USING LUNAR QUICKMAP FOR SYNTHETIC LUNAR IMAGE MODELING (SLIM)



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Outline

- Overview of QuickMap (<u>https://quickmap.lroc.asu.edu</u>)
- QuickMap recent new capabilities
 - Including Rapid Environmental Assessment (**REA**) of lighting conditions
- Lunar QuickMap and Synthetic Lunar Image Modeling (**SLIM**)
- Demonstrations and Live DEMO (if circumstances permits)
- Concluding Remarks

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Overview of ACT-REACT-QuickMap ™

- <u>ACT-REACT-QuickMap™</u> is a commercial product developed by ACT.
- It is **mission proven**: it has directly supported NASA's : **MESSENGER**, **MRO/CRISM**, and **LRO**
 - providing immediate access to available data for early analysis and cross-validation.
 - additionally, the public has access to higher-level products delivered to the NASA/PDS.
- It provides an easy-to-use yet powerful web interface for cartographic products. (2D & 3D)
- It offers seamless access to numeric data layers without the tedium of handling file format details and data ingestion and archive structures.

Overview of Lunar QuickMap

Lunar QuickMap is the result of a collaboration between NASA's LRO project, LROC team at Arizona State University (**ASU**), and **ACT**.

It has similarities to other web-based lunar data viewers, but <u>it differs by exposing</u> <u>features such as</u>:

- Interactive visualization of <u>numeric data layers</u>
- visualization of probes, data profiling
- Extraction of data probes or carto sub-cube with all geophysical parameters
- * Loading user provided data: GeoTIFF / GeoJSON /...
- * Supports both stack and grid view of layers
- * Layer based algebraic expression \rightarrow Enables Decision Support Tools (<u>DST</u>).
- * Advance search/display of individual (or mosaicked) LROC NAC images
- * (beta) QuickMap TerrainShadows (QTS)

'*' are used to achieve Rapid Environmental Assessment of lighting conditions

Overview of Lunar QuickMap

During CY2021&2022 Lunar QuickMap had an average of **over 1000 unique daily users!**

- The new version of QuickMap is rich in LRO map products, and data from many other missions.
- The user has access to over 1.5 PBytes of lunar products!

play animation...



Synthetic Lunar Image Modeling

- Modeling lunar illumination at any location on the moon (including the polar regions and terminator regions) and time (past, present, future) is of critical importance for the Artemis mission planning.
 - tangential sunlight has its challenges → shadows can originate from over 100 Km away!
- **QuickMap** now include **Terrain Shadows** (**QTS**) modules to simulate illumination conditions, making the best use of:
 - O Digital Elevation Models (DEM) available via the QuickMap 'TERRAIN' data layer,
 - core SPICE kernels,
 - fast ray tracing capabilities to generate detailed illumination conditions (including shadows),
 - interactive 3D maps with fine control on visualization options (leveraging on GPUs)
 - A beta version of QTS is enabled in the public Lunar QuickMap.
 - Go to '?' on lower left of the screen for links to QTS.
 - Documentation is available <u>online</u>.
- Key assumptions (at this time):
 - Light sources- **Sun & Earth & Antenna** are modeled as point source(s).
 - No secondary reflection is being considered

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Synthetic Lunar Image Modeling (cont.)



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Check QTS Documentation <u>on-line</u> + examples ...

Use case	QTS-2D	QTS-3D	
precision shadow map products	YES	~ YES Within limits.	
evaluation over continuously increasing discrete times (discrete time vector)	In a limited way. QTS-2D is a web based application with server side execution time limits.	YES	
Interactive navigation & visualization	No (But its output map product can be visualized in 3D using QuickMap or QTS-3D.)	YES, in 3D Globe type projection	
polar and nonpolar regions	Only over the polar regions. Presently QTS-2D only supports the polar region, i.e. abs(LAT)>70 deg.	YES. Supports optimized polar views!	
lander based perspective views FIRST PERSON VIEW (FPV)	N/A	YES, i.e. First Person View (FPV) Especially if there is supportive DEM at high resolution, e.g. NAC DTM or LOLA 5m polar DEMs. The MESH BUILDER behind QTS-3D stacks the available DEMs available over the Lunar surface. That is, the best resolution will be used as available. (HillShade basemap with no shadows computations results in fastest response)	

QuickMap Terrain Shadows - 2D

- QTS-2D is optimized for the complex illumination geometry of the polar regions.
- It computes precision shadows <u>using DEM data</u> <u>located inside and outside of the output map region</u> <u>of interest</u>.
 - Depending on the topography and Sun position, shadows can originate from mountain peaks further than 100Km away.
- In addition to solar and earth illumination conditions it also supports an antenna visibility mode, and aa traverse mode
- User can control QTS-2D requests via URL commands. The web interface of QTS-2D has an execution time limit of about 3min.
- Try to reduce your area of interest if you need to reduce execution time.

QTS-2D is a simulation engine for quick inspection of terrain topography and illumination. It provides many control options to speed up results, at the expense of accuracy in the resulting view. Shadows can be computed using the subset of the topographic model loaded requested by the user.



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QuickMap Terrain Shadows - 2D (cont.)

Using QTS-2D: Timelapse of simulated shadows over Mercury's north pole.

• **Fun Fact** - Mercury's terminator goes retrograde a number of times in this video. Look for it.

Map Product Details:

- Projection polar stereographic, centered at pole (Latitudes : 78 deg. to 90 deg.)
- Map resolution = 500 m/pixel
- Timelapse matches BepiColombo timeline UTC start = 2025-12-05T00 UTC end = 2027-04-05T00 Time increment = 24 hrs
- Source Data Used MESSENGER's MLA DEM
- Simulation Software: QuickMap Terrain Shadows

[play animation \rightarrow]



QuickMap Terrain Shadows (3D)

QuickMap Terrain Shadows 3D (QTS-3D):

QTS-3D is an interactive simulation engine for quick inspection of terrain topography and illumination. It provides options to speed up results by trading off accuracy in the resulting view. Shadows are computed using the subset of the topographic model loaded for a given camera perspective.

[play animation \rightarrow]

Suggestions on QTS-3D

- For best performance use high end GPU graphics machine , e.g., new MacBook pro
- Terrain serialization benefits from good transfer rates.
- User can save URL to recall a previous state.



· . A C T QTS-3D ...

Navigation options: on upper right of screen , click on '?' on for :

- Use keyboard mapping
- FPV is supported using PlayStation or Xbox gamepad controller (connected via USB)
 [see mapping of controls] → play animation...

Documentation: On upper left click on doc icon for QTS tutorial document

• Map screen shows center pixel scale info

Two camera mode is supported:

- Drone like camera (default screen)
- Nadir looking camera (activate via settings)

PLAYER 1 Wireless Controller (STANDARD GAMEPAD Vendor: 054c Product: 0ce6)	PLAYER 2 None detected	PLAYER 3 None detected	PLAYER 4 None detected
Wireless Contr Product: Occe6) NDEX CONNECTED MAPPING T 0 Yes standard 7	roller (STANDAR MESTAMP 9580152.10000	RD GAMEPAD Ve	endor: 054c
NA n/a n/a n/a 80 B1 B2 B3 0.00 0.00 0.00 0.00 89 B10 B11 B11 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.0125 0.0351 0.00	n/a 84 B5 0.00 28 B13 B14 B15 20 0.00 0.00 0.00 28 B13 B14 B15 20 0.00 0.00 0.00 27 0.01176	87 88 0.00 0.00 816 817 0.00 0.00	0 0
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$\cdot . \ \ ACT$ Rapid Environmental Assessment of lighting conditions...

This is easily achievable in QuickMap by following these simple steps:

- Using actual observations, e.g. LROC's Narrow Angle Camera (NAC) Data
 - → Identify NAC Images collected under similar lighting conditions.
 - Use QuickMap's <u>DRAW&SEARCH Tool</u> or open <u>NAC@POI@TOI</u> directly
 - Note: this is an <u>accurate predictor</u> (as long as there is imagery) with similar subsolar_LatLon !
- Using a Synthetic Lunar Image Modeling approach Leverage on QuickMap TerrainShadow (QTS)
 - FOR ACCURACY → Use QTS-2D
 - The exposed Web base mode is effective for rapid evaluations over midsize regions
 - Alternatively, parallelized version is used at ACT for large regions over many times
 - FOR INTERACTIVE and REAL TIME → Use QTS-3D.
- Cross validation is a critical step!
- → Link to QTS tutorial examples <u>here</u>

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REA of lighting conditions along a user entered traverse

One more modality of QTS-2D is the <u>light profile tool</u>. It can be also accessed from QuickMap by drawing a path profile and select the search option of "QTS-2D light profile", and edit control parameters.

This provides WHERE / WHEN / HOW much light along a traverse. Note: example selected goes into a permanently shadow region.

Control Parameters				
SOURCE OF ILLUMINATION				
START UTC TIME	END UTC TIME	DE	LTA TIME HOURS	
2023-11-01T00:00:00	2023-11-30T00:00:00		6	
LAT/LON VALUES LIST				
-85.39838, 31.61519				
-85.39973, 31.67601				
-85.40327, 31.70329				
-85.41306, 31.77891				11
OUTPUT RESOLUTION (M/PIX)	SHADOW MAX DISTANCE ALLOWED (KM	4)		
60mpp	\$ automatic 🗘			Reset



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· ACT Live DEMO...(if circumstances permit)

- Start Lunar QuickMap , <u>https://quickmap.lroc.asu.edu</u>
- Demonstrate QuickMap's New capabilities
 - New layers, added during CY2021 & so far in CY2022
 - New DST capabilities (using Boolean layers and expression layers) [VIPER example]
 - Grid view and stack of data
 - Search Tools
 - from map screen
 - from layers panels screen
 - Data Extraction tools
 - Point probe, and cube extraction
 - Line profiles
 - Terrain Shadows tools → <u>Tutorial & Examples</u>

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Concluding Remarks

- Lunar QuickMap is rapidly expanding with <u>new</u> <u>data products</u> and also with <u>new synthetic lunar</u> <u>image modeling capabilities</u>.
- Rapid Environmental Assessment of lighting conditions for any site on the moon (at a future time) can be easily achieved with QuickMap by using:
 - New LROC/NAC search tools or
 - Terrain Shadows 2D&3D (beta tools)

In Conclusion: QuickMap with its the new (beta) capabilities can be used to assess future illumination conditions and perform FPV drone like flyover and landing simulations.

Explore ...More Lunar Views with QTS [link] or stay tuned to QuickMap's World of Worlds (WOW) [link]

PUBLIC QUICKMAPS



Lunar QuickMap

In collaboration with the LRO/LROC team, this Lunar map features over 1.2 Petabytes of LROC data alone. Explore Wide Angle Camera global mosaics and Narrow Angle Camera observations. Get to know the terrain with a variety of global and regional terrain products - LOLA, SLDEM2015, NAC DTMS. Also featuring data from Clementine, Chandrayaan-1, and Kaguya.

EXPLORE NOW \rightarrow



Mercury QuickMap

Explore Mercury like never before with over 1TB of products. In support of the MESSENGER mission the system provides easy access to MDIS global and regional mosaics, rapid access to MDIS, MASCS/VIRS spectra, terrain elevation models, observation footprints, and more.

EXPLORE NOW →



Mars QuickMap

In collaboration with the MRO/CRISM team, this active Mars mission has delivered over 92 Terabytes of data. Browse CRISM's global multispectral products or it's over 4700 High Resolution target image browse products.

EXPLORE NOW →