Analysis (Barnes 11:45)





11:30–11:45 EPSC2015-23

PRo3D – a tool for remote exploration and visual analysis of multi-resolution planetary terrains

C. Traxler, G. Hesina, and *T. Ortner*

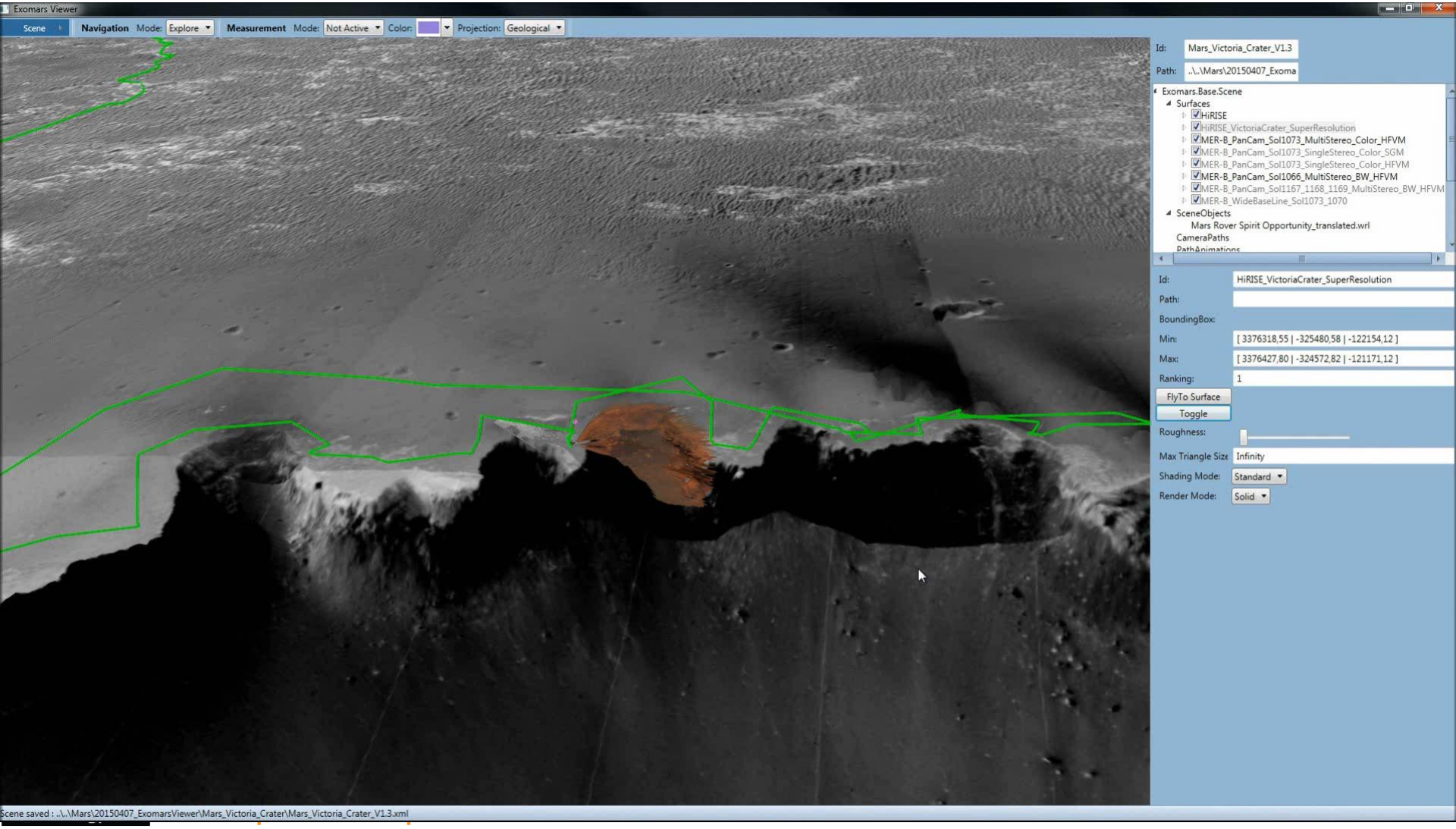
11:45–12:00 EPSC2015-375

Geological interpretation and analysis of surface based, spatially referenced planetary imagery data using PRoGIS 2.0 and Pro3D.

R. Barnes, S. Gupta, M. Giordano, J.G. Morley, J.P. Muller, Y. Tao, J. Sprinks, C. Traxler, G. Hesina, T. Ortner, K. Sander, B. Nauschnegg, G. Paar, K. Willner, and T. Pajdla

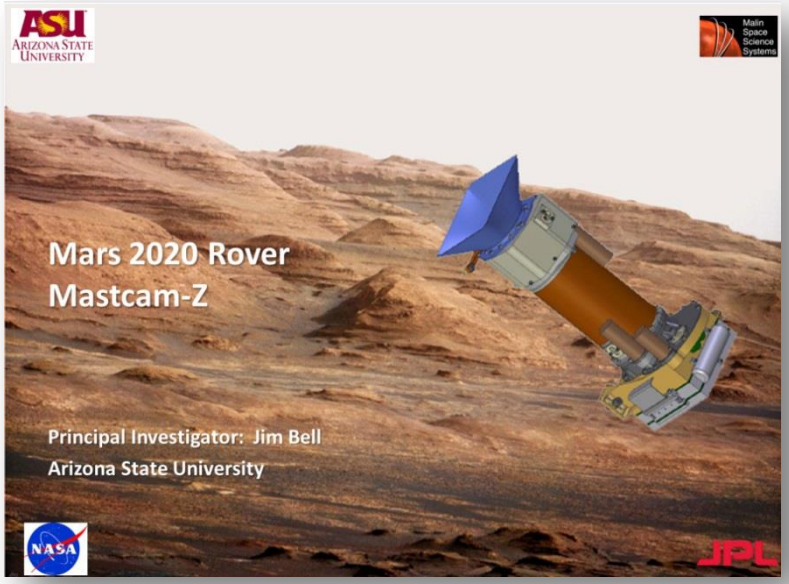
Version: 12.10.2015

PRo3D: Embedding in full context of HiRISE DEM:Tens of Gbytes of data / scene

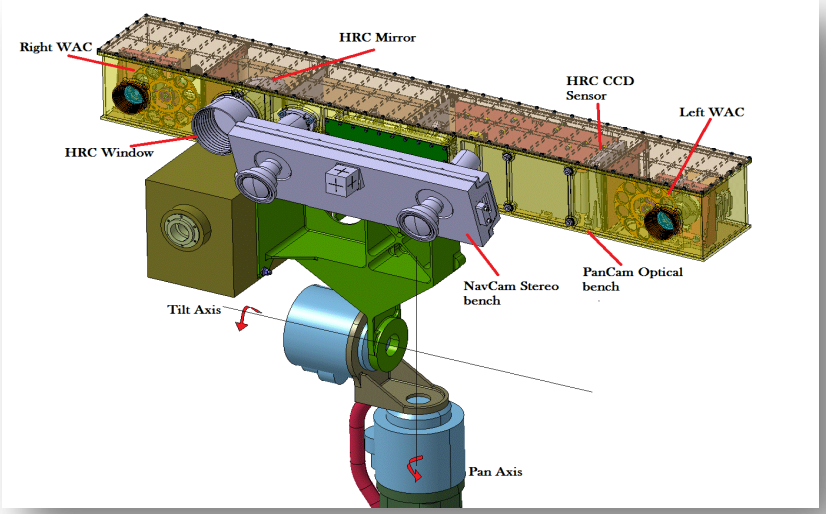


Further Exploitation of PRoViP / PRo3D

- **NASA Mars 2020 Mastcam-Z**

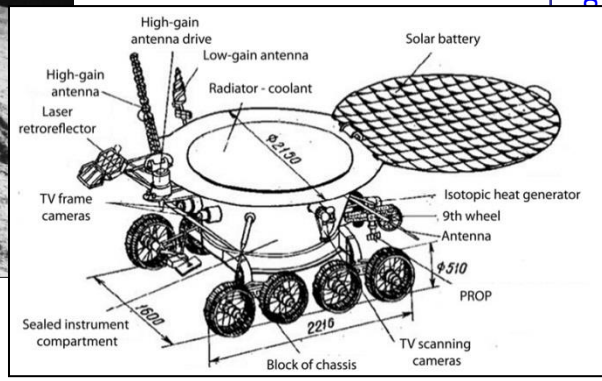


- **ExoMars PanCam**



And the Moon…

- Lunar surface data processing (new orbital images and rover's archive panoramas);
- Science exploitation of lunar data;
- Lunar data import engine;
- Access to Lunar data via MExLab Planetary Geoportal.



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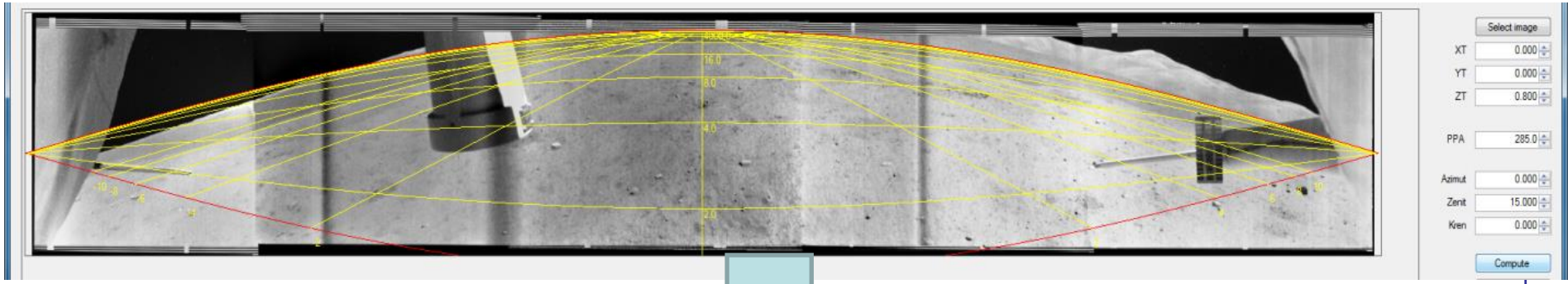
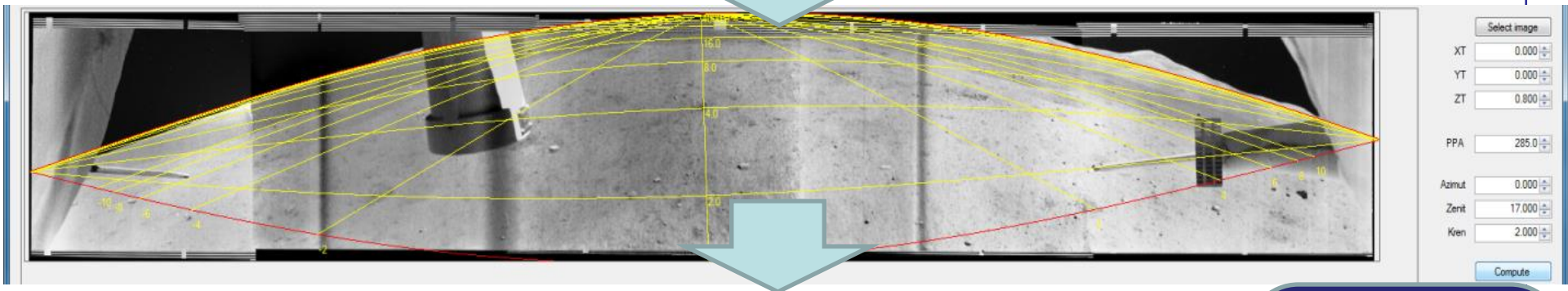
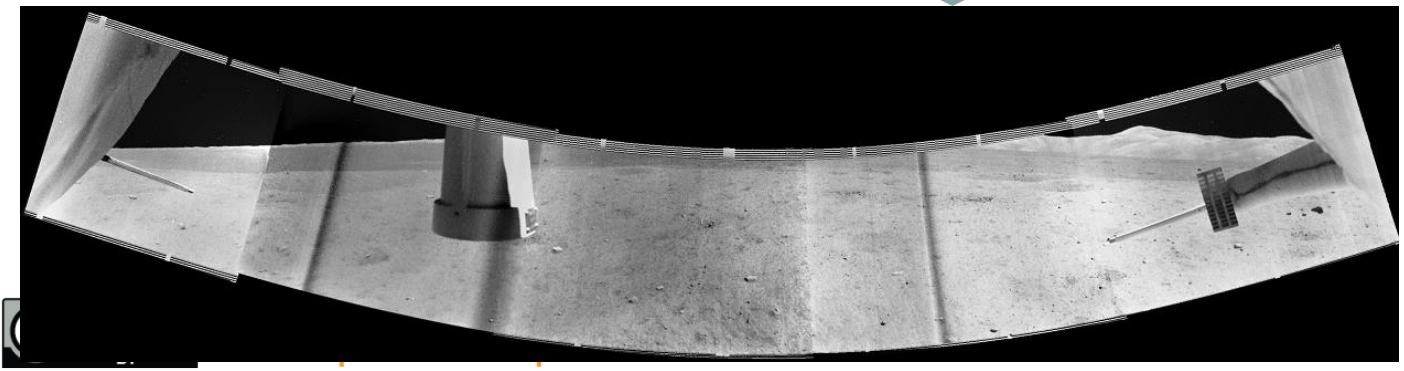
Lunar rovers and archive panoramas: Past for the Future

N. Kozlova, A. Zubarev, A. Solodovnikova, Yu. Rybakin, A. Garov, A. Abdrakhimov, and I. Karachevtseva

Determination of Lunokhod tilts and geometric corrections



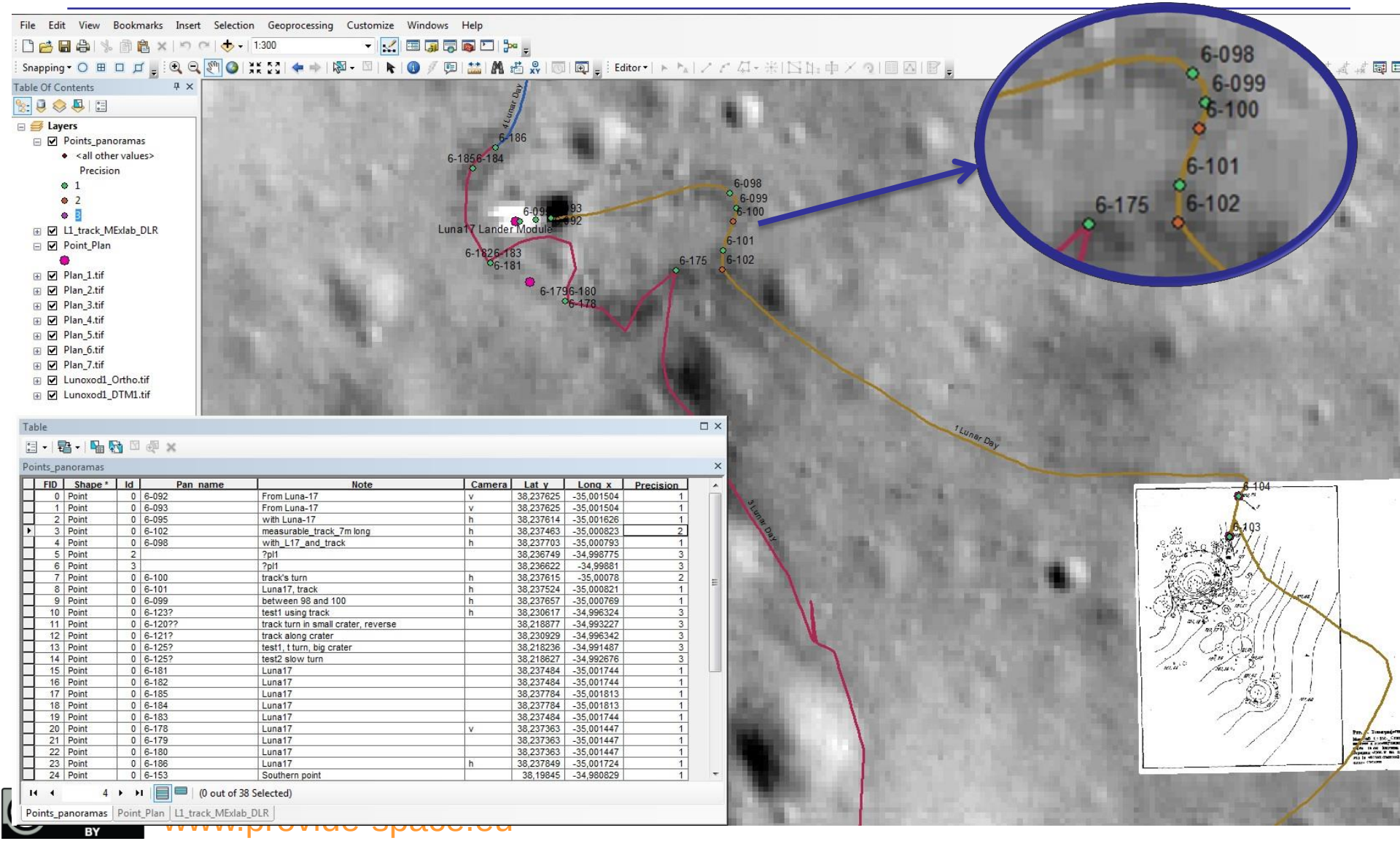




Horizontal and vertical tilts

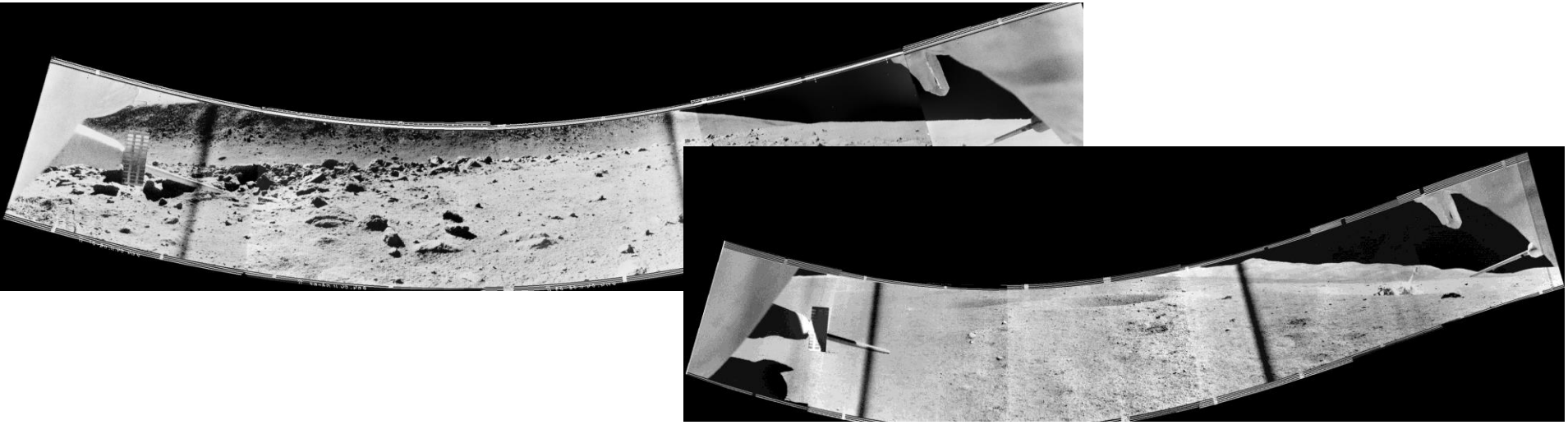
Principal point in the image

Determination of observation points in ArcGIS



FID	Shape *	Id	Pan_name	Note	Camera	Lat_y	Long_x	Precision
0	Point	0	6-092	From Luna-17	v	38,237625	-35,001504	1
1	Point	0	6-093	From Luna-17	v	38,237625	-35,001504	1
2	Point	0	6-095	with Luna-17	h	38,237614	-35,001626	1
3	Point	0	6-102	measurable_track_7m long	h	38,237463	-35,000823	2
4	Point	0	6-098	with_L17_and_track	h	38,237703	-35,000793	1
5	Point	2		?pl1		38,236749	-34,998775	3
6	Point	3		?pl1		38,236622	-34,99881	3
7	Point	0	6-100	track's turn	h	38,237615	-35,00078	2
8	Point	0	6-101	Luna17, track	h	38,237524	-35,000821	1
9	Point	0	6-099	between 98 and 100	h	38,237657	-35,000769	1
10	Point	0	6-123?	test1 using track	h	38,230617	-34,996324	3
11	Point	0	6-120??	track turn in small crater, reverse		38,218877	-34,993227	3
12	Point	0	6-121?	track along crater		38,230929	-34,996342	3
13	Point	0	6-125?	test1, t turn, big crater		38,218236	-34,991487	3
14	Point	0	6-125?	test2 slow turn		38,218627	-34,992676	3
15	Point	0	6-181	Luna17		38,237484	-35,001744	1
16	Point	0	6-182	Luna17		38,237484	-35,001744	1
17	Point	0	6-185	Luna17		38,237784	-35,001813	1
18	Point	0	6-184	Luna17		38,237784	-35,001813	1
19	Point	0	6-183	Luna17		38,237484	-35,001744	1
20	Point	0	6-178	Luna17	v	38,237363	-35,001447	1
21	Point	0	6-179	Luna17		38,237363	-35,001447	1
22	Point	0	6-180	Luna17		38,237363	-35,001447	1
23	Point	0	6-186	Luna17	h	38,237849	-35,001724	1
24	Point	0	6-153	Southern point		38,19845	-34,980829	1

Science exploitation of archive panoramas



The geologic description of panoramas includes next characteristics:

1) The general description of terrain around - mare, highland.
2) Characteristics of environment: characteristics of relief, such as flat smooth plains, or rugged terrain.
3) Prominent geologic objects - big craters, mountains, large rock fragments.
4) The description of neighboring craters, including their size, class, type.
5) The description of rock fragments, including their size, class, type.
6) The description of the ground, including their structure, the characteristics of rover tracks.

References:

Karachevtseva I., Kozlova N., Nadezhdina I., Zubarev A., Abdrakhimov A., Basilevsky A., and Oberst J. New processing of Luna archive panoramas and geologic assessment of the Lunokhod landing sites // European Planetary Science Congress, London, United Kingdom, [EPSC2013-532], September 08-13, 2013. http://meetingorganizer.copernicus.org/EPSC2013/EPSC2013-532.pdf

Abdrakhimov A., Basilevsky A., Karachevtseva I. Geological review of Lunokhod-1 area // 4M-S3, IKI RAS, Moscow, Russia, 14-18 October 2013.

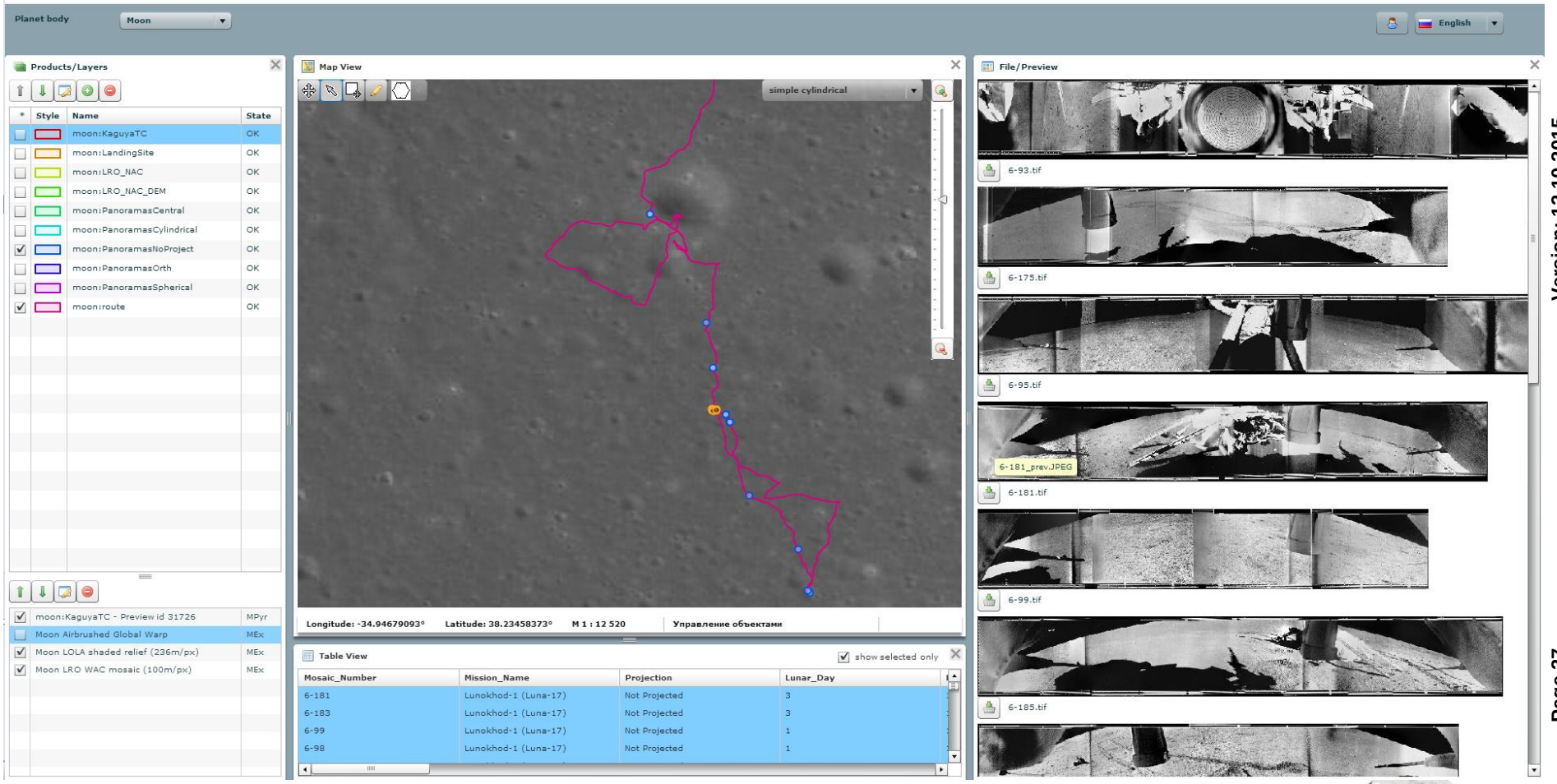
Access to Lunar archive data via Geoportal

Planetary Geoportal

MIIGAiK Extraterrestial Laboratory (MExLab)

Moscow State University of Geodesy and Cartography (MIIGAiK)

Geodesy and Cartography Node



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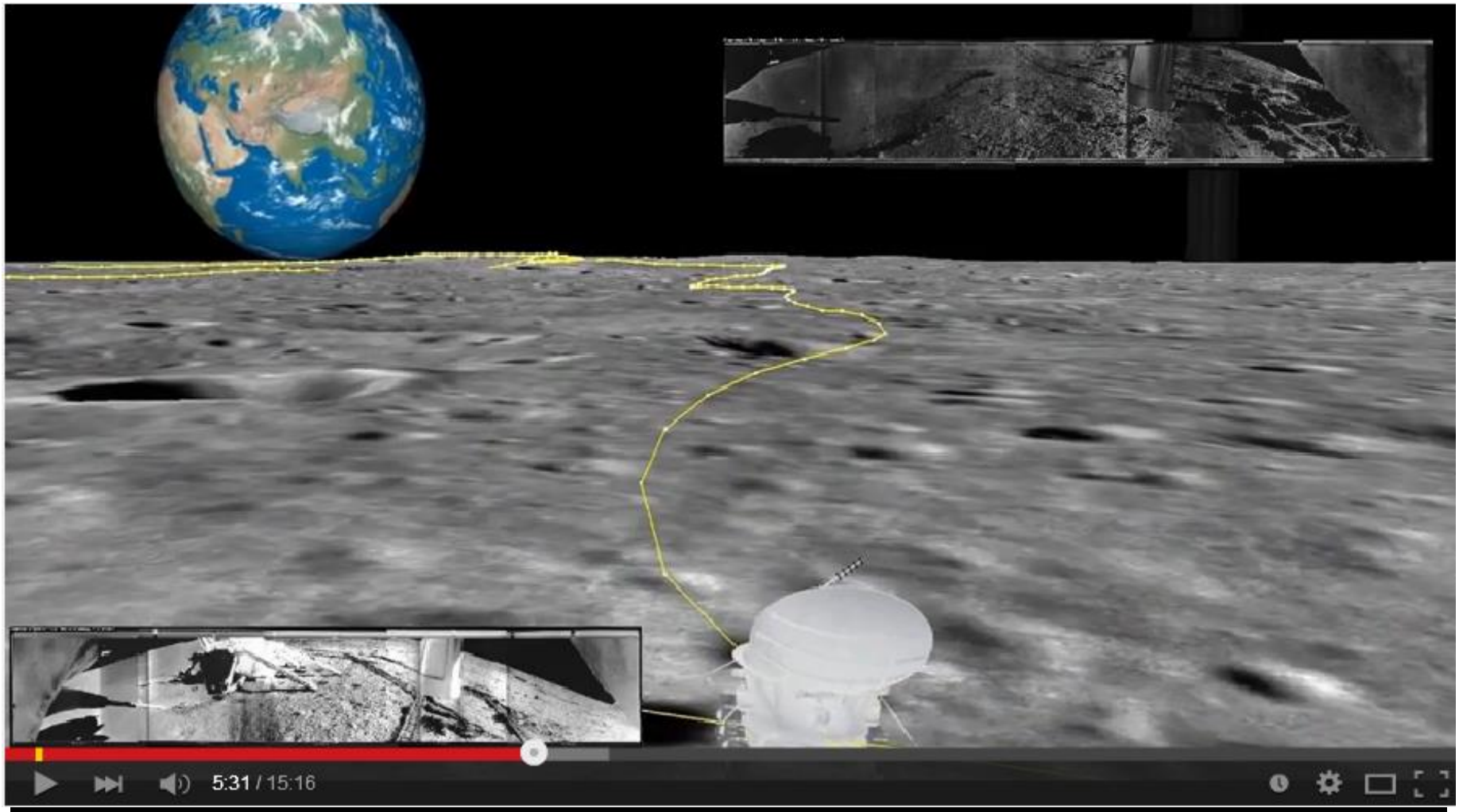
P68 EPSC2015-804

MExLab Planetary Geoportal: 3D-access to planetary images and results of spatial data analysis

I. Karachevtseva and A. Garov

Lunokhod-1 journey on Youtube



https://www.youtube.com/watch?v=QXKkmpsWPuQ

Wrapup: PRoViDE Innovations into Planetary Science Community

- Surface Image 3D Batch Processing, based on Scheduler / processing everything in Data Base directly from PDS
- MSL Mastcam processed 1st time fully in batch
- PRoGIS 2.0: 2.5 D GIS for pre-assessment
- Lunokhod Image Data & Web Portal
- PRo3D: 3D Geologic Assessment / Remote Rendering
- Fusion Satellite & Rover 3D Data / Super Resolution
- Serendipitous stereo / wide baselength stereo / multistereo
- FIRST INTEGRATED AUTOMATIC PROCESSING / DATA BASE / GIS / 3D RENDERING SYSTEM FOR PLANETARY SCIENCE

Dealing with Data & Software only…

SMW1.8

Demonstration - Zooming in-and-out of Mars: new tools to interact with multi-resolution Mars datasets (public)

Wed, 30 Sep, 16:00–17:30 / Room Mars

Convener: K. Willner

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