

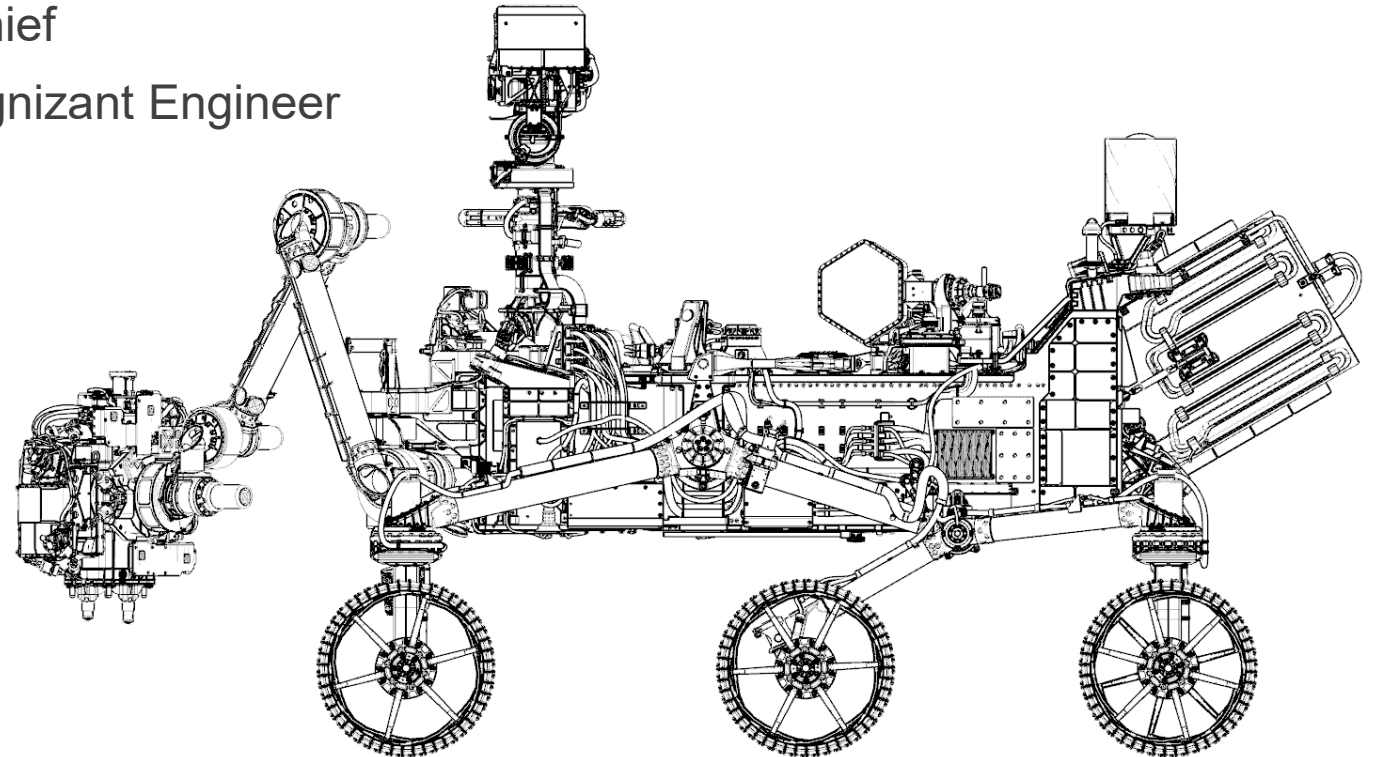
Science Intent Capture Architecture

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MARS 2020
PROJECT

M2020 Science Intent Architecture Overview

Mission Objective: Identify opportunities for, and acquire rock and soil samples during its mission.

Challenge: The different levels of science planning, from high-level strategic mission planning to daily tactical planning, needs to be more closely coordinated than on previous Mars surface missions in order to ensure that the sampling objectives of the mission in Jezero crater are accomplished.

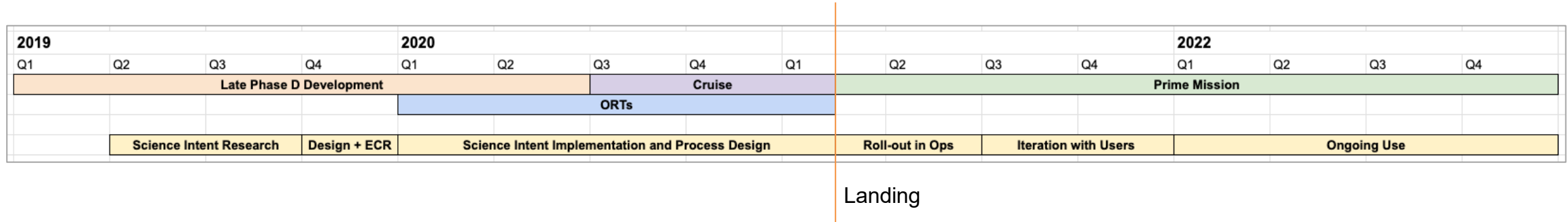
Strategy: Facilitate alignment of the science team around the objectives of the mission in order to improve collaborative decision making, and help it to be more efficient and strategic

Solution: A cross-cutting software architecture that links the science objectives for each Campaign to all the pertinent planning and analysis tools so that these objectives are present as guideposts to the Science Team throughout the Science Planning processes.

Science Intent Architecture Primary Goals

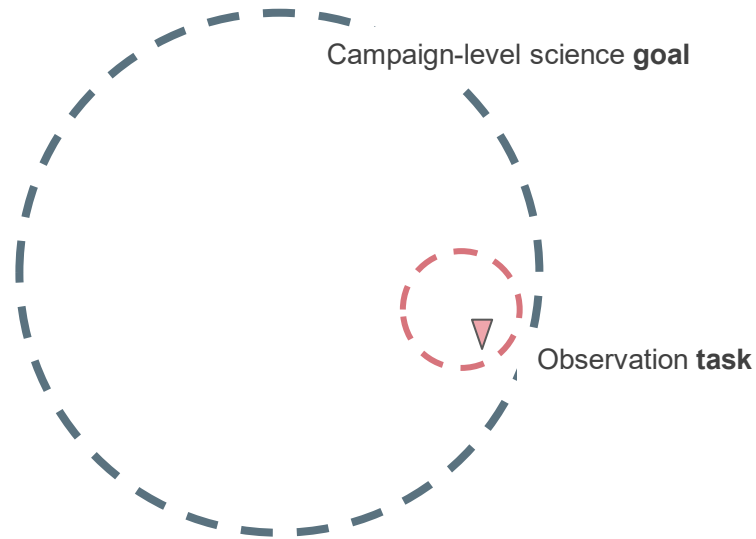
- **Decision making**
Capture science rationale for observations as relates to the broader objectives for each rover location in the team's planning tools. This can help facilitate decision-making about priorities, observation design, and to provide transparency to the team around these rationale.
- **Handoff sol to sol and process to process**
Provide a mechanism for consistent visibility into science intent as part of handoff guidance
- **Tracking Progress**
To provide a central science intent tracking tool to manage and understand the team's progress towards accomplishing science goals at each rover location.
- **DL Analysis context**
Enhance Downlink Analysis of science data by linking science rationale for observations with their associated data products
- **Searchable historical archive**
Record of science rationale mapped to observations at each campaign (included in the PDS as of release 4)

Development and Rollout Timeline



- Began work in late phase D
- Added Science Intent Architecture design to existing near-complete GDS
- ECR-ed work into mission Oct 2019, 15 months before landing
- Built out solution and associated process design in time for landing
- Incorporated use in science team procedures and included in Strategic, mid-range and Tactical Planning
- Iterated on design during the first year of operations
- Continued use for second year of prime mission, and ongoing

Science Intent - Goals and Tasks



Goal

High-level science objective that is addressed via observation outcomes.

Task

Investigation of a specific aspect of a Goal, via one or more observations.

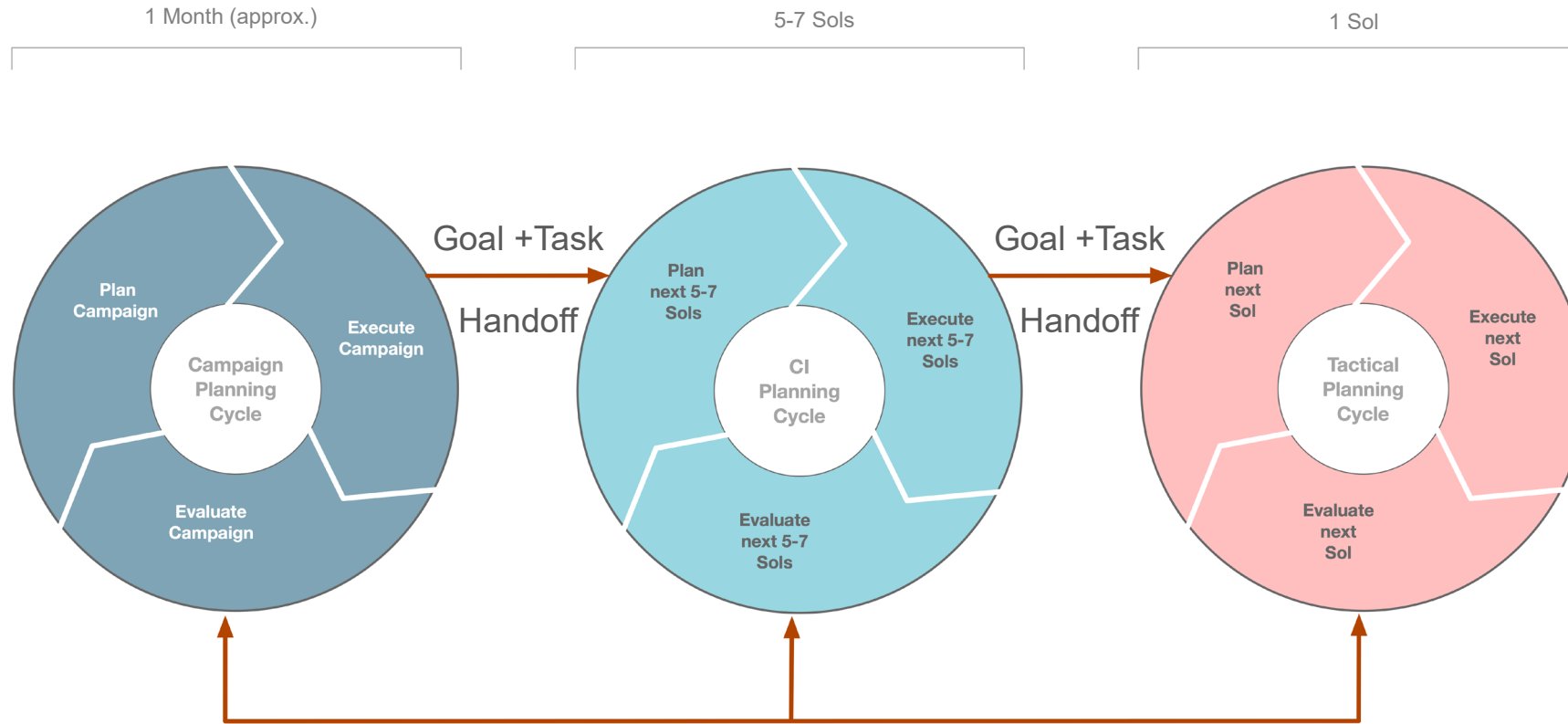
Goals – *written at campaign scale*

These statements describe the higher-level science questions we want to address at a location, and are used to define the science that will be done at that location.

Tasks – *written for the scale of observations*

These are a defined set of more granular objectives that, when carried out, will inform our understanding of the broader science question that a Goal describes. Each Task should lead to one or more observations, and tell you the “what” and the “why” – what feature are you observing, with what technique, and why does this help us address the relevant Goal?

Science Intent — Planning Phase Iteration



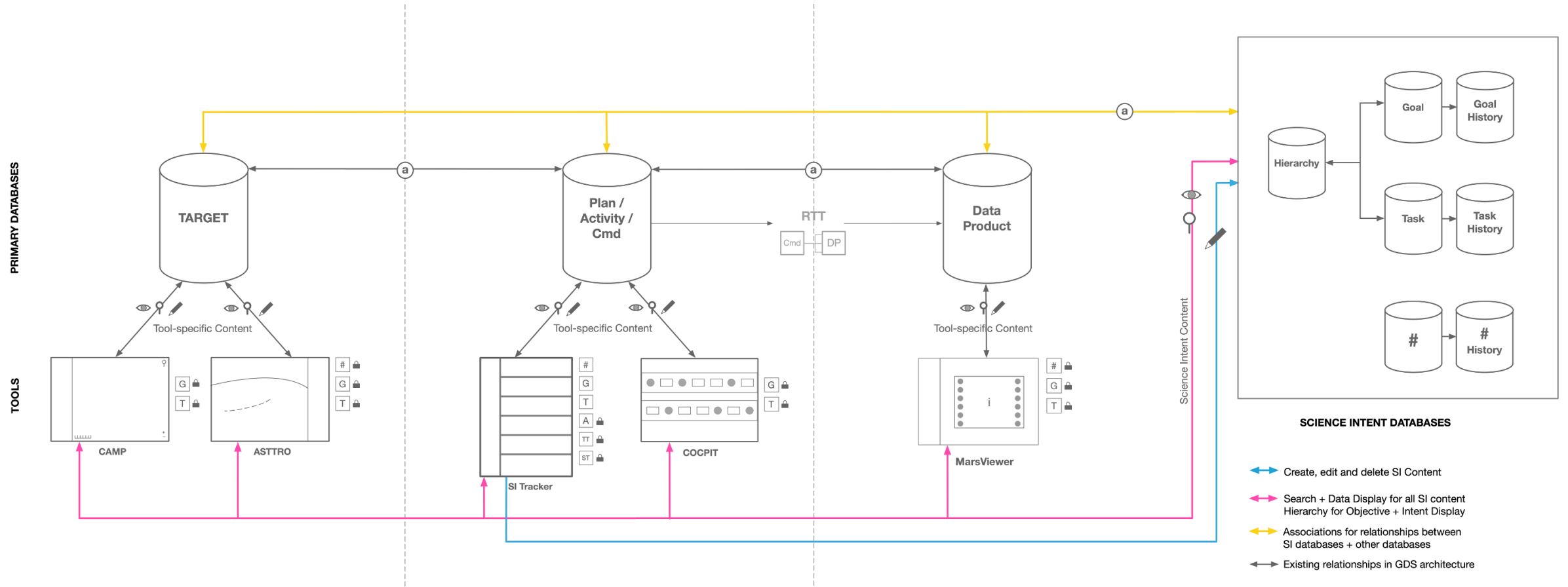
Goal and Task Updates Informed by Other Processes

Science Intent – During Planning Phases

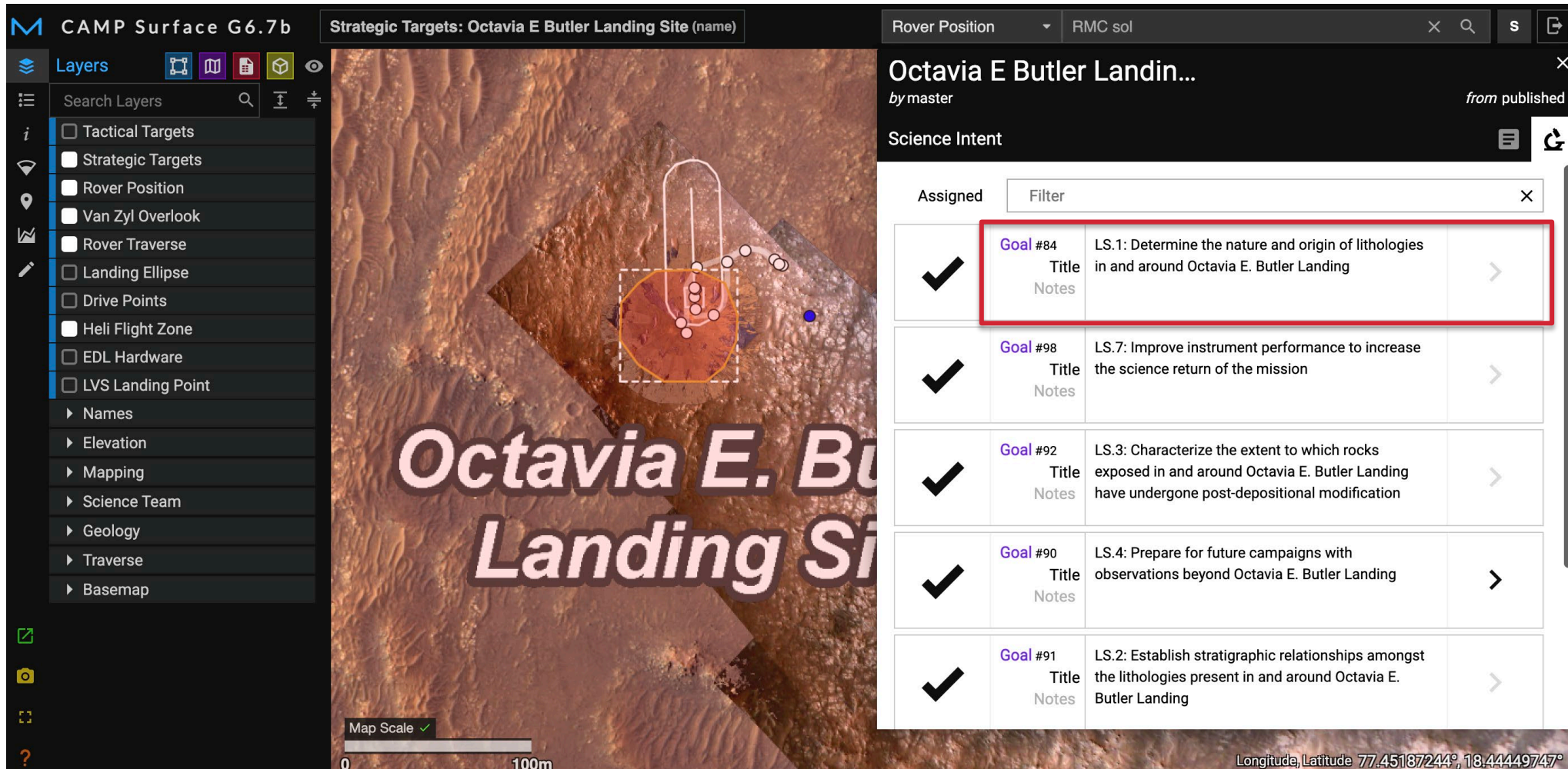
Goals and Tasks in the Planning Phases

- During **Campaign Planning**, a set of Goals and notional Tasks is defined for the campaign.
- As a product of **Campaign Implementation**, relevant Goals are identified for the next few sols, and a set of Tasks are identified and/or created to address these Goals at this location. New insights from the previously executed Tasks inform each Goal, and also inform the definition of new Tasks if needed.
- On the **Tactical Shift**, the set of Tasks notionally provided by CI is reviewed and mapped to actual Activities and Targets in the plan. As the team makes progress on accomplishing these Tasks and Goals, this progress is documented and accessible, via the tools, in all of the processes so that each planning group has the most recent information to revise their plan.

Science Intent Architecture



CAMP – Goals for a Campaign




The screenshot displays the CAMP Surface G6.7b interface. The central map shows the Octavia E. Butler Landing Site with a rover position and various tactical and strategic targets overlaid. A sidebar on the left lists layers such as Tactical Targets, Strategic Targets, Rover Position, Van Zyl Overlook, Rover Traverse, Landing Ellipse, Drive Points, Heli Flight Zone, EDL Hardware, and LVS Landing Point. A right-hand panel titled 'Octavia E Butler Landin...' shows a list of assigned science goals. The first goal, Goal #84, is highlighted with a red box.


Assigned	Filter	
✓	Goal #84	LS.1: Determine the nature and origin of lithologies in and around Octavia E. Butler Landing
	Title	
	Notes	
✓	Goal #98	LS.7: Improve instrument performance to increase the science return of the mission
	Title	
	Notes	
✓	Goal #92	LS.3: Characterize the extent to which rocks exposed in and around Octavia E. Butler Landing have undergone post-depositional modification
	Title	
	Notes	
✓	Goal #90	LS.4: Prepare for future campaigns with observations beyond Octavia E. Butler Landing
	Title	
	Notes	
✓	Goal #91	LS.2: Establish stratigraphic relationships amongst the lithologies present in and around Octavia E. Butler Landing
	Title	
	Notes	


Map Scale: 0 100m

Longitude, Latitude: 77.45187244°, 18.44449747°

SI Tracker – Goal + Task Tracking View


G6.8 Tracker Keywords Goals Tasks Connections



Science Intent Tracker 

Octavia E Butler Landing Site

campaign overview (7 goals / 41 tasks)

Goals
Sols

[campaign details >](#)

Goals (7)

Goal #84

LS.1: Determine the nature and origin of lithologies in and around Octavia E. Butler Landing

To Do

5 tasks >>

Tasks (41 total)

To Do
In Progress
Done

Task #286

1. Acquire contextual observations of outcrop structure and stratigraphy

Task #265

2. Acquire grain-scale texture observations of rocks around the landing site

Task #287

3. Acquire elemental

In Progress

Nothing in progress

Done

Nothing done

Sort By Status

SI Tracker – Detail View

SI G6.8 Tracker Keywords Goals Tasks Connections
schmidt

Science Intent Tracker 🔒

Octavia E Butler Landing Site

Octavia E Butler Landing Site ↕ 🔄

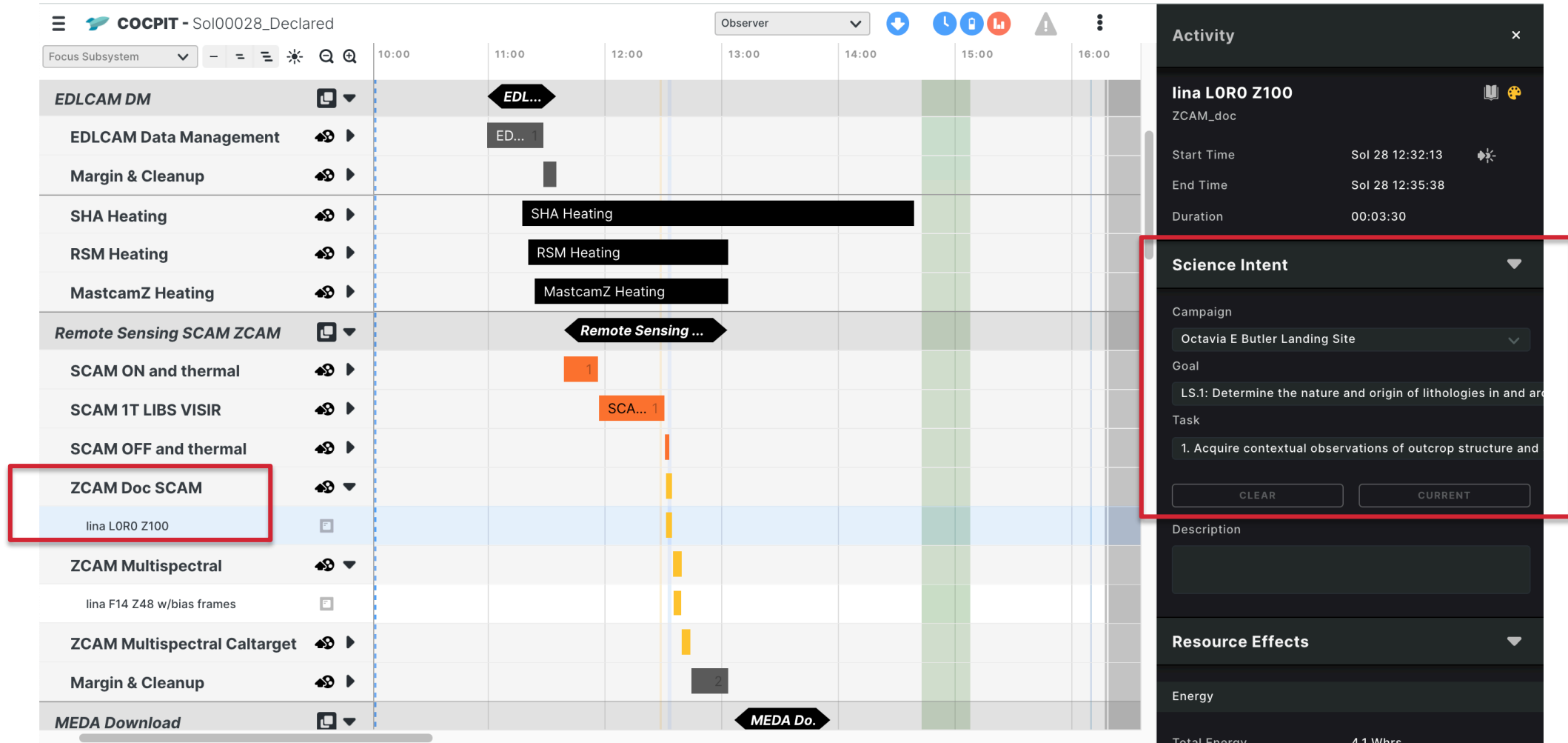
campaign details (7 goals) ⏮ ⏭ Goals Sols ← campaign overview

Goal #84 To Do details » 5 tasks ▾

LS.1: Determine the nature and origin of lithologies in and around Octavia E. Butler Landing

Tasks	Notes	Sols	Activities	Targets	Products
Task #286 details » To Do 1. Acquire contextual observations of outcrop structure and stratigraphy	e.g., Navcam, Hazcam, ZCAM, RMI, WATSON	28	lina LORO Z100	lina	MV DD
Task #265 details » To Do 2. Acquire grain-scale texture observations of rocks around the landing site	e.g., ZCAM, RMI, WATSON	15	tselhchee_scam_LORO_Z100	Tselhchee	MV DD
		46	Caltarget F14 Z48 w/ bias L7R7		MV DD
		46	Peppermint and Prickly Pear pavers 25 LORO Z110 w/ 1 LORO Z34	Peppermint	MV DD
		46	Peppermint paver	Peppermint	MV DD

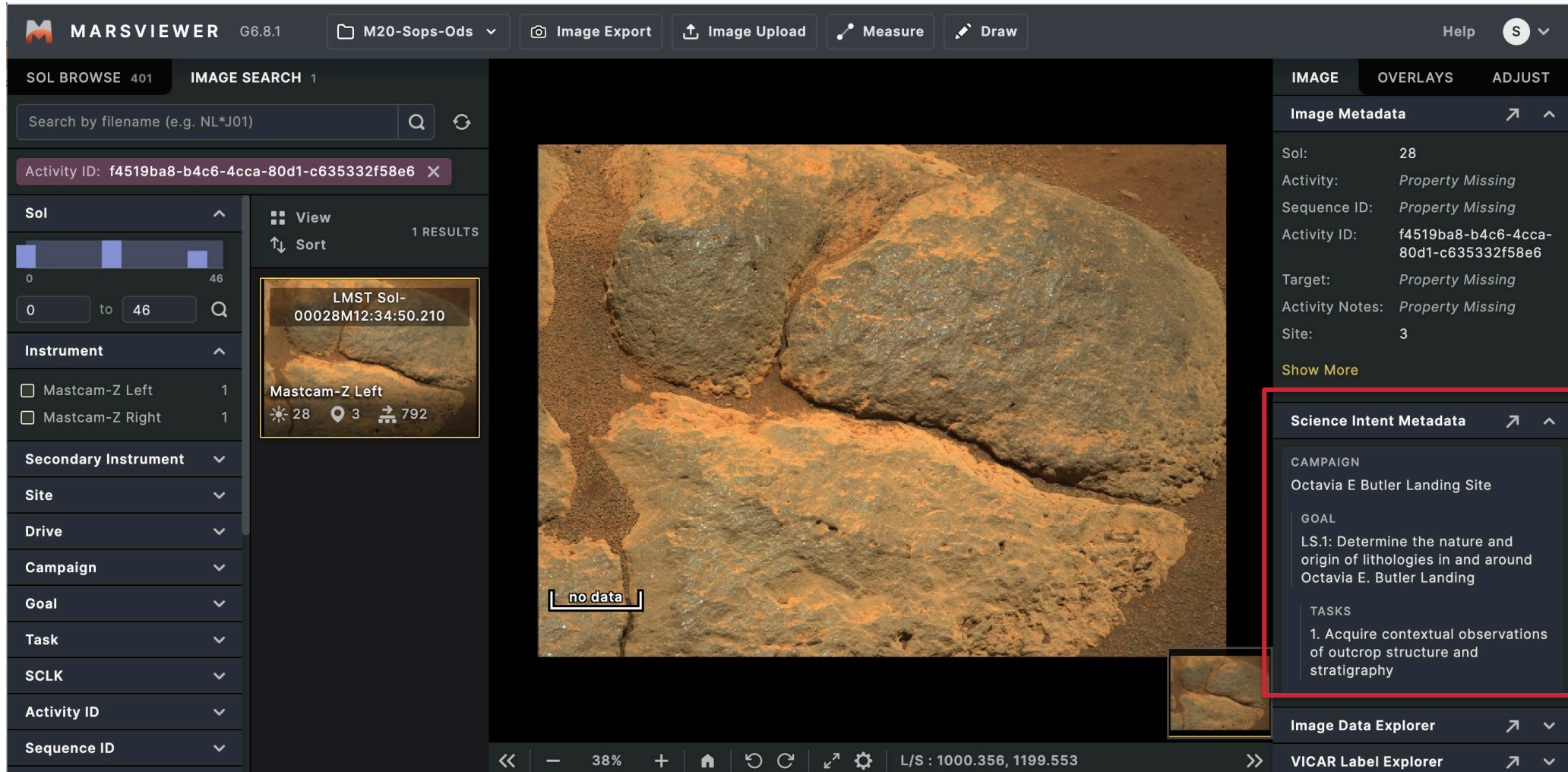
COCPIT – Goal + Task Associated to an Activity



The screenshot displays the COCPIT interface for Sol00028_Declared. The main view is a Gantt chart showing various activities over time from 10:00 to 16:00. A red box highlights the 'ZCAM Doc SCAM' activity, which includes the sub-activity 'lina LORO Z100'. A detailed view of this activity is shown on the right, also highlighted with a red box. The detailed view includes the following information:

- Activity:** lina LORO Z100
- Start Time:** Sol 28 12:32:13
- End Time:** Sol 28 12:35:38
- Duration:** 00:03:30
- Science Intent:**
 - Campaign: Octavia E Butler Landing Site
 - Goal: LS.1: Determine the nature and origin of lithologies in and around the landing site
 - Task: 1. Acquire contextual observations of outcrop structure and composition
- Resource Effects:**
 - Total Energy: 4.1 Whrs

MarsViewer– Goal + Task Metadata on Image



The screenshot displays the MarsViewer interface with the following components:

- Top Bar:** MARSVIEWER G6.8.1, M20-Sops-Ods, Image Export, Image Upload, Measure, Draw, Help, S.
- Left Panel:**
 - SOL BROWSE 401, IMAGE SEARCH 1
 - Search by filename (e.g. NL*J01)
 - Activity ID: f4519ba8-b4c6-4cca-80d1-c635332f58e6
 - Sol: 0 to 46
 - Instrument: Mastcam-Z Left (1), Mastcam-Z Right (1)
 - Secondary Instrument, Site, Drive, Campaign, Goal, Task, SCLK, Activity ID, Sequence ID
- Center Panel:**
 - View, Sort, 1 RESULTS
 - Thumbnail: LMST Sol-00028M12:34:50.210, Mastcam-Z Left, 28, 3, 792
 - Main Image: A large rock formation on Mars with a "no data" label at the bottom.
 - Zoom: 38%
 - Coordinates: L/S : 1000.356, 1199.553
- Right Panel:**
 - IMAGE, OVERLAYS, ADJUST
 - Image Metadata: Sol: 28, Activity: Property Missing, Sequence ID: Property Missing, Activity ID: f4519ba8-b4c6-4cca-80d1-c635332f58e6, Target: Property Missing, Activity Notes: Property Missing, Site: 3.
 - Science Intent Metadata (highlighted in red):
 - CAMPAIGN: Octavia E Butler Landing Site
 - GOAL: LS.1: Determine the nature and origin of lithologies in and around Octavia E. Butler Landing
 - TASKS: 1. Acquire contextual observations of outcrop structure and stratigraphy
 - Image Data Explorer, VICAR Label Explorer

SI Tracker – Keywords Creation + Management

SI
G7.2 Tracker Keywords Goals Tasks Connections

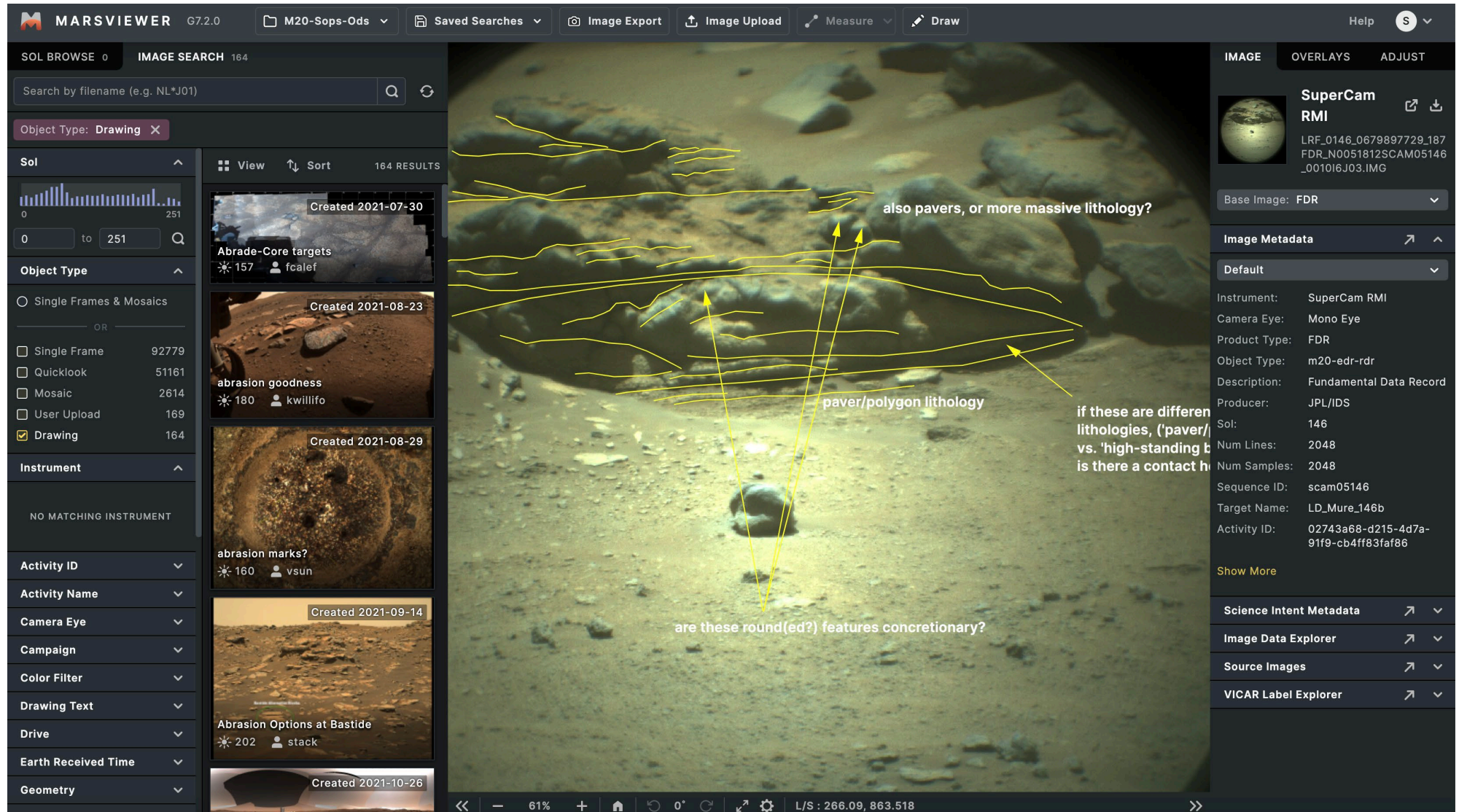
Keywords

↻
⬇
✕

+ Add New Keyword

- ▶ Atmosphere +
- ▶ Biosignatures +
- ▶ Compounds +
- ▶ Elements +
- ▶ General Descriptive +
- ▼ Landscape +
 - ▶ Age +
 - Formation +
 - Landscape Features +
 - Landscape Properties +
- ▶ Minerals +
- ▶ Mission +
- ▶ Rocks +

MarsViewer– Annotations, Keywords on Image



MARSVIEWER G7.2.0 M20-Sops-Ods Saved Searches Image Export Image Upload Measure Draw Help

SOL BROWSE 0 IMAGE SEARCH 164

Search by filename (e.g. NL*J01)

Object Type: Drawing

Sol View Sort 164 RESULTS

Created 2021-07-30
Abrade-Core targets
157 fcalef

Created 2021-08-23
abrasion goodness
180 kwillifo

Created 2021-08-29
abrasion marks?
160 vsun

Created 2021-09-14
Abrasion Options at Bastide
202 stack

Created 2021-10-26

also pavers, or more massive lithology?

paver/polygon lithology

if these are different lithologies, ('paver' vs. 'high-standing b... is there a contact h...

are these round(ed?) features concretionary?

IMAGE OVERLAYS ADJUST

SuperCam RMI
LRF_0146_0679897729_187
FDR_N0051812SCAM05146_001016J03.IMG

Base Image: FDR

Image Metadata

Default


Instrument: SuperCam RMI
Camera Eye: Mono Eye
Product Type: FDR
Object Type: m20-edr-rdr
Description: Fundamental Data Record
Producer: JPL/IDS
Sol: 146
Num Lines: 2048
Num Samples: 2048
Sequence ID: scam05146
Target Name: LD_Mure_146b
Activity ID: 02743a68-d215-4d7a-91f9-cb4ff83faf86

Show More

Science Intent Metadata
Image Data Explorer
Source Images
VICAR Label Explorer

61% L/S : 266.09, 863.518

Rock Atlas – Catalog of features w/ Keywords



[Team Resources](#)
[Strategic Planning](#)
[Pre-Landing](#)
[Working/Planning Groups](#)
[Science Team Meetings](#)
[The Rock Atlas](#)
[EDIT LINKS](#)

The Rock Atlas

Team Resources

The Rock Atlas

End of Sol Reports

Spectral Library

Instrument Resources

Science Activity Requests

Science Team Guidelines

Outreach Materials

Publications

Conferences

Housekeeping

Student Theses

Science Team Meetings

Mars Time

Recent


- Sample Initial Reports
- SAR Cards
- Blog Library
- Blog List
- Blog Calendar

Blog Logistics

Site Contents

[EDIT LINKS](#)

Filter
Sort
...



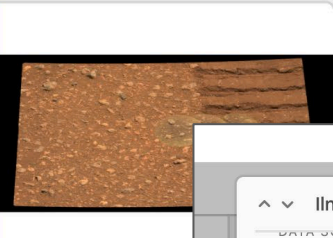
Ilina

SOL
28

CAMPAIGN
Octavia E Butler Landing Site

DATA TYPES
IR LIBS RMI

STATUS
Complete



Keyah

SOL
30

CAMPAIGN
Octavia E Butler Lan

DATA TYPES
IR RMI

STATUS
Complete

^ v Ilina
✕

DATA SOURCE/DATE/TIME/COMPOSITION

KEYWORD (FROM KEYWORDS)

low relief

dark toned

dust free

smooth

highly reflective

PIXL MCC

Development + Roll-out Challenges

- The science intent solution, and also the processes that it supports, were new
- Work began late in phase D when all other GDS tools had been built, tool budgets had been allocated, and the GDS architecture was complete
- The overall mission science operations processes were being designed in parallel to this architecture
- These processes, as they matured in early operations, addressed the core need for more strategic science intent alignment, decision making and planning than on the previous mission. This was a significant evolution from MSL processes (whose use cases informed the science intent architecture).
- The architecture includes an interface with the mission's uplink plan-building tool, which (due to lack of time for performance testing of the architecture prior to landing) caused the core science intent tool to load slowly in early operations
- Since the new operations process provided an alternative to using the science intent architecture, the architecture was fragile to loading issues for user adoption

What We Actually Accomplished

- **Decision making**

Is addressed primarily through process and definition of a key new role present in all planning processes – the Long Term Planner (LTP). However the LTPs do use science intent to inform their decision-making and governance of what proposed activities are in scope

- **Handoff sol to sol and process to process**

Is addressed primarily through process and LTPs guidance, as well as robust use by the science team of real time chat tools. Some context from science intent is included in handoff reports.

- **Tracking Progress**

Science Intent is used in strategic and campaign planning along with other planning approaches. However the core Science Intent tool, SI Tracker, is not used for tracking campaign progress as designed.

- **DL Analysis context**

Science Intent statements are present with downlinked science data products to provide some context. However much context also comes from other solutions including science team presentations and detailed documentation in reports

- **Searchable historical archive**

Science Intent is available with science data products as part of the mission's Planetary Data Systems delivery

Lessons Learned

- Designing an architecture for a new process comes with significant uncertainty, and the outcome may vary widely from the initial plan.
- When your solution is not on the team's critical path, it is particularly vulnerable to early mission adoption issues
- When you collaborate on design with key mission operations staff, expect them to be otherwise occupied once prime mission begins
- Testing with realistic data volumes and processes prior to operations is important