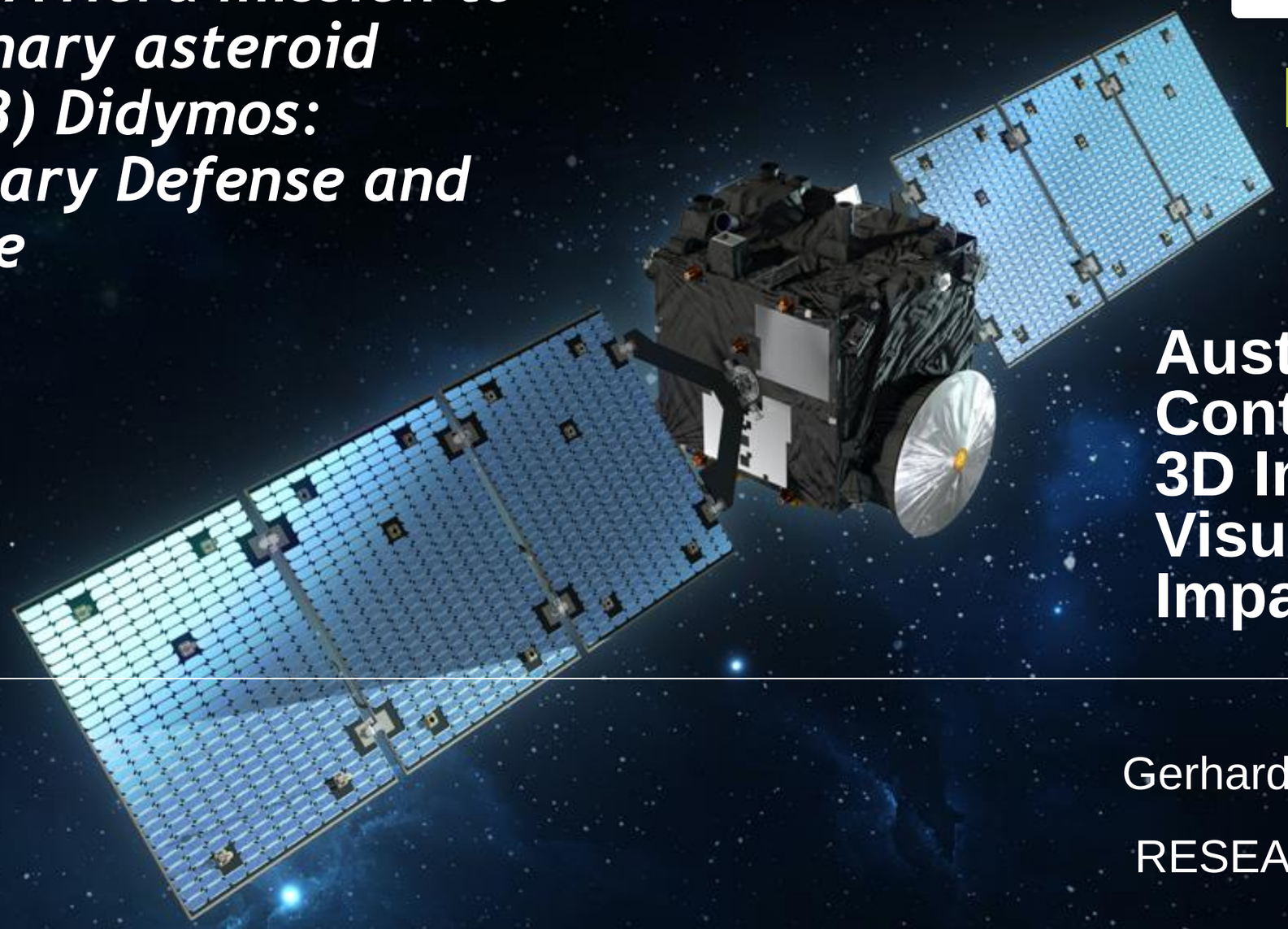
The ESA Hera mission to the binary asteroid (65803) Didymos: Planetary Defense and Science



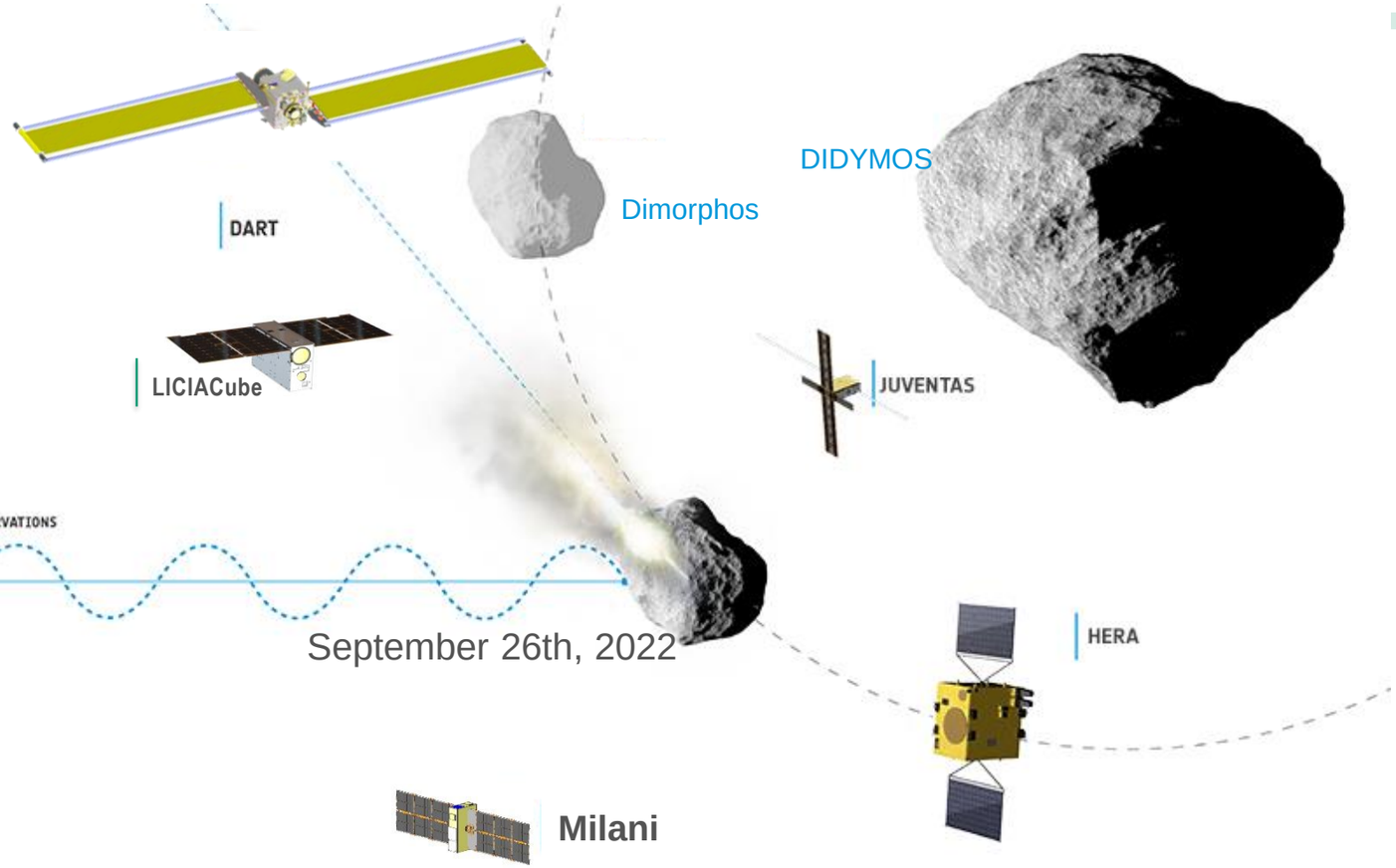
Austrian Contribution: 3D Imaging & Visualization; Impact Science

Gerhard Paar, JOANNEUM RESEARCH, Graz, Austria

Contains slides provided by: Michael Küppers, Patrick Michel, Stephan Ulamec, Alan Fitzsimmons, Simon Green, Monica Lazzarin, Ian Carnelli, Paolo Martino and the The Hera Science Team

AIDA international collaboration

November 23, 2021 at 10:20 pm pacific time



AIDA

Synergy from

First demonstration of asteroid deflection by kinetic impact on Dimorphos, to change its orbit

with

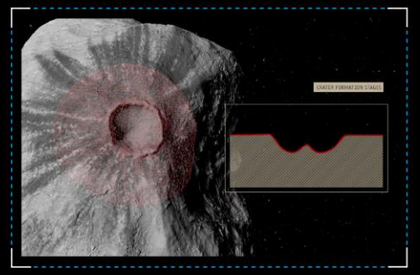
LICIACube

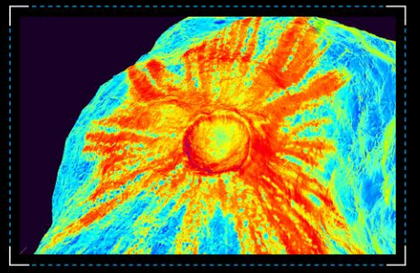
First prompt imaging of the impacted surface, ejecta plume evolution and of the non-impacted hemisphere of Dimorphos

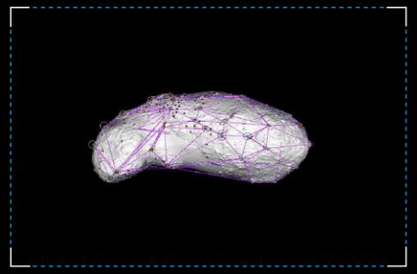
+

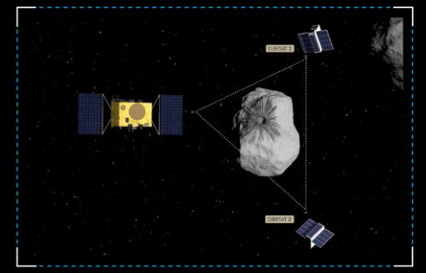
Mass of Dimorphos
Detailed dynamical characterization
Detailed investigation of final crater
Overall characterization of the asteroids

Hera mission scenario









08/10 2024
HERA LAUNCH

October 2024

DETAILED CRATER SHAPE INVESTIGATION

DETAILED SUBSURFACE CRATER INVESTIGATION

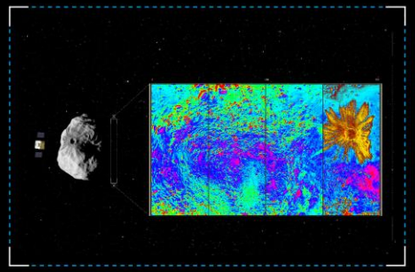
AUTONOMOUS PROXIMITY OPERATIONS DEMONSTRATION

MULTI-POINT ASTEROID INVESTIGATION
low-frequency radar, multispectral imager, dust dector, gravimeter.

DIDYMOS

2.3 YEARS CRUISE

6-Month Characterization



2 x Asteroid Framing Cameras
2 x 6U CubeSats
Laser Altimeter
Thermal Infrared Camera (JAXA)
Hyperspectal Imager

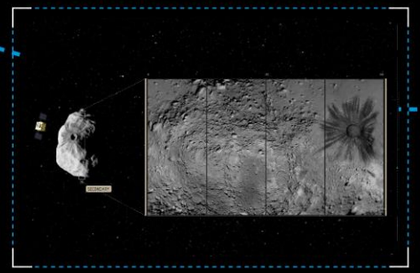
LANDING ON DIDYMOS
MISSISON ENDS

DETAILED CHARACTERISATION PHASE
Measuring surface and interior properties

28/12 2026
ASTEROID ARRIVAL

Early 2027

DIMORPHOS

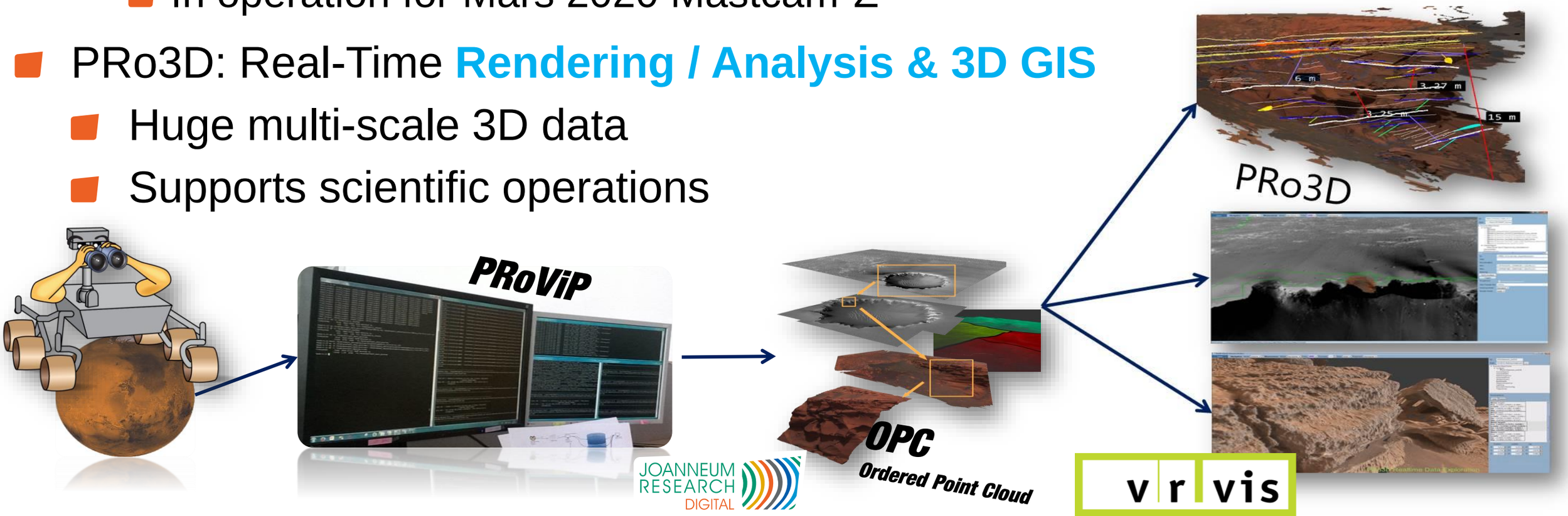


CUBESATS RELEASE

EARLY CHARACTERISATION PHASE
Measuring mass and dynamics

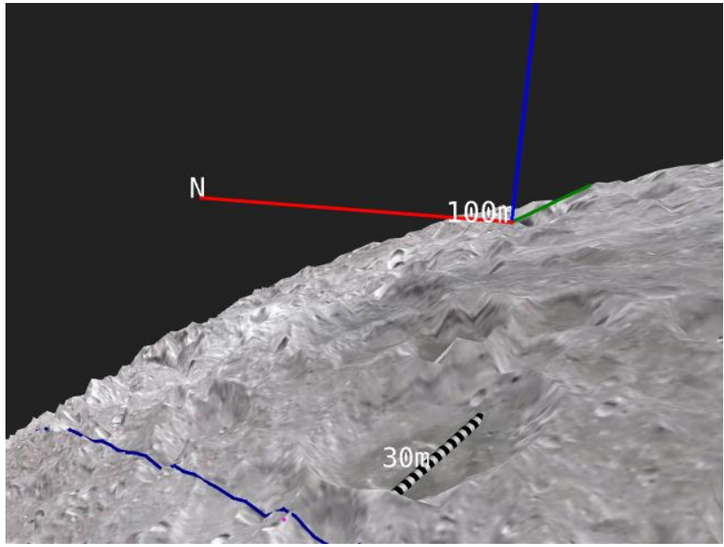
AT Background: PRoViP & PRo3D

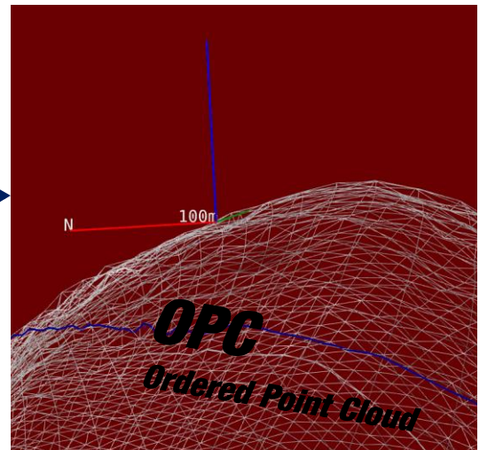
- PRoViP: Batch 3D Vision **Processing**
  - DTM & additional products
  - Automatic service for tactical use
    - Designed for ExoMars Pan/Nav/LocCam)
    - In operation for Mars 2020 Mastcam-Z
- PRo3D: Real-Time **Rendering / Analysis & 3D GIS**
  - Huge multi-scale 3D data
  - Supports scientific operations

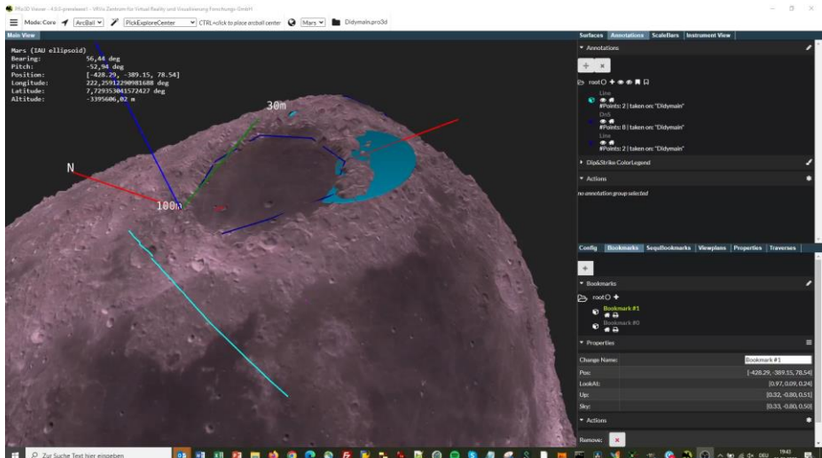


Exploit PRoViP & PRo3D also for HERA

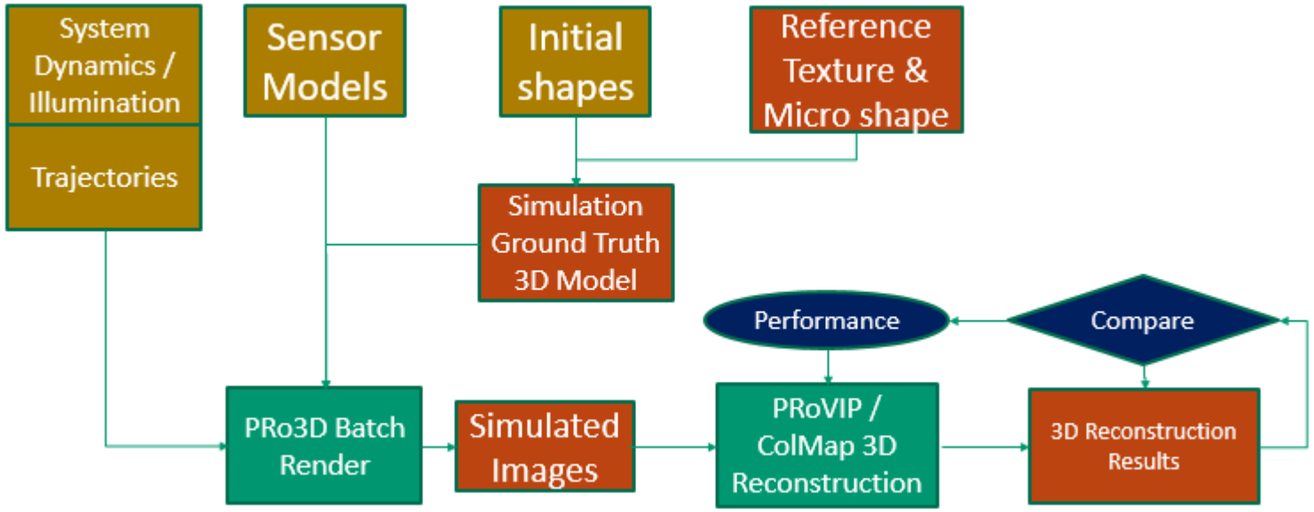
- PRoViP: Batch 3D Vision **Processing**
  - DTM & additional products
  - Automatic service for tactical use
    - Designed for ExoMars Pan/Nav/LocCam)
    - In operation for Mars 2020 Mastcam-Z
- PRo3D: Real-Time **Rendering / Analysis & 3D GIS**
  - Huge multi-scale 3D data
  - Supports scientific operations



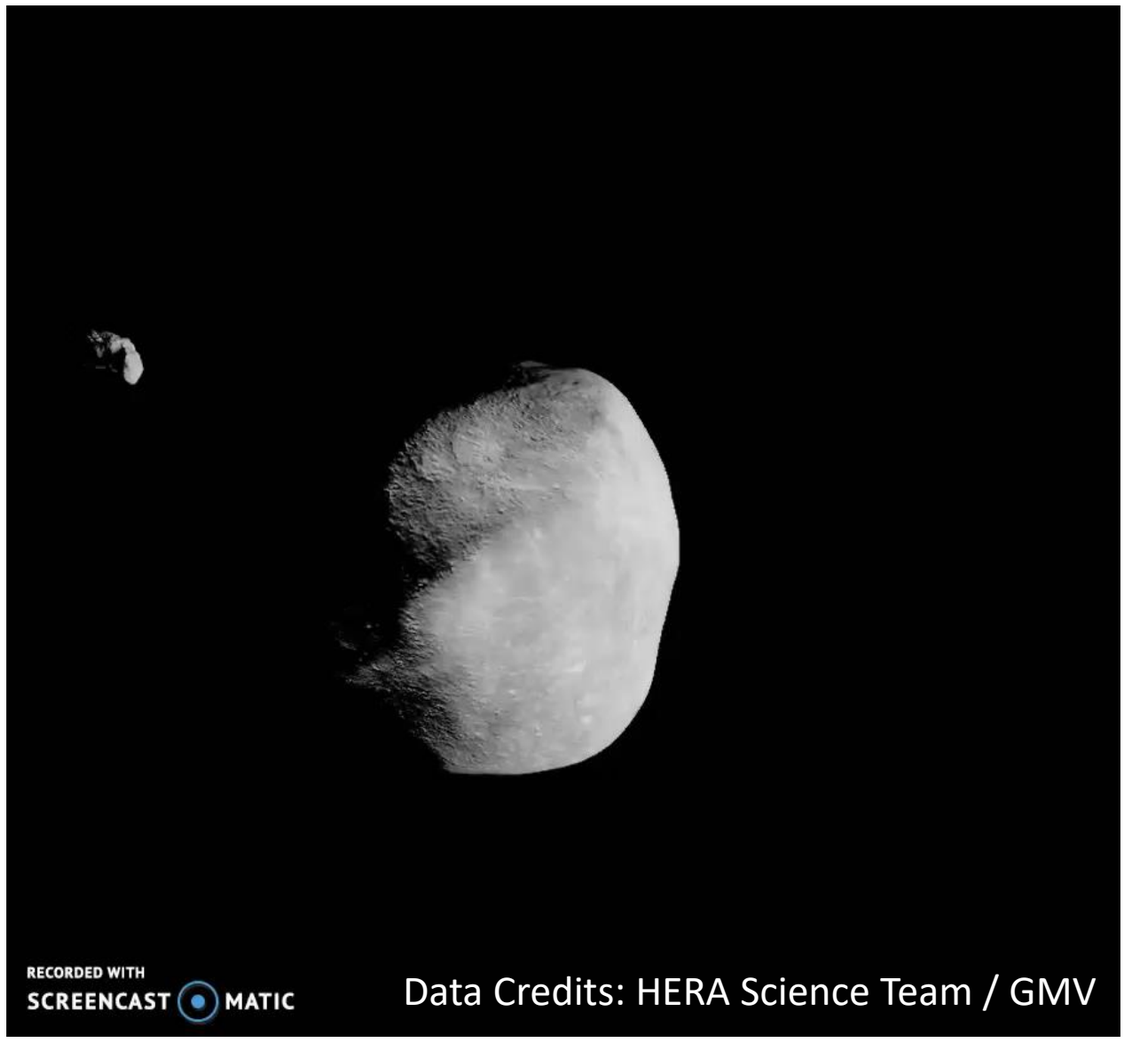




3D Processing „rehearsed“ during Phase B2 (under GMV Contract)

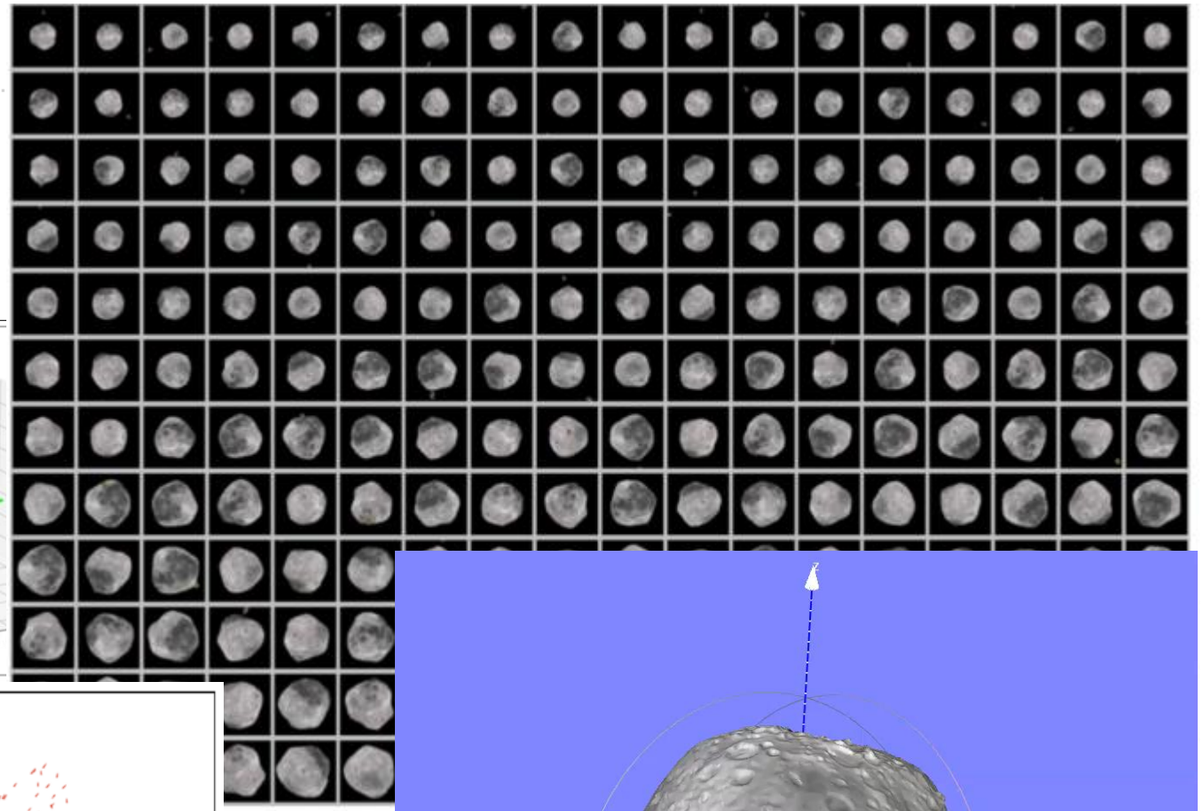


Data Credits: HERA Science Team / GMV

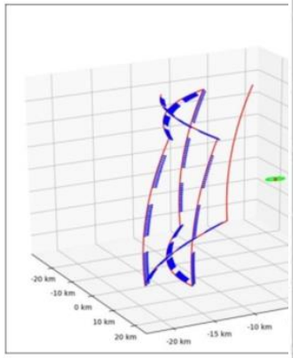


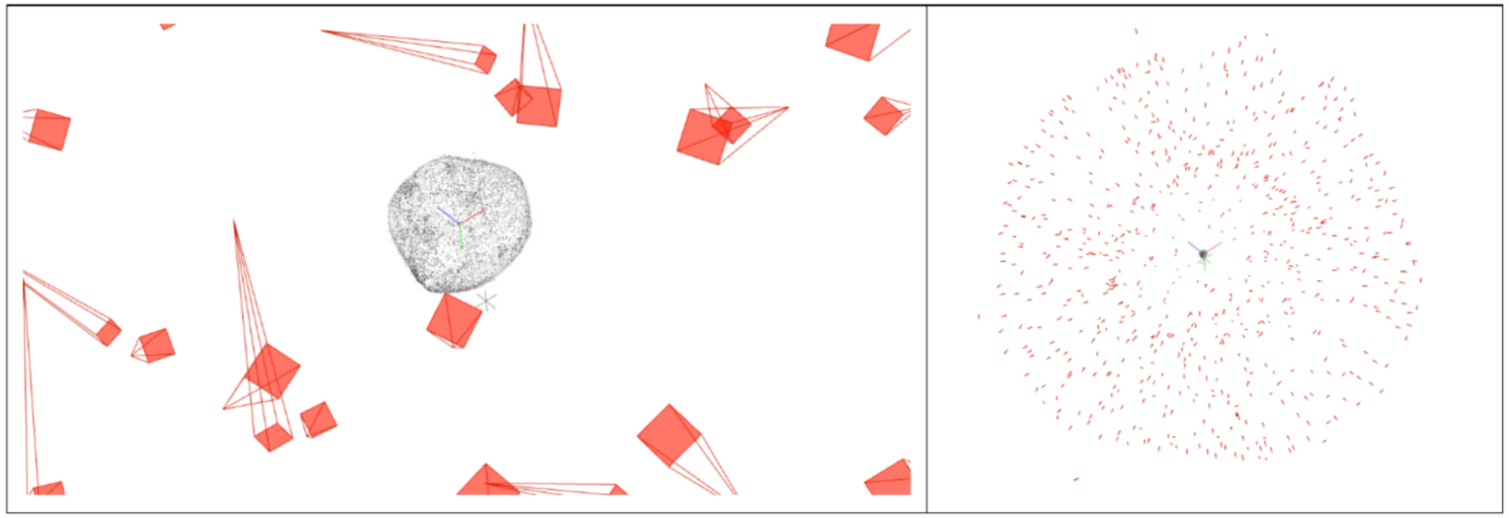
Data Credits: HERA Science Team / GMV

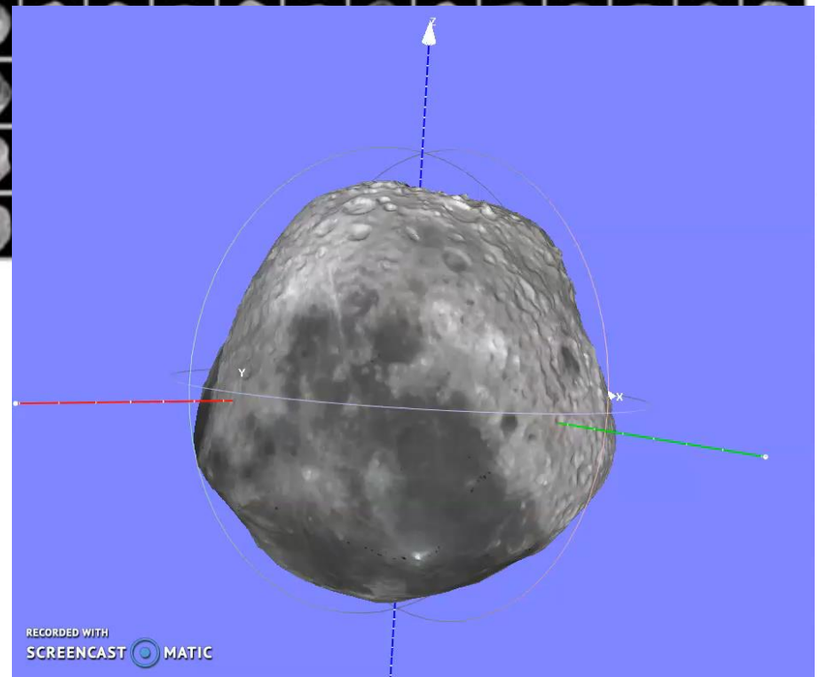
B2 Activities ctd.



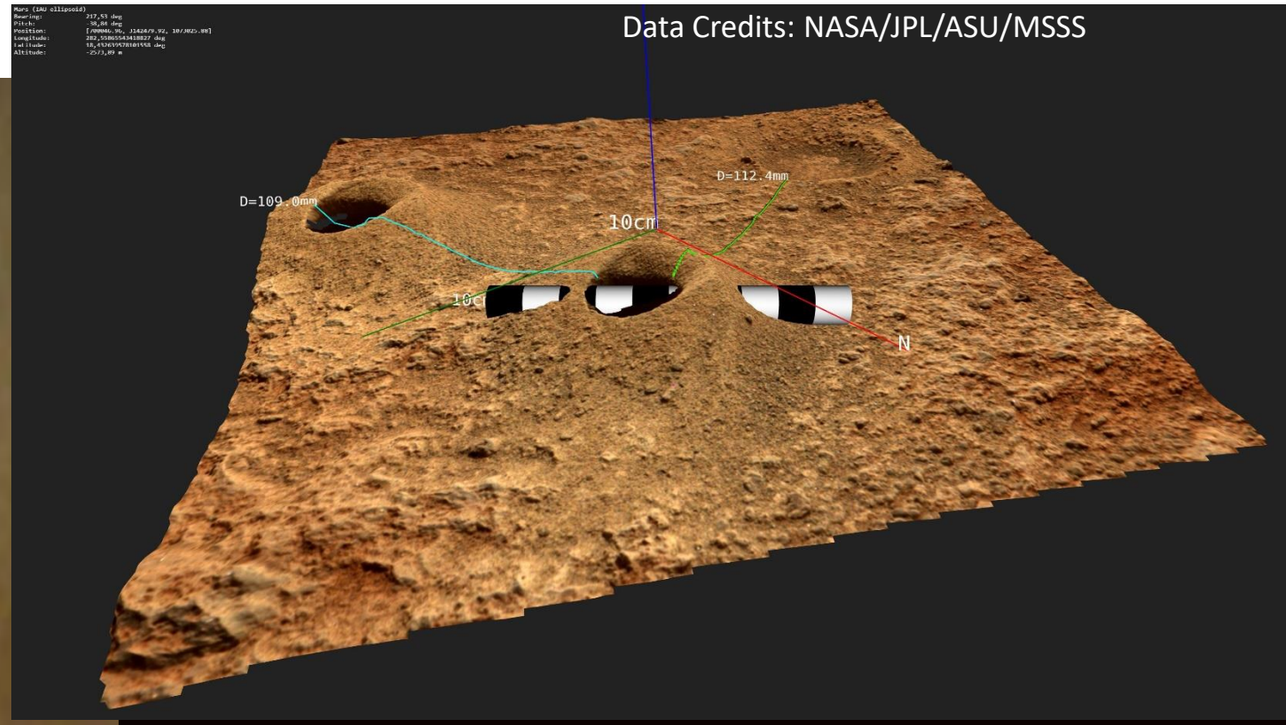
Time	AFC Pointing Vector				HERA Pointing vector(Spice)				Position Hera		
2027-01-28 08:15:00	[0.8883763	-0.16204848	-0.42956703]	--->	[0.88828093	-0.16228441	-0.42967518]	--->	[-26.65772716	4.86262865	12.89012395]
2027-01-28 09:15:00	[0.89420794	-0.15962509	-0.4182248]	--->	[0.89412236	-0.15968821	-0.41838366]	--->	[-26.68317223	4.76321403	12.47983142]
2027-01-28 10:15:00	[0.89993777	-0.15719703	-0.40669534]	--->	[0.8998897	-0.15706781	-0.4068516]	--->	[-26.70725003	4.66510088	12.06940567]
2027-01-28 11:15:00	[0.90556153	-0.15476424	-0.39497639]	--->	[0.90555548	-0.15448446	-0.39509748]	--->	[-26.72956009	4.56826173	11.65873652]
2027-01-28 12:15:00	[0.91107322	-0.15232736	-0.38306913]	--->	[0.91111281	-0.15195893	-0.38312131]	--->	[-26.75126505	4.47269658	11.2478283]
2027-01-28 13:15:00	[0.91646603	-0.14988704	-0.37097456]	--->	[0.91653367	-0.14954603	-0.37054746]	--->	[-26.7712481	4.37840524	10.83668545]
2027-01-28 14:15:00	[0.92173625	-0.147444	-0.35869562]	--->	[0.92181302	-0.14721112	-0.35859397]	--->	[-26.78981307	4.28538758	10.42531278]
2027-01-28 15:15:00	[0.92687536	-0.14499897	-0.34623312]	--->	[0.92693876	-0.14494079	-0.34608771]	--->	[-26.8065842	4.1936439	10.01371505]
2027-01-28 16:15:00	[0.93187798	-0.14255278	-0.33358976]	--->	[0.93190957	-0.14268863	-0.3334434]	--->	[-26.82275609	4.10317503	9.60189738]
2027-01-28 17:15:00	[0.93673796	-0.14010629	-0.32076819]	--->	[0.93673165	-0.14040275	-0.32065694]	--->	[-26.83712334	4.0139824	9.18986509]
2027-01-28 18:15:00	[0.94144909	-0.13766041	-0.30777137]	--->	[0.94140946	-0.13803606	-0.30772436]	--->	[-26.85008034	3.92606751	8.77762375]
2027-01-28 19:15:00	[0.94600524	-0.13521613	-0.2946026]	--->	[0.94594668	-0.13557083	-0.2946276]	--->	[-26.86162111	3.8394337	8.36517921]
2027-01-28 20:15:00	[0.95040026	-0.13277445	-0.28126552]	--->	[0.95034127	-0.13301003	-0.28135352]	--->	[-26.87173921	3.75408184	7.95253763]
2027-01-28 21:15:00	[0.95462809	-0.13033641	-0.26776414]	--->	[0.95458774	-0.13038138	-0.26788608]	--->	[-26.88042757	3.6700141	7.53970545]
2027-01-28 22:15:00	[0.95868273	-0.12790308	-0.25410277]	--->	[0.95866976	-0.12774841	-0.2542295]	--->	[-26.88768066	3.5872318	7.12668944]
2027-01-28 23:15:00	[0.9625583	-0.12547553	-0.2402861]	--->	[0.96257787	-0.12516011	-0.24037221]	--->	[-26.89345086	3.50573575	6.71349668]
2027-01-29 00:15:00	[0.96624901	-0.12305486	-0.22631913]	--->	[0.96576007	-0.12238665	-0.22875533]	--->	[-26.89785271	3.42552634	6.3001345]
2027-01-29 01:15:00	[0.96974922	-0.12064218	-0.21220723]	--->	[-0.14023959	-0.98674945	-0.08159823]	--->	[-26.90076107	3.34660382	5.88661045]
2027-01-29 02:15:00	[0.97305345	-0.11823865	-0.19795605]	--->	[-0.13519766	-0.98792473	-0.0756724]	--->	[-26.90221156	3.26896854	5.47293228]
2027-01-29 03:15:00	[0.97615639	-0.11584545	-0.18357162]	--->	[-0.13040602	-0.98901845	-0.06954689]	--->	[-26.90220046	3.19262127	5.05910751]
2027-01-29 04:15:00	[0.9790529	-0.11346384	-0.16906025]	--->	[-0.12581397	-0.99003592	-0.0632433]	--->	[-26.90072449	3.11756333	4.64514542]
2027-01-29 05:15:00	[0.9817381	-0.11105508	-0.15442858]	--->	[-0.12139916	-0.99097806	-0.05678672]	--->	[-26.89778056	3.04379661	4.23105308]
2027-01-29 06:15:00	[0.9842073	-0.10874051	-0.13968356]	--->	[-0.11711212	-0.99185037	-0.0501756]	--->	[-26.89336555	2.97132348	3.81683938]

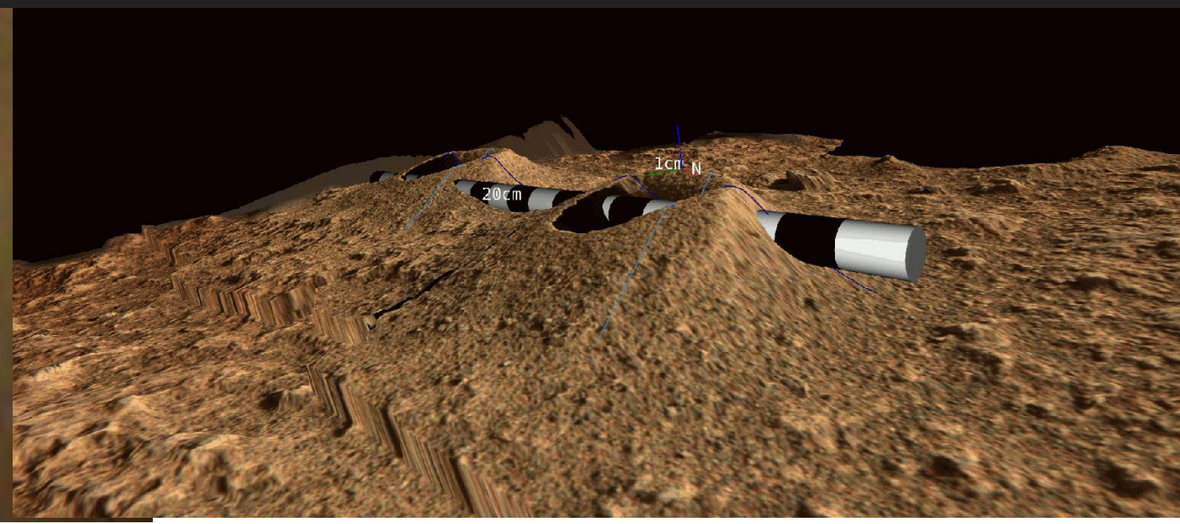




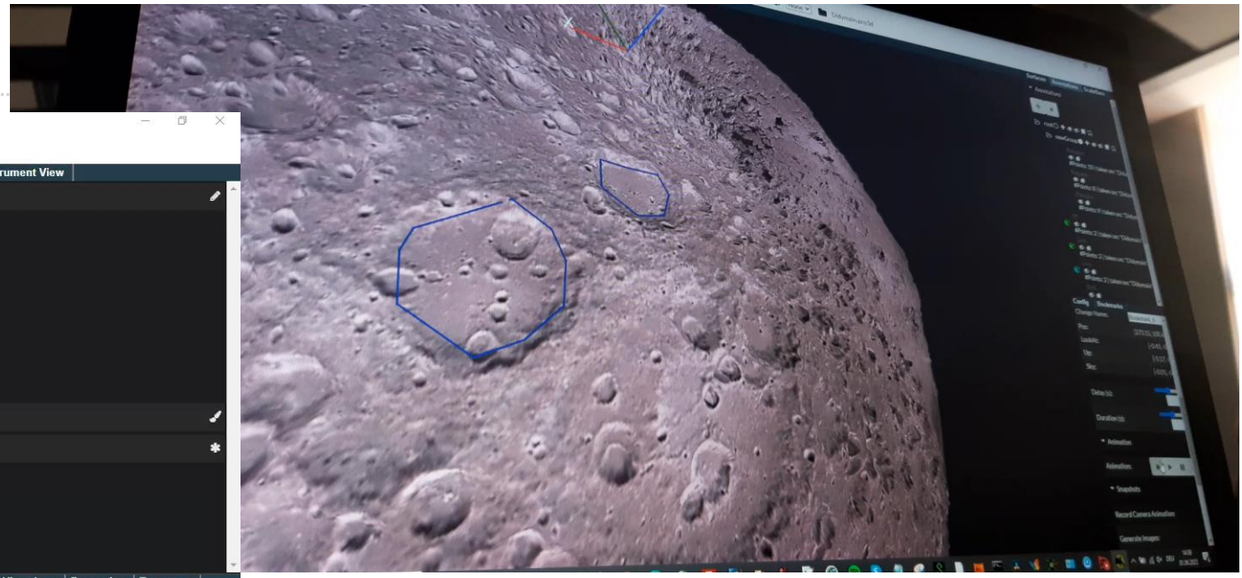


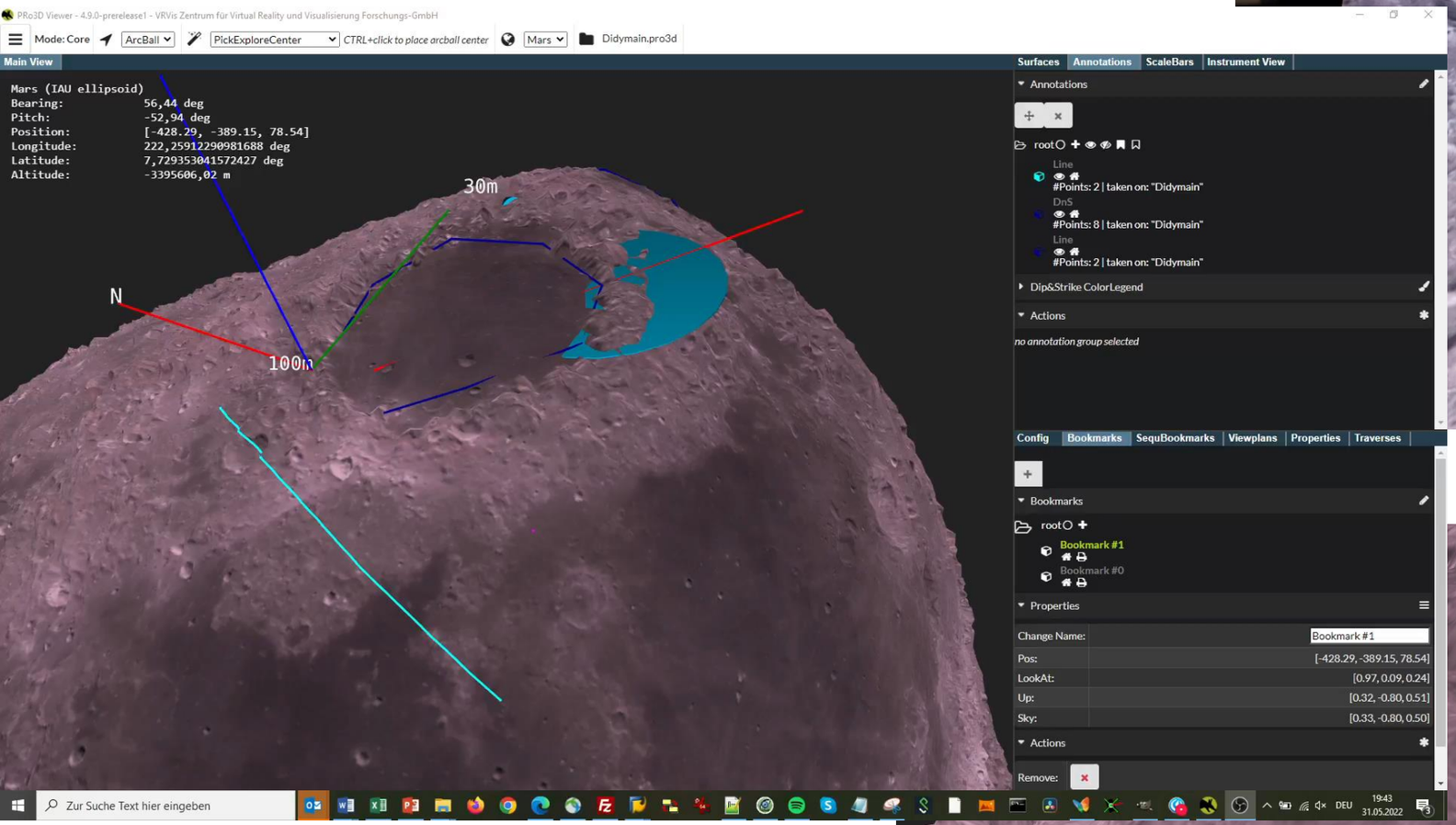
Scale Bars embedded in 3D shape….

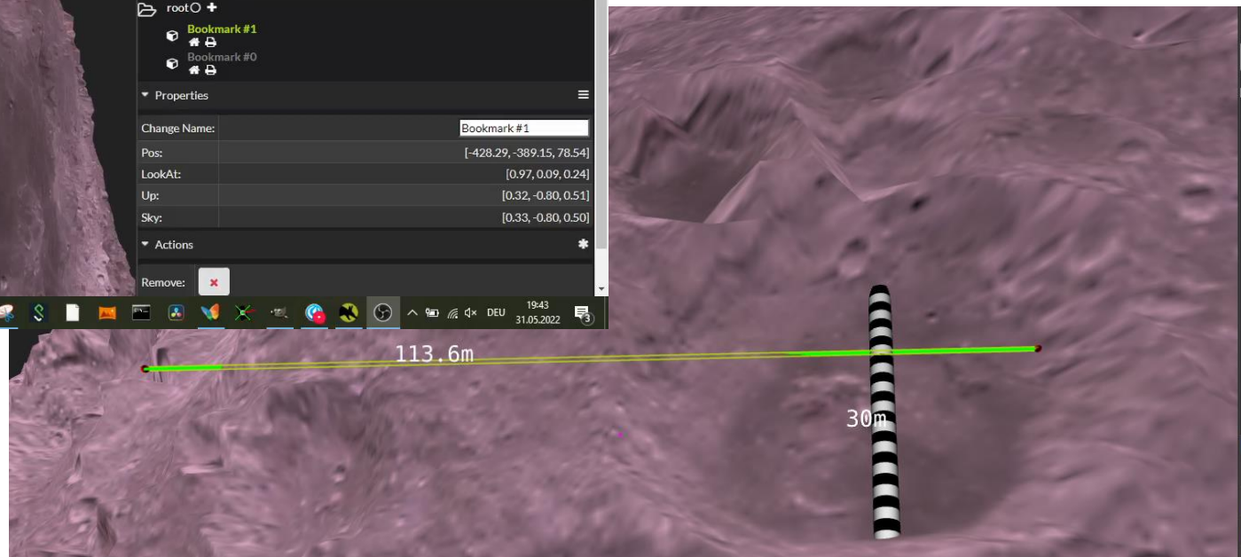




3D Annotations / GIS / Measurements

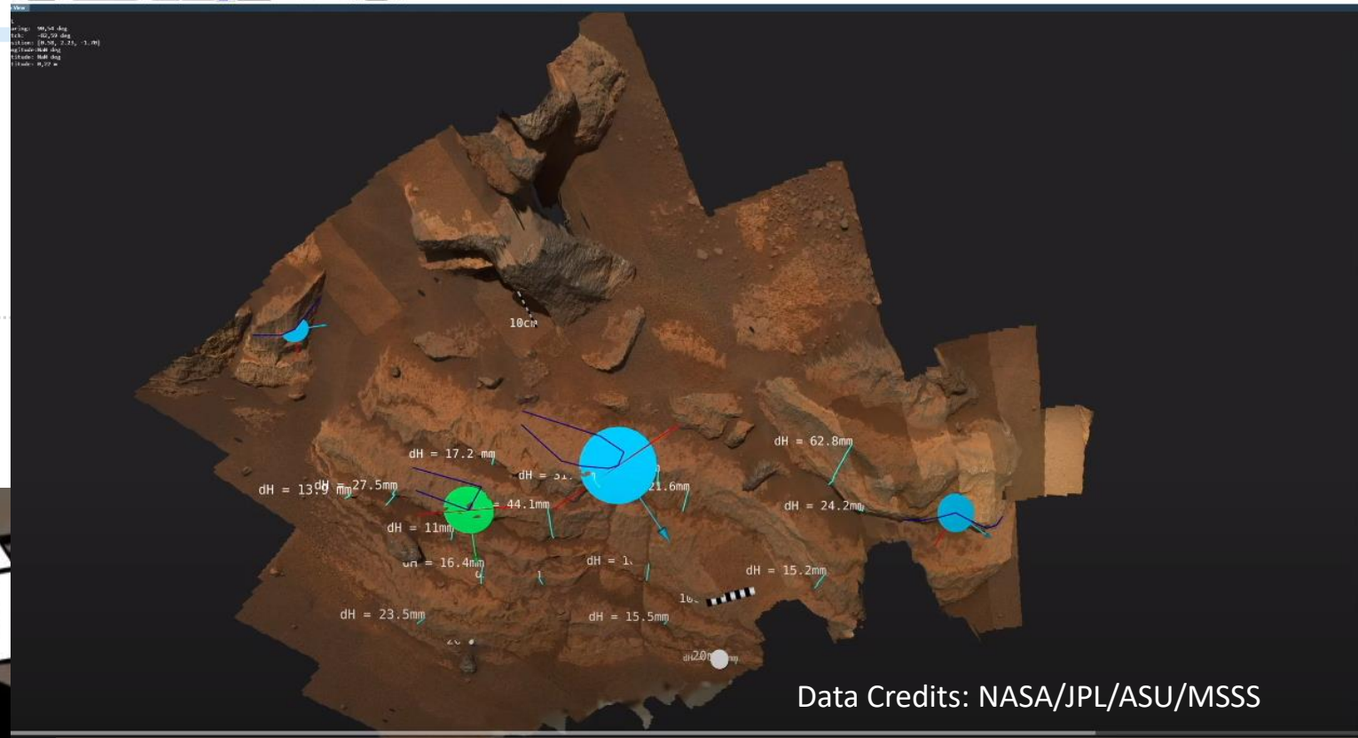






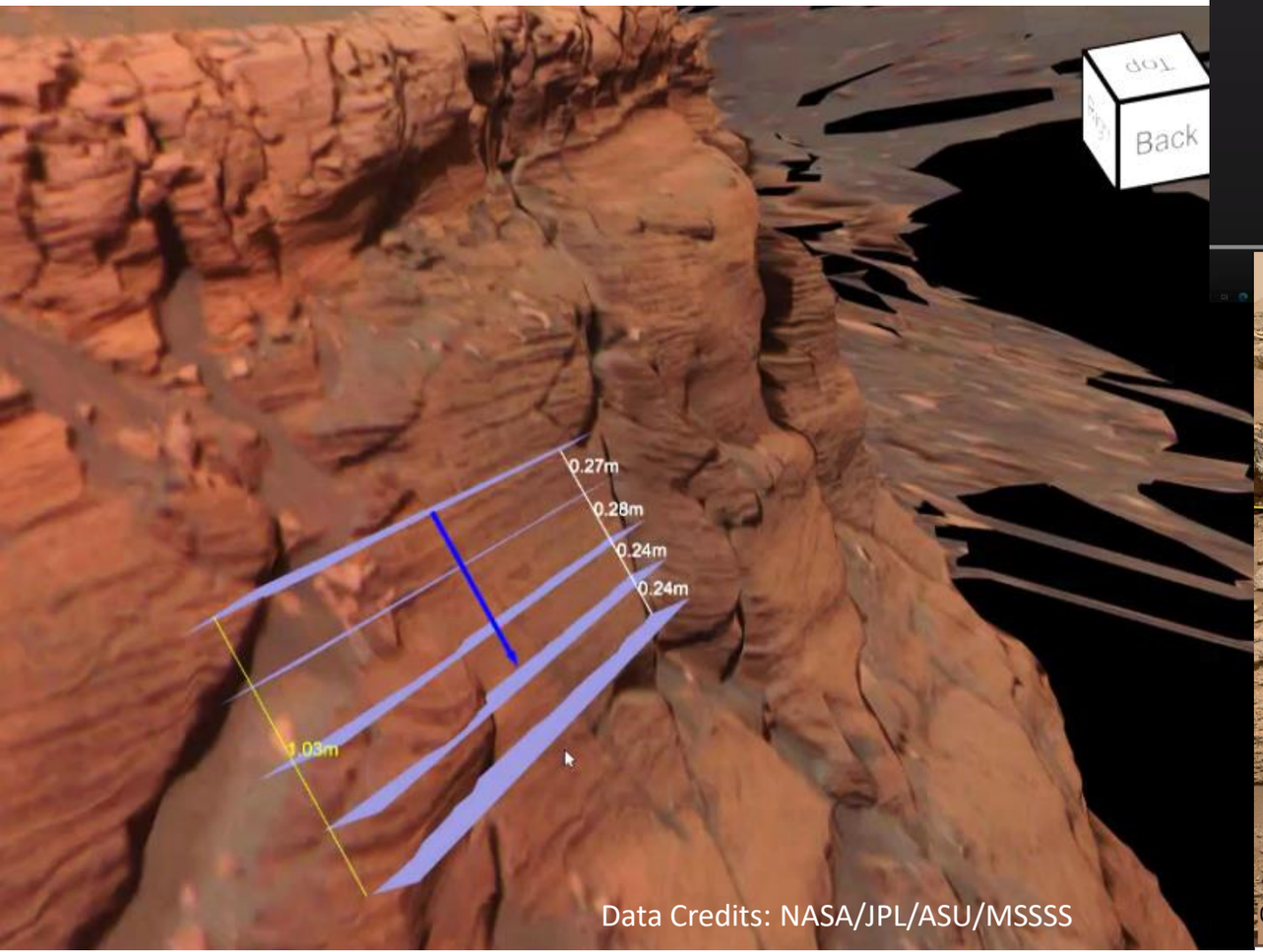
Geologic et al annotations

Strike & Dip

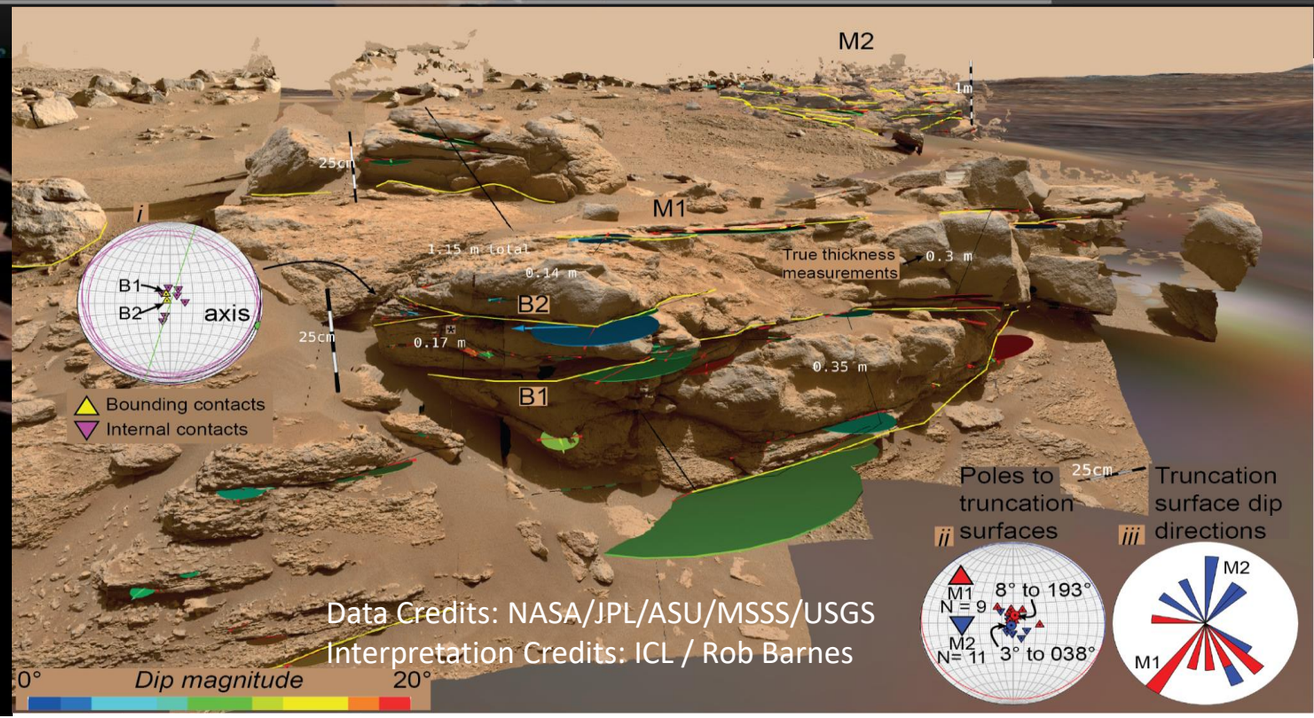


Data Credits: NASA/JPL/ASU/MSSS

True Thickness



Data Credits: NASA/JPL/ASU/MSSSS

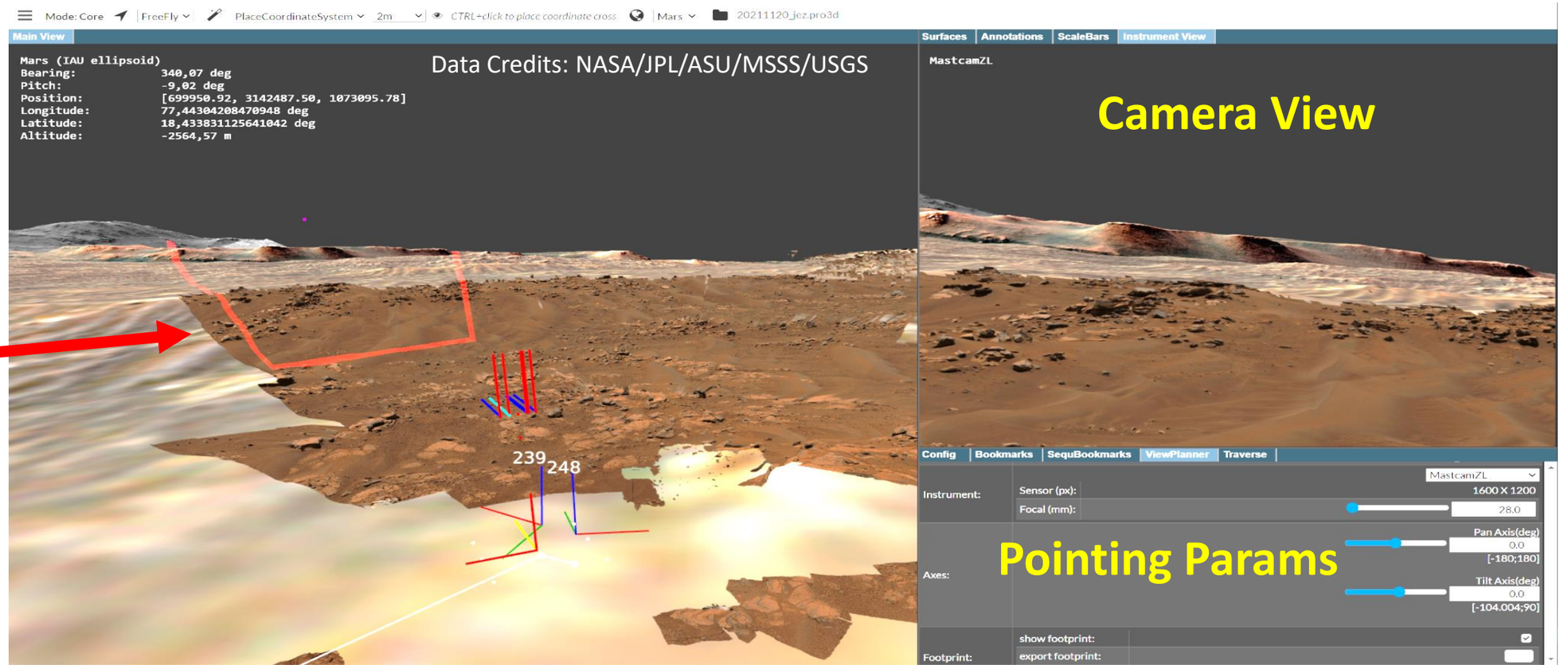


Data Credits: NASA/JPL/ASU/MSSS/USGS
Interpretation Credits: ICL / Rob Barnes

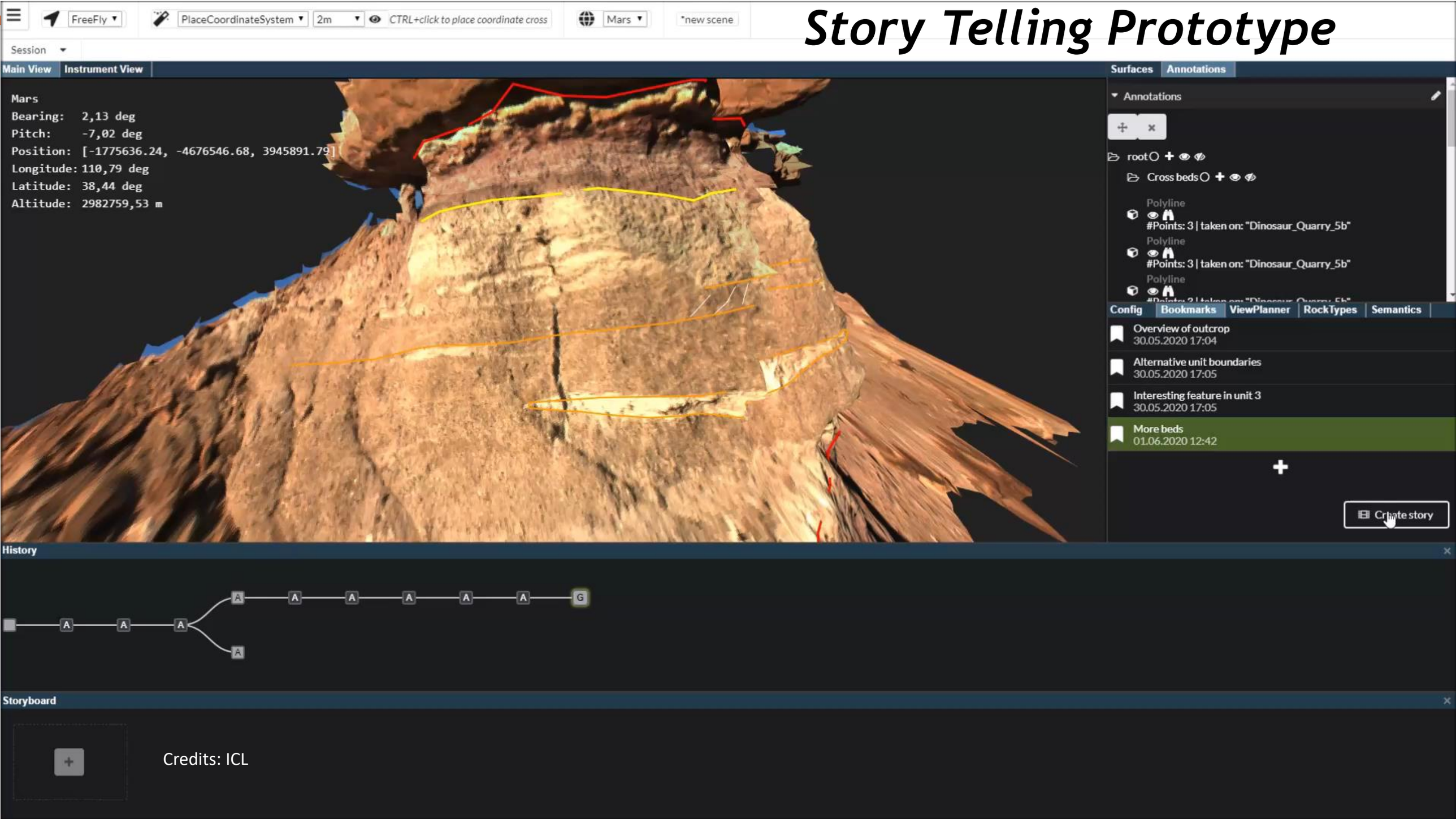
View Simulation & Planning

- Ingest camera & instruments‘ pointings
- Display simulated views
- Support instruments‘ cross calibration (superimpose observations, manually co-align,…) – even at early flyby occasions

FoV in Overall Scene



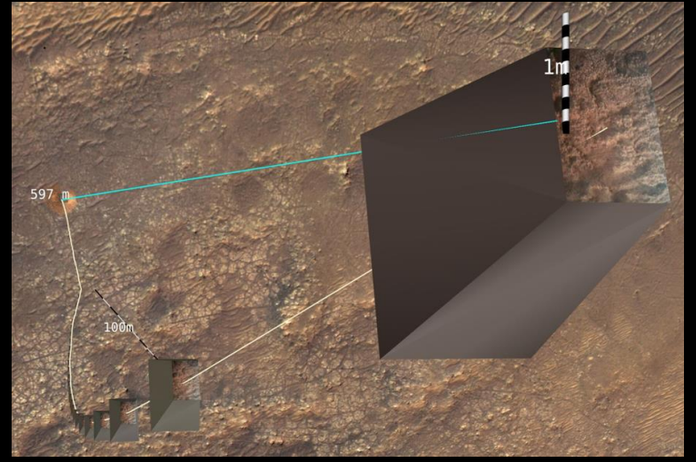
Story Telling Prototype

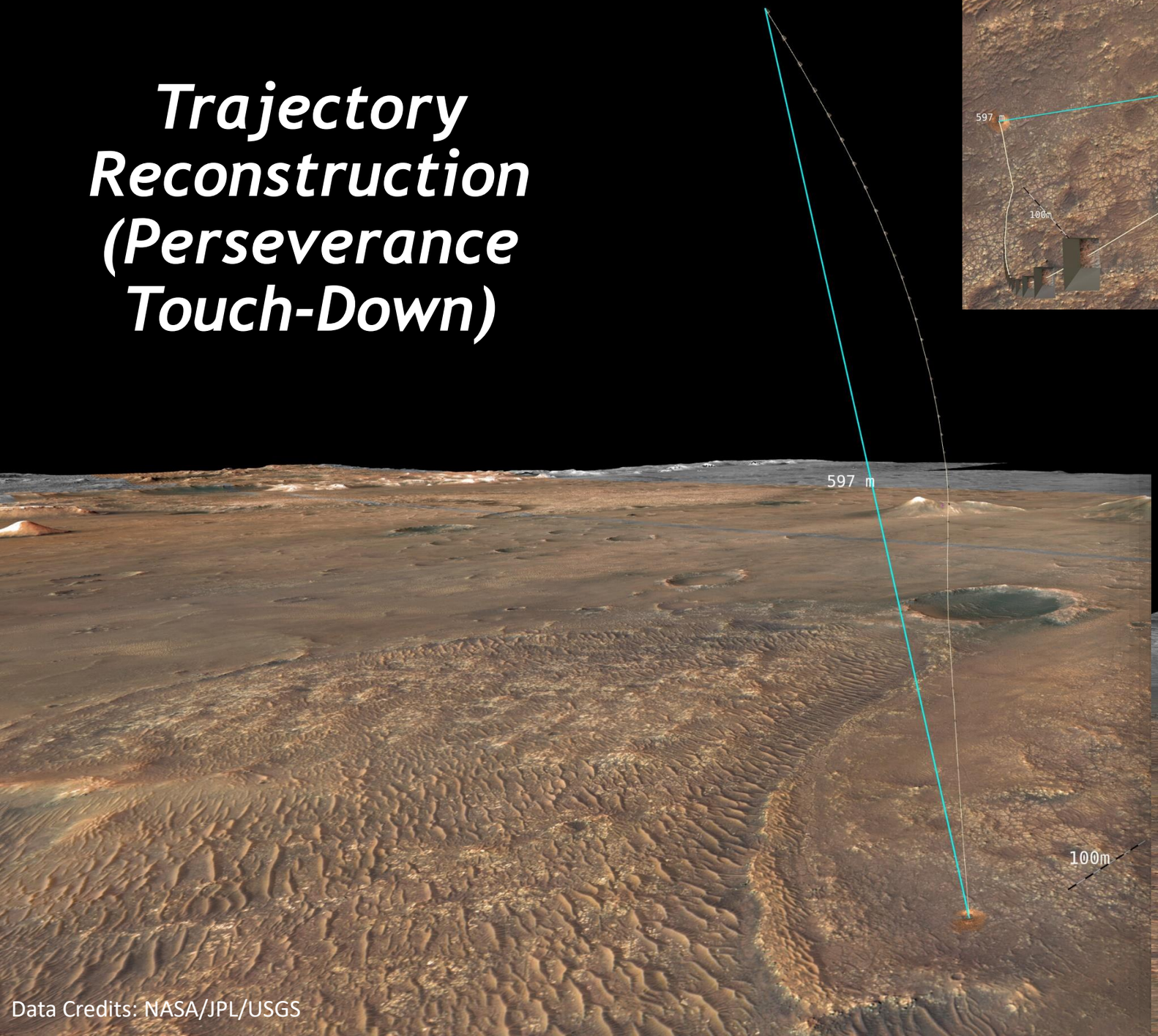


Credits: ICL


PRo3D Viewer - 4.0.2 - Sequenced Bookmarks Prerelease 3 - VRVis Zentrum für Virtual Reality und Visualisierung Forschungs-GmbH
Mode: Core
ArcBall
PickExploreCenter
CTRL+click to place arcball center
None
EDL.pro3d
Main View
Trajectory Reconstruction (Perseverance Touch-Down)
None
Bearing: 52,15 deg
Pitch: 8,67 deg
Position: [696141.75, 3150747.17, 1071458.24]
Longitude:NaN deg
Latitude: NaN deg
Altitude: 505413,72 m
Surfaces
Annotations
LL-Traj-Overview
Properties
Change Name:
Pos:
LookAt:
Up:
Sky:
Delay (s):
Duration (s):
Animation
Animation:
Snapshots
Record Camera Animation:
Properties
Config
ViewerConfig
Picking Tolerance:
Near Plane:
Far Plane:
Navigation Sensitivity:
Import Triangle Size(m):
Arrow Length:
Arrow Thickness:
D+S Plane Size:
Lod colors:
Orientation Cube:
Coordinate System
Camera
Data Credits: NASA/JPL/USGS
14°C Meist sonnig
DEU
12:10
08.04.2022

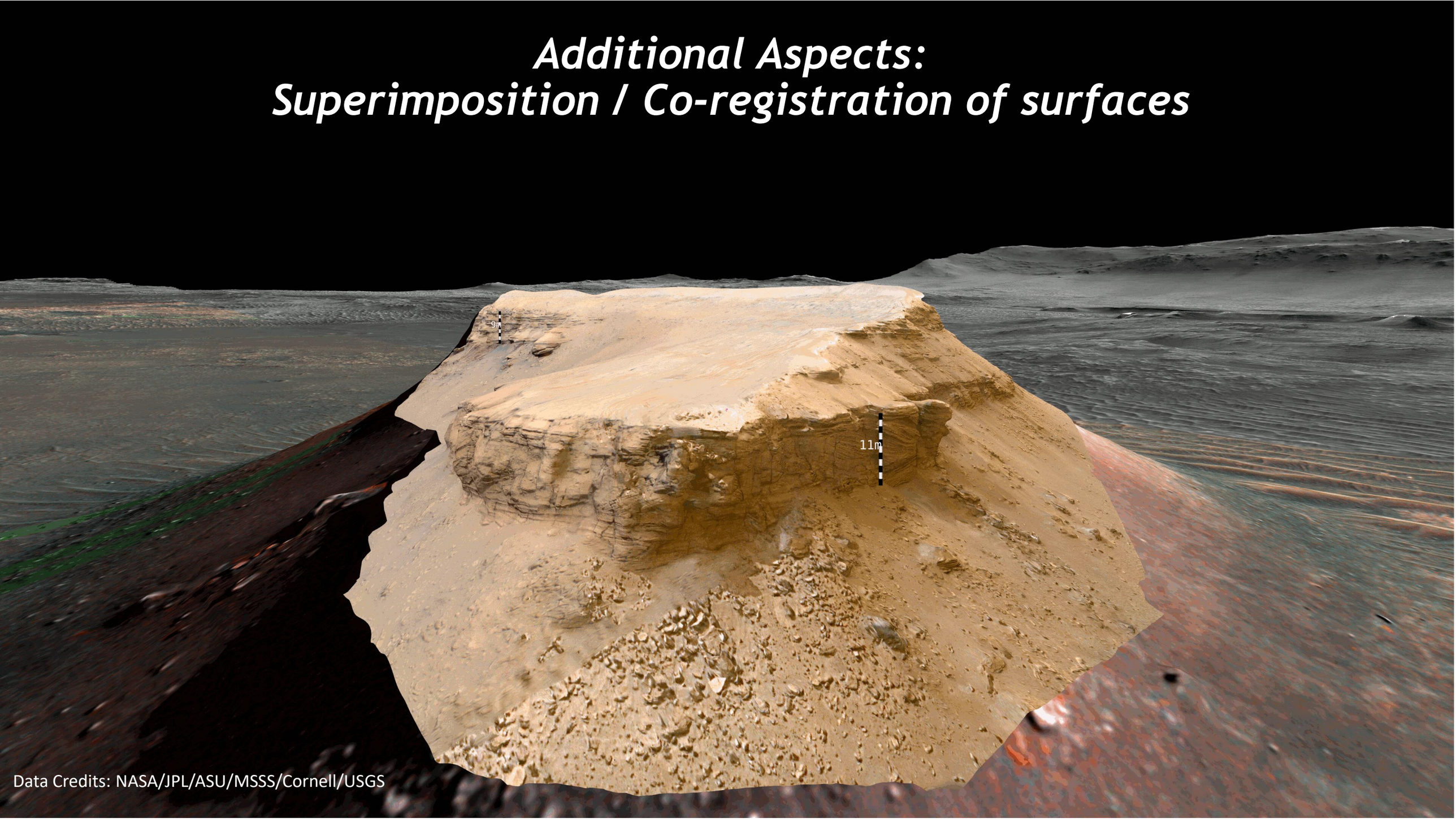
Trajectory Reconstruction (Perseverance Touch-Down)





Data Credits: NASA/JPL/USGS

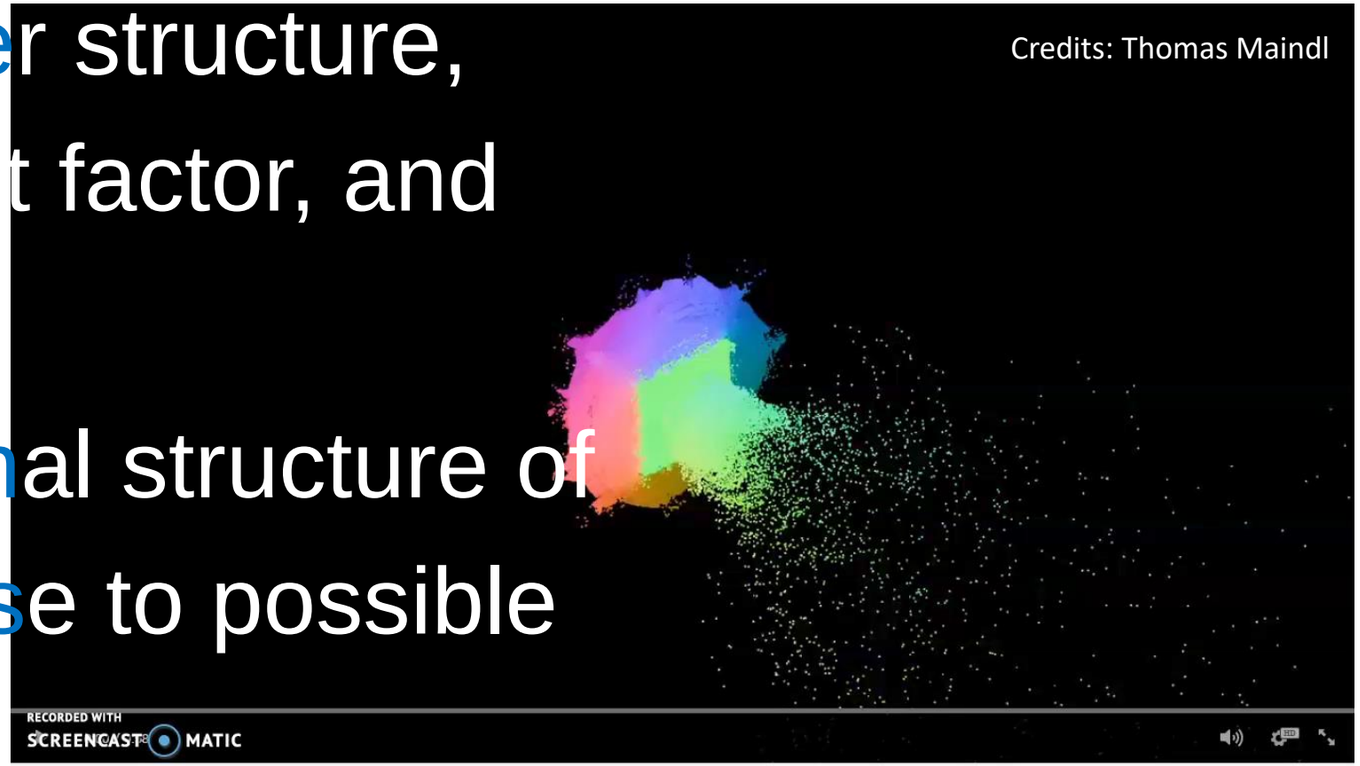
Additional Aspects: Superimposition / Co-registration of surfaces



Data Credits: NASA/JPL/ASU/MSSS/Cornell/USGS

Support by AT Scientists

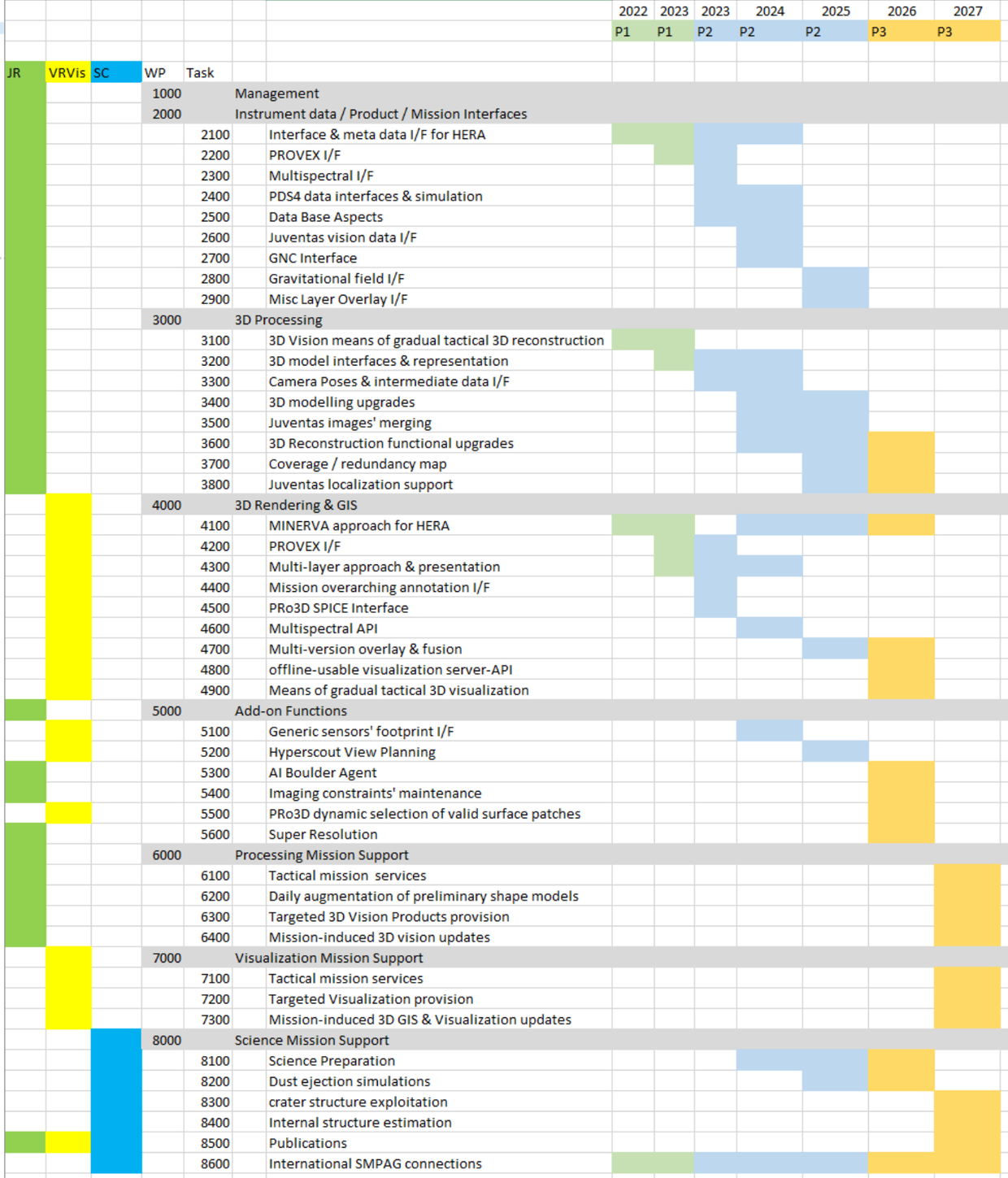
- Strategies for hazardous asteroid deflection based on crater structure, momentum enhancement factor, and deflection method
- Help determine the internal structure of the asteroid, and response to possible deflection mechanisms.
- High Level Product „Satellites/Debris/Dust ejection“



Programmatics

- AT signed up for HERA

- PROVEX – Provenance starts in July
- 3D (Process & Visu) Activity to start ~Sept (proposal currently set-up)
  - Complement to tools & frameworks available already for HERA
  - Further activities > 2023 subject to Ministerial
- Work Plan until 2027 exists



						2022	2023	2023	2024	2025	2026	2027
						P1	P1	P2	P2	P2	P3	P3
JR	VRVis	SC	WP	Task								
			1000		Management							
			2000		Instrument data / Product / Mission Interfaces							
				2100	Interface & meta data I/F for HERA							
				2200	PROVEX I/F							
				2300	Multispectral I/F							
				2400	PDS4 data interfaces & simulation							
				2500	Data Base Aspects							
				2600	Juventas vision data I/F							
				2700	GNC Interface							
				2800	Gravitational field I/F							
				2900	Misc Layer Overlay I/F							
			3000		3D Processing							
				3100	3D Vision means of gradual tactical 3D reconstruction							
				3200	3D model interfaces & representation							
				3300	Camera Poses & intermediate data I/F							
				3400	3D modelling upgrades							
				3500	Juventas images' merging							
				3600	3D Reconstruction functional upgrades							
				3700	Coverage / redundancy map							
				3800	Juventas localization support							
			4000		3D Rendering & GIS							
				4100	MINERVA approach for HERA							
				4200	PROVEX I/F							
				4300	Multi-layer approach & presentation							
				4400	Mission overarching annotation I/F							
				4500	PRo3D SPICE Interface							
				4600	Multispectral API							
				4700	Multi-version overlay & fusion							
				4800	offline-usable visualization server-API							
				4900	Means of gradual tactical 3D visualization							
			5000		Add-on Functions							
				5100	Generic sensors' footprint I/F							
				5200	Hyperscout View Planning							
				5300	AI Boulder Agent							
				5400	Imaging constraints' maintenance							
				5500	PRo3D dynamic selection of valid surface patches							
				5600	Super Resolution							
			6000		Processing Mission Support							
				6100	Tactical mission services							
				6200	Daily augmentation of preliminary shape models							
				6300	Targeted 3D Vision Products provision							
				6400	Mission-induced 3D vision updates							
			7000		Visualization Mission Support							
				7100	Tactical mission services							
				7200	Targeted Visualization provision							
				7300	Mission-induced 3D GIS & Visualization updates							
			8000		Science Mission Support							
				8100	Science Preparation							
				8200	Dust ejection simulations							
				8300	crater structure exploitation							
				8400	Internal structure estimation							
				8500	Publications							
				8600	International SMPAG connections							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Thank You
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