

# Scientist-Guided Autonomy for Self- Reliant Rovers

Gary Doran, Umaa Rebbapragada, Eugenie Song,  
Kiri Wagstaff, Daniel Gaines, Robert Anderson,  
and Ashwin Vasavada

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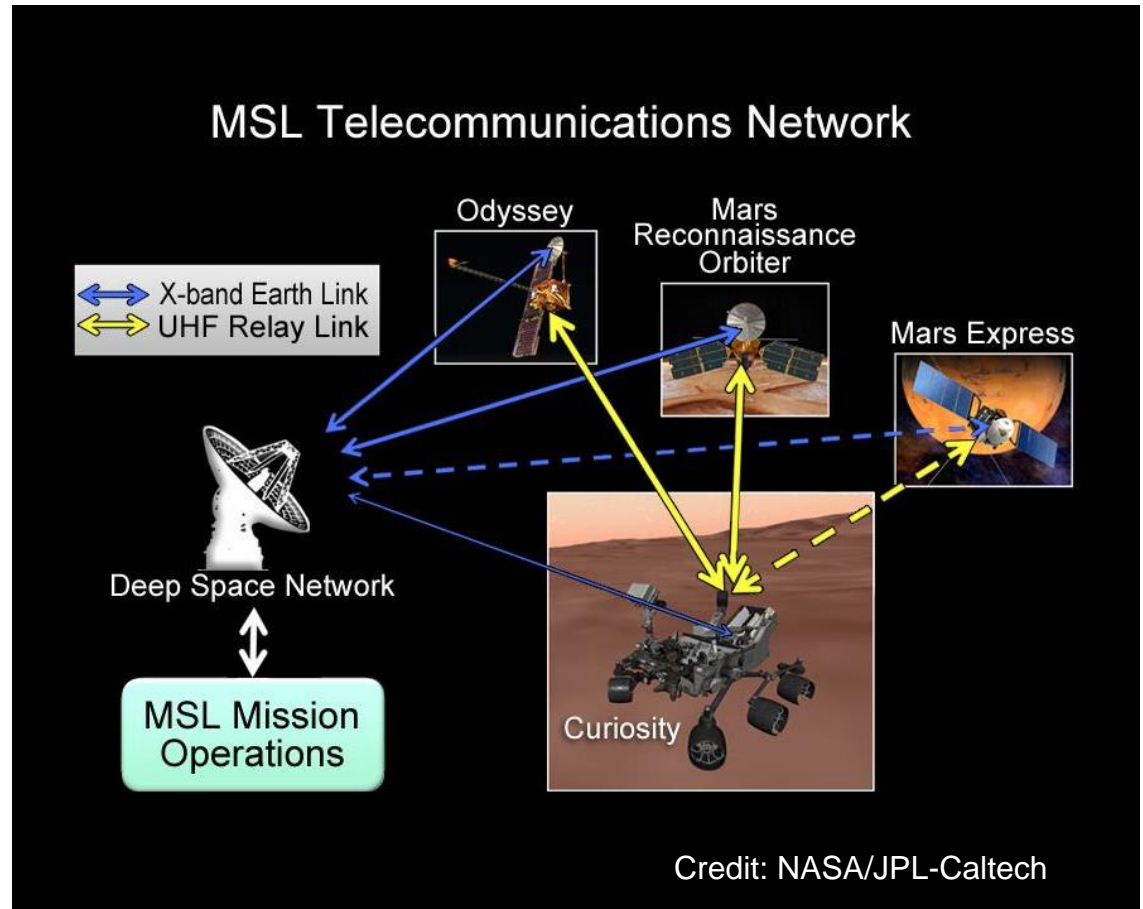
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**Jet Propulsion Laboratory**  
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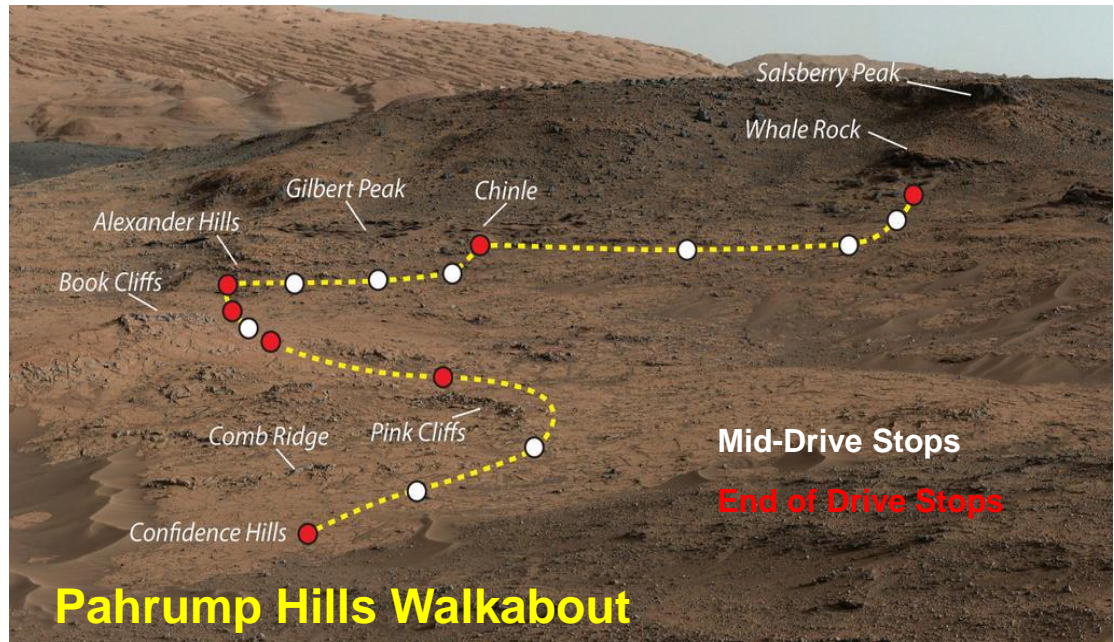
# Mars Operations Challenges

- Mars rovers primarily communicate through **relay orbiters** with regular over-flights.
- Operations constrained by **alignment** of Mars and Earth days as well as relay over-flight pattern.
- **Self-reliant rovers** can better take advantage of time between ground commands to achieve science objectives.



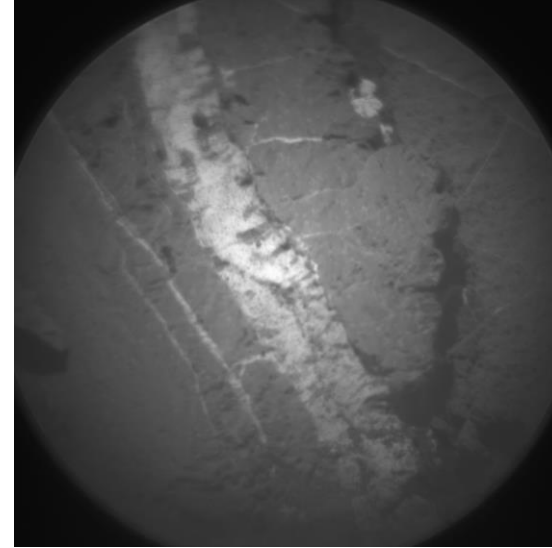
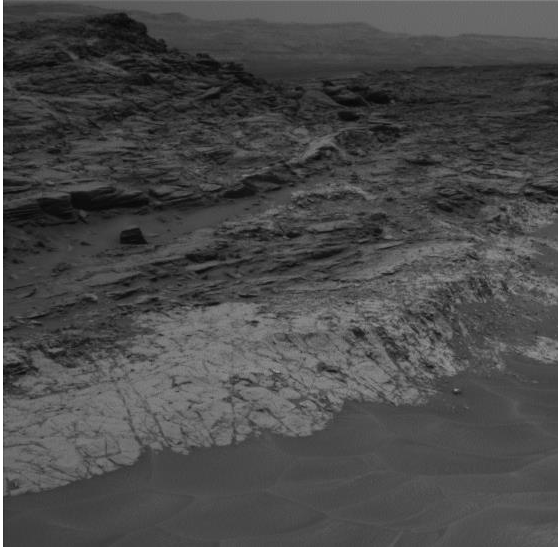
# Science Strategy: The “Walkabout”

- The rover traverses a region of interest, stopping occasionally to take measurements.
- The first “loop” of the walkabout is focused on gathering remote sensing data and imaging.
- Subsequent loops focus on detailed studies or sampling of locations selected using the first loop’s observations.



**Opportunity for science autonomy:**  
Perform the first loop automatically using only general guidance from scientists.

# Science Guidance: What to Measure?

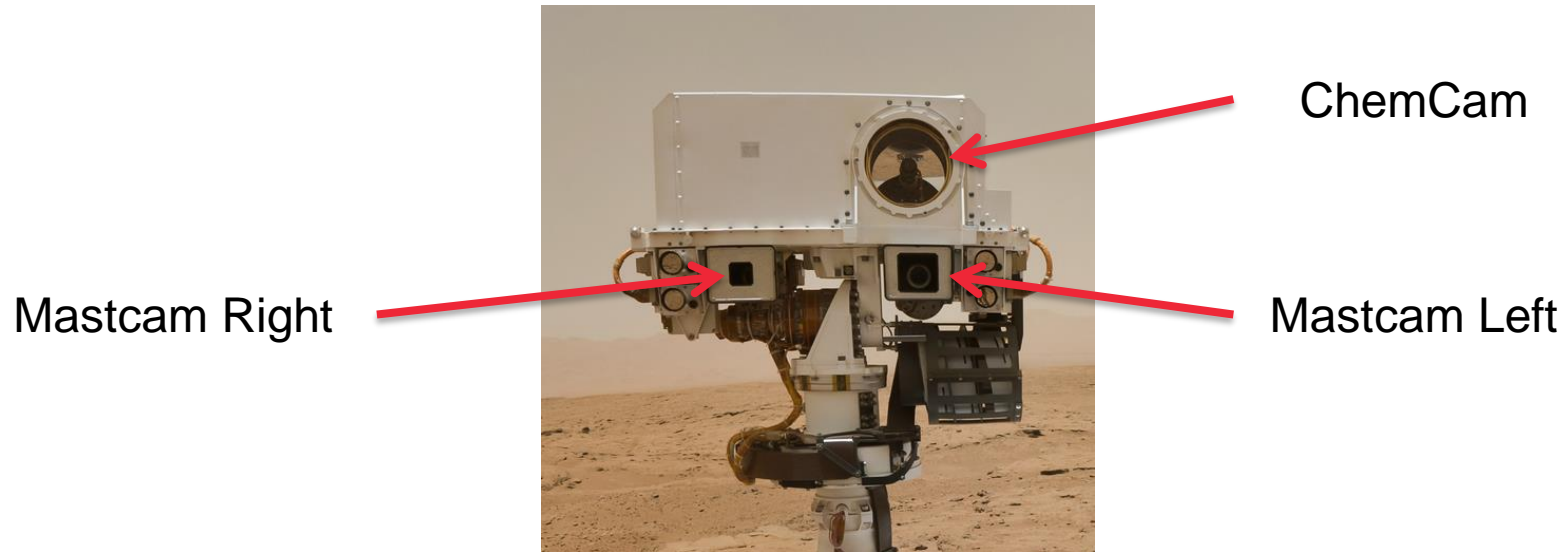


## Examples:

- A particular rock unit
- A “contact” between two rock units
- A particular feature (e.g., sedimentary layering or veins)
- Novel or interesting features



# Science Guidance: How to Measure?



## Examples:

- ChemCam (LIBS) of diverse targets
- LIBS across layers
- LIBS following a vein or other feature
- Mastcam mosaic covering region or feature

# Technologies using Science Guidance

## What?

**TextureCam**  
region/unit detection

**FORC**  
contact detection

**FOLD**  
layer detection

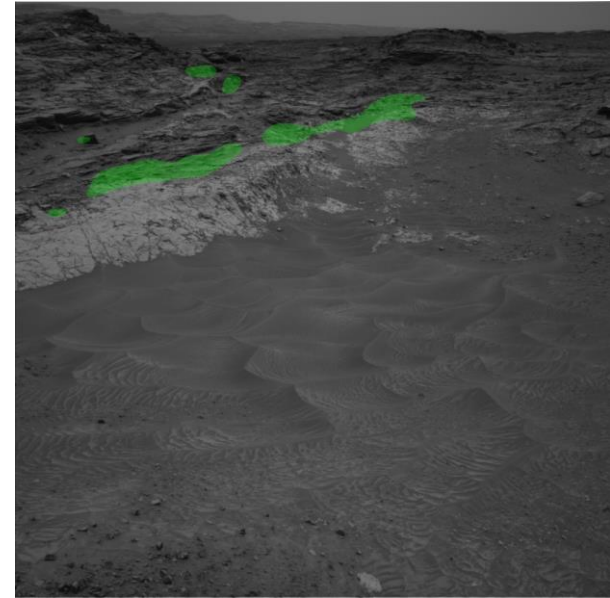
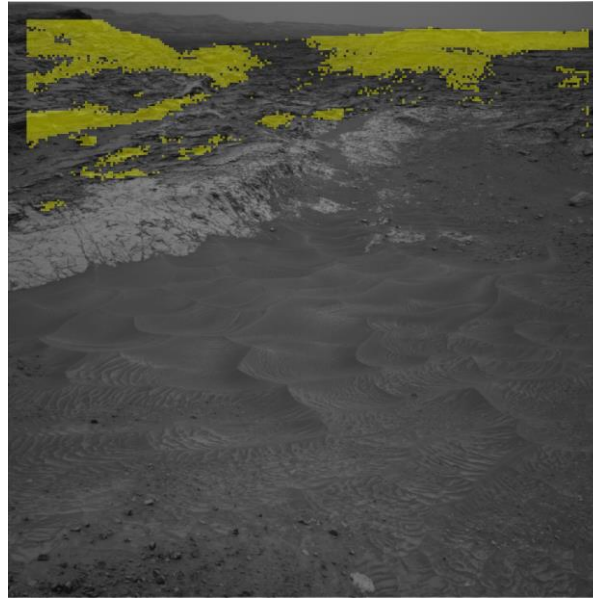
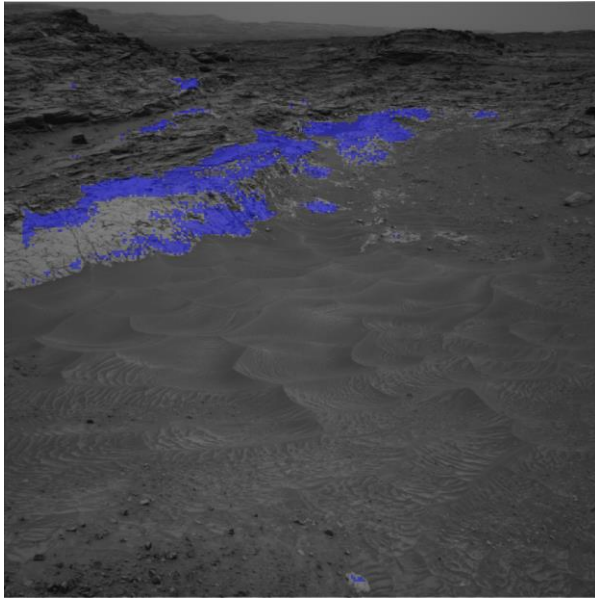
**Novelty Detection**

## How?

**DOTS**  
diverse target selection

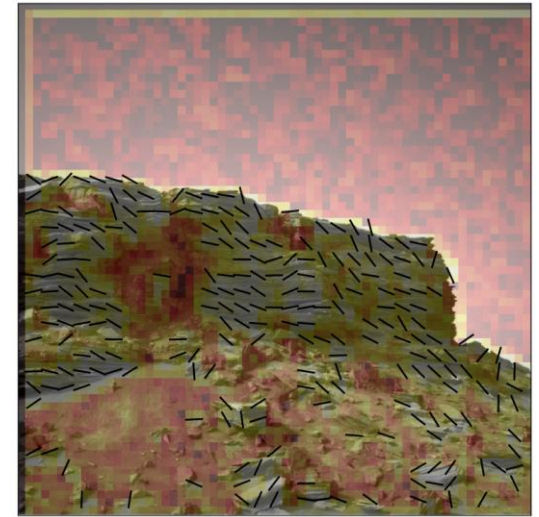
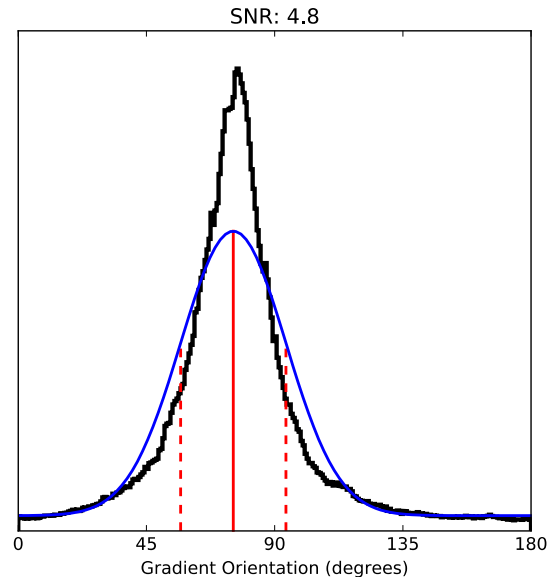
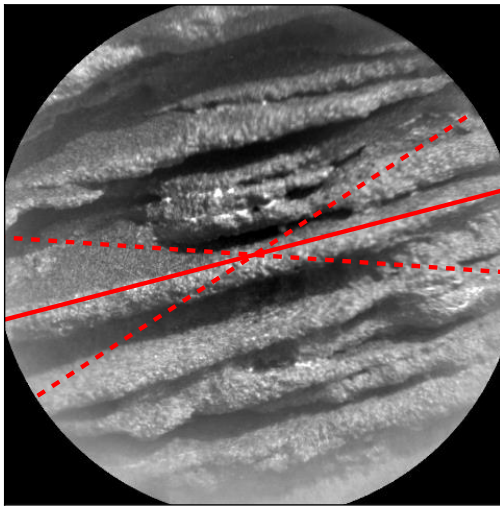
**OnRAMP**  
raster/mosaic planning to  
cover/follow region

# TextureCam/FORC



- **TextureCam**: pixel-wise image classification using random forests (Thompson et al., 2012)
- **FORC**: Finding Oriented Regions of Contact

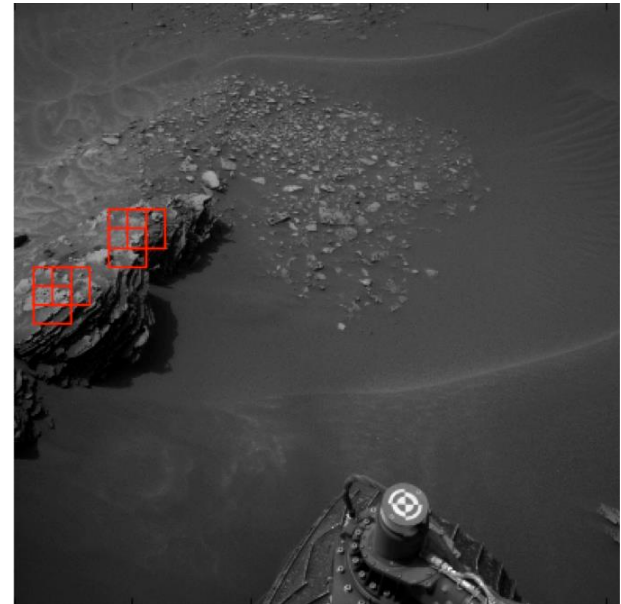
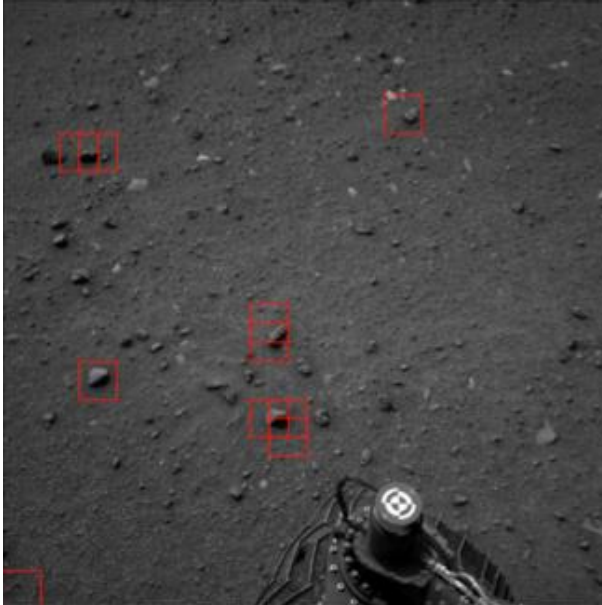
# FOLD: Fast Oriented-Layer Detector



- Uses distribution of image gradients to determine layer orientation in a small-field-of-view camera
- Can be operated in a window mode to find layered regions in a wide-field-of-view camera



# Novelty Detection

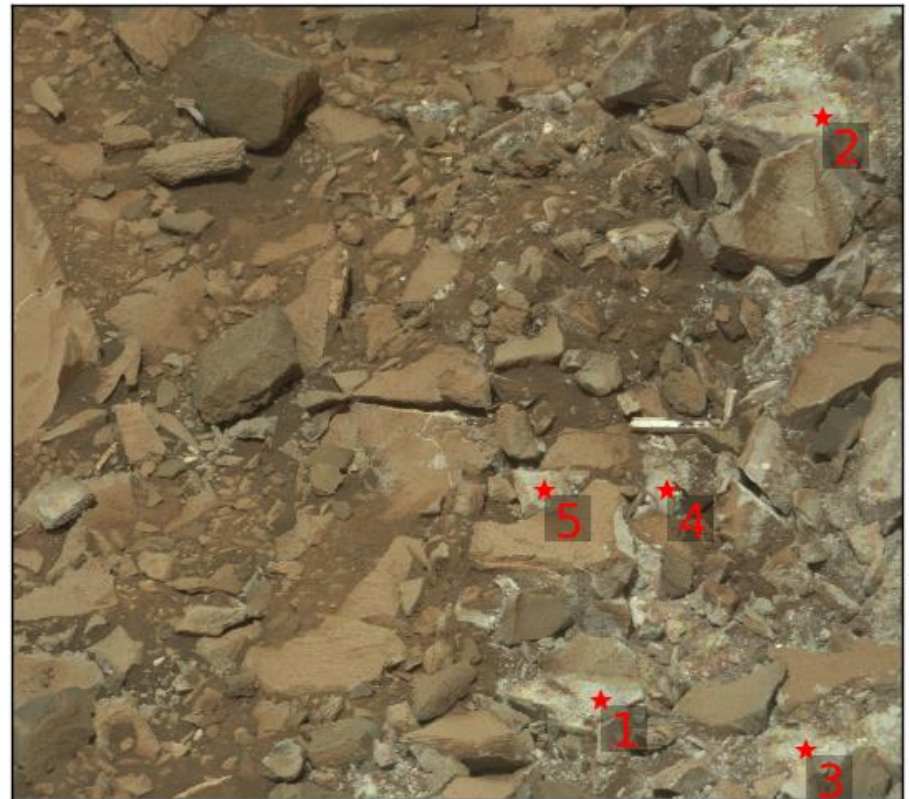


- Uses an “isolation forest” model to learn typical image patches (Liu, Ting, and Zhou 2008)
- Looks for anomalous image regions different from those previously observed

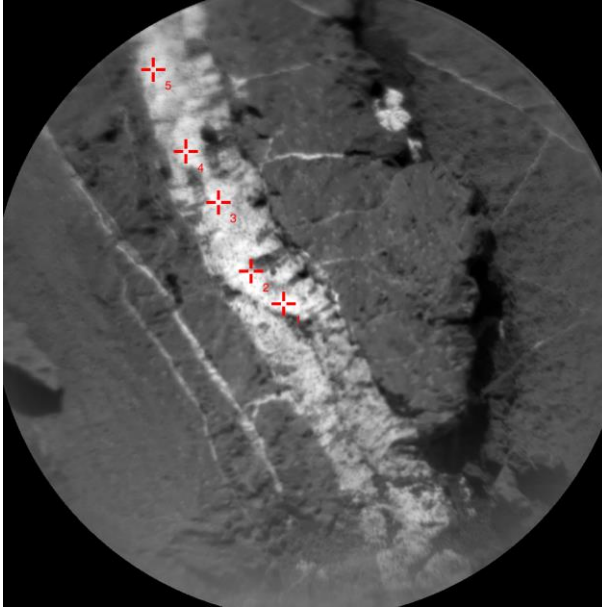
# DOTS: Diverse Onboard Target Selection

Given TextureCam output, select a set of distinct targets

Example: exposed, fractured rock



# OnRAMP: Onboard Raster and Mosaic Planner



Given a feature identified with TextureCam, follow the feature with a LIBS raster (left), or cover the feature with a Mastcam mosaic (right).

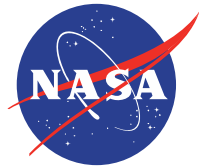
# Demonstration: Athena Rover

- Autonomous science capabilities were integrated with other self-reliant rover systems for the Athena testbed rover.
- A geologic “contact” in the mini Mars Yard at JPL served as a test case.
- Demonstrated use of FORC to find contact and OnRAMP to plan follow-up mosaic (video)

# Conclusions

- Future rover missions could use a walkabout approach to collect preliminary data while rover is out of contact with operators on Earth.
- We have identified several capabilities that would be useful to scientists during a walkabout.
- These capabilities help decide both what to measure and how to measure it, given scientist guidance.
- We have performed an initial demonstration of these capabilities, with future studies to follow.





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