MARS SCIENCE LABORATORY

Surface Science Scenarios

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Autonomy Levels

- **A1 - MER-like autonomy scaled for larger rover size**
  - Limited traverse distances without “ground-in-the-loop”
  - 3-sol cycle to approach a rock or soil target
  - Traverse 40-50 m/sol

- **A3 - Enhanced MSL autonomy**
  - Traverse autonomy - ability to safely drive outside of Navcam images
  - Location science autonomy
    - Allows approach of rock or soil to occur from 10m distance to within 1 cm of target in about 1 hour (no “ground-in-the-loop”)

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Surface System Requirements Sample from SDT Report

- The rover shall be capable of traversing up to 3km in less than or equal 13 sols using 1 command cycle per sol or less.
- The minimum traverse per sol capability of the rover shall be 450m unless limited by energy or time constraints (onboard autonomy shall not limit traverse range).
- The rover shall detect all credible hazards.
- The rover shall avoid all credible hazards.
- The rover system shall be able to approach a designated target, deploy the instrument arm, mini-corer, or drill, and begin science activities (measurements or drilling/coring), using only a single command cycle to initiate the full suite of activity.
- The rover system shall allow a sequence of instrument measurements to be commanded to take data as part of initial target designation. The rover vehicle shall then autonomously place instruments onto the target and provide for necessary data collection.
- The rover system shall use on-board state estimation, resource management, and planning in order to execute all other autonomous capabilities in a robust and safe manner with minimal ground interface.

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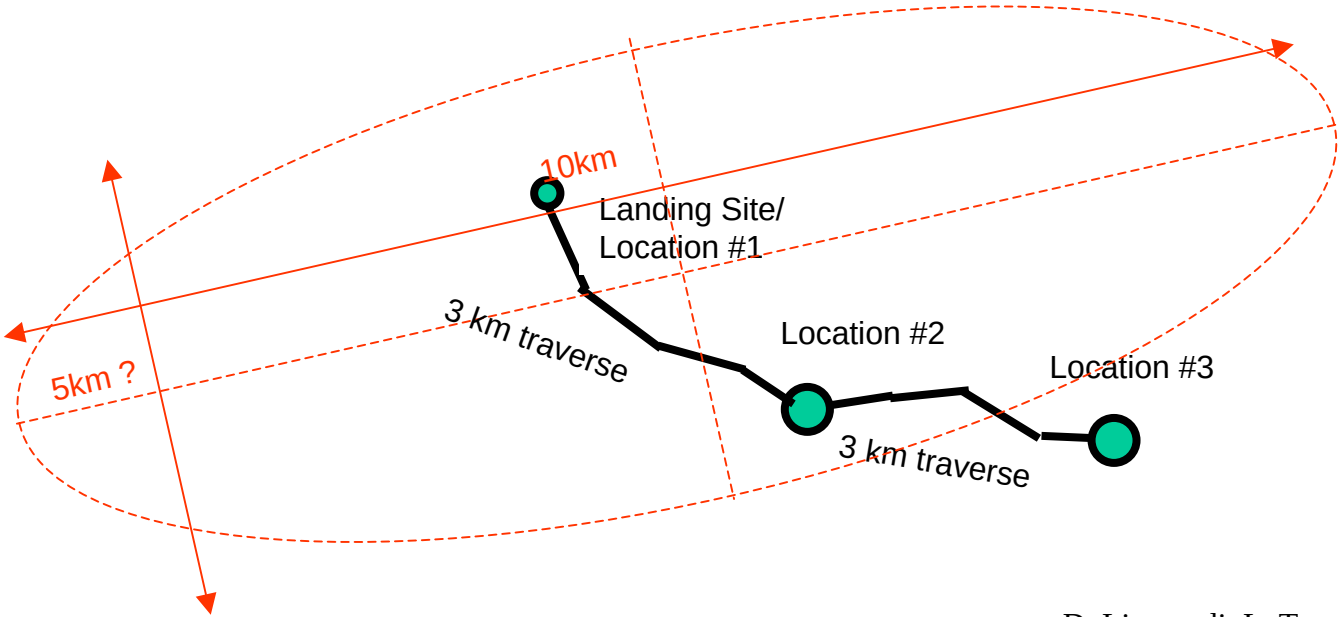
Reference Mission – Big Picture Example

- **Total duration of mission = 1000 sols**
  - 33% margin held on mission duration, so available # of sols = 667
- **Landing season Ls = 160-180**
- **Total distance traversed = ~69 km**
- **23 locations total including landing site**
  - 3 km traverse between locations



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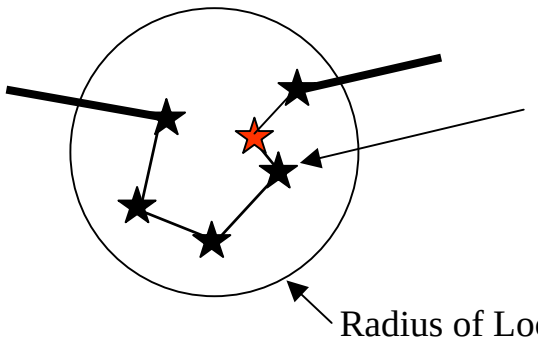
Mission Scenario – Each Location

- **Site reconnaissance and rock/soil analysis:**
  - Once at the location, the rover performs remote science first to investigate the site and to choose the rock and soil targets.
  - Scientists choose which 4 rock targets and 1 soil target to approach.
  - Approach and core soil target. Transfer core to analysis laboratory.



Individual targets will be nominally within 10m of each other, allowing single command cycle movement and instrument placement scheme

Radius of Location is <60m (TBR)

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Mission Scenario – Traverse

- **Traverse:**
  - Before setting out, take 180º Pancam, and other observations behind the rover
  - While driving, use Navcams and Hazcams to avoid obstacles and stay on course
  - Enhancement: Take autonomous observations while driving. Use on-board spectral detection algorithm to identify important signatures. If found, stop and radio home. May also take autonomous Pancam images and playback as downlink is available.
  - At the end of a driving day, take 180º Pancam and other observations in drive direction. Send back overnight.

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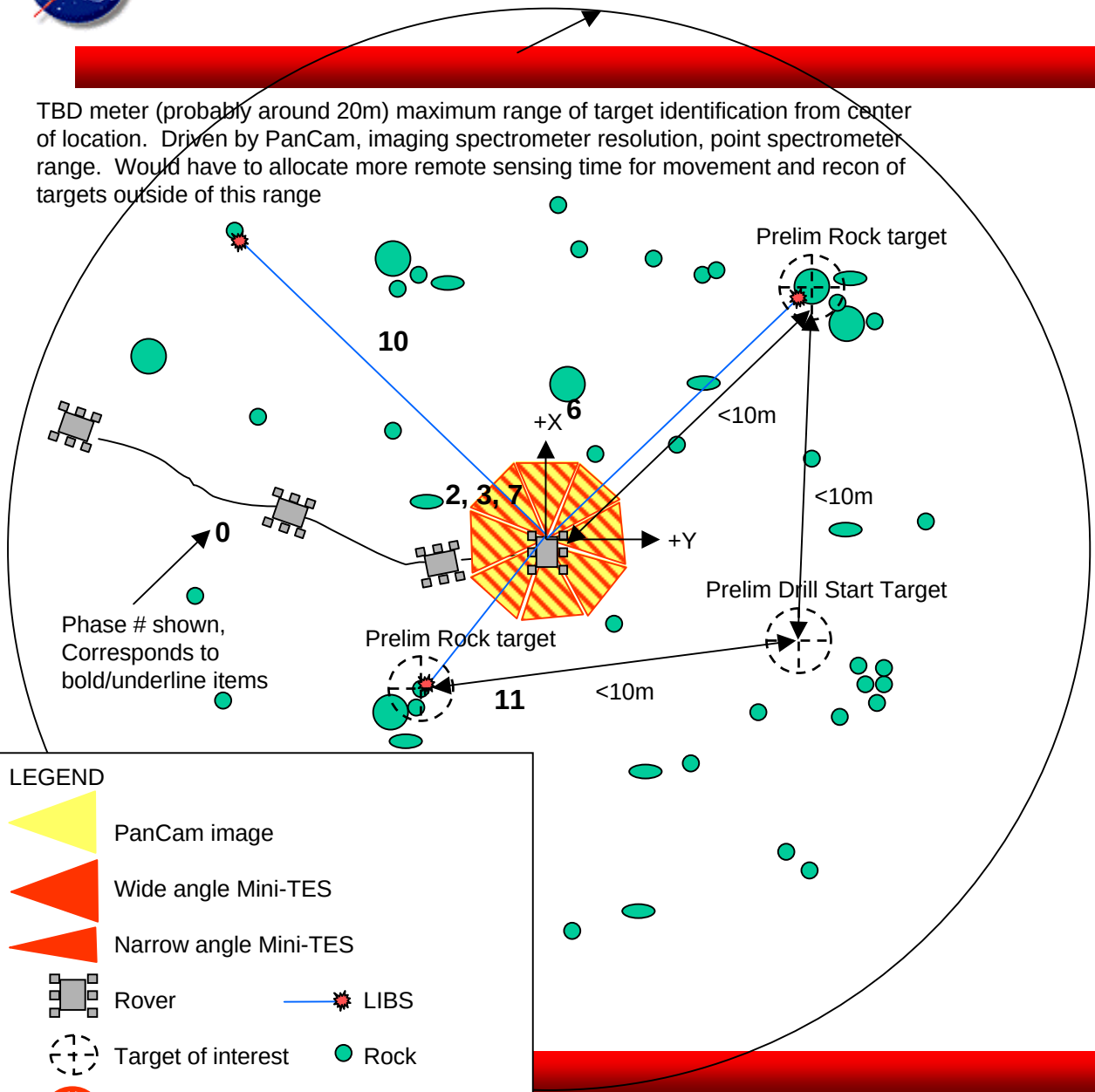
Detail – Site Reconnaissance

TBD meter (probably around 20m) maximum range of target identification from center of location. Driven by PanCam, imaging spectrometer resolution, point spectrometer range. Would have to allocate more remote sensing time for movement and recon of targets outside of this range



0) Rover finishes traverse into location

Sol 1

1) Rover start sol at desired location

2) Take 360 degree panorama with Pancam (probably at least B&W and 1 color)

3) Start 360 panorama with thermal emission spectrometer

4) Downlink data to Earth with UHF and DTE

5) Ground starts figuring out which targets are interesting enough for point spectrometer (LIBS) follow up

6) PanCam data is used to create new coordinate frame for location specific activities

Sol 2

7) Finish 360 panorama with thermal emission spectrometer

8) Finish sending data to Earth with DTE and UHF

Sol 3 & 4

9) Ground uplinks point spectrometer (LIBS) targets to rover (possibly via feature designation, not local coordinate frame)

10) Rover hits targets with LIBS and returns data to Earth

11) Scientists finish preliminary pick of 4 rock targets and drill hole within location (shown with cross-hairs in figure)

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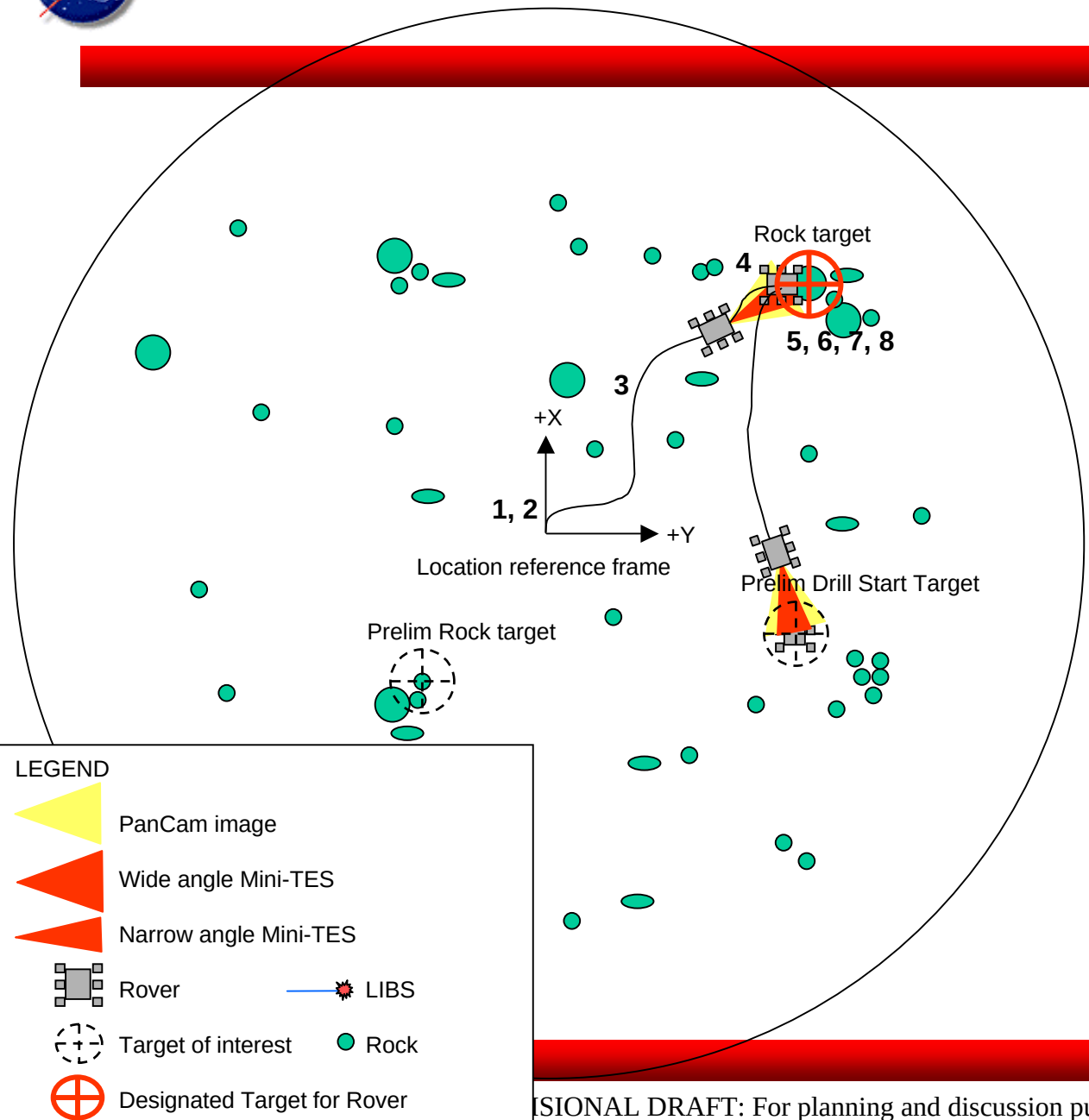
Detail – Rock Analysis



Rock Analysis

3 sols for mini-core only

4-4.5 sols for contact science and mini-core

1) Rover starts from recon site. Recon site local coordinate frame is used as reference throughout location exploration (TBR)

2) 1st target is designated via command uplink from initial location. Step 3-7 should be done autonomously by rover, but key decision of mix of contact science and whether or not mini-core will be acquired will be designated by the ground, or involve ground in the loop.

3) Approach rock target from <10m distance. At some point close to target, stop, take focused full color PanCam and Mini-TES scan of target rock, from the final approach angle to the designated sample point

4) Complete final approach to target

5) If part of sequence, deploy contact sensors, spend roughly 24 hours collecting data (due to integration time of APXS and Mossbauer)

6) If rock is still deemed "interesting enough", deploy mini-corer onto designated point, acquire sample with corer, place into sample transfer system

7) Prepare sample, transfer to analysis instruments

8) Time, energy, and downlink bandwidth permitting, do parallel remote sensing science of general location and next target with PanCam, scanning IR spectrometer, and LIBS

9) Once analysis of sample is complete, ground designates new target and move on (repeat above if rock, see other figure for drilling)

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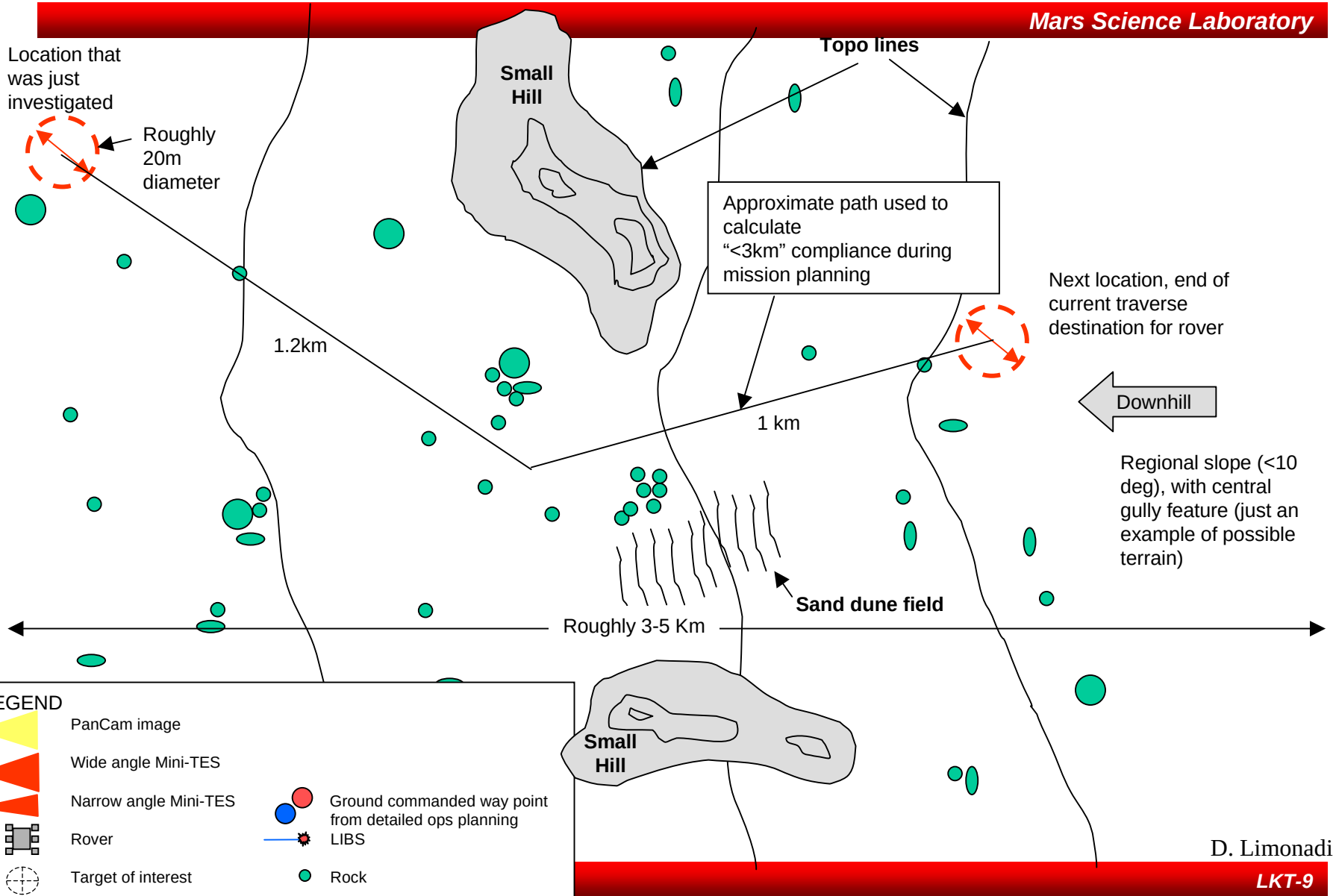
Traverse Operations
Multi-sol View



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Traverse Operations
Multi-sol View

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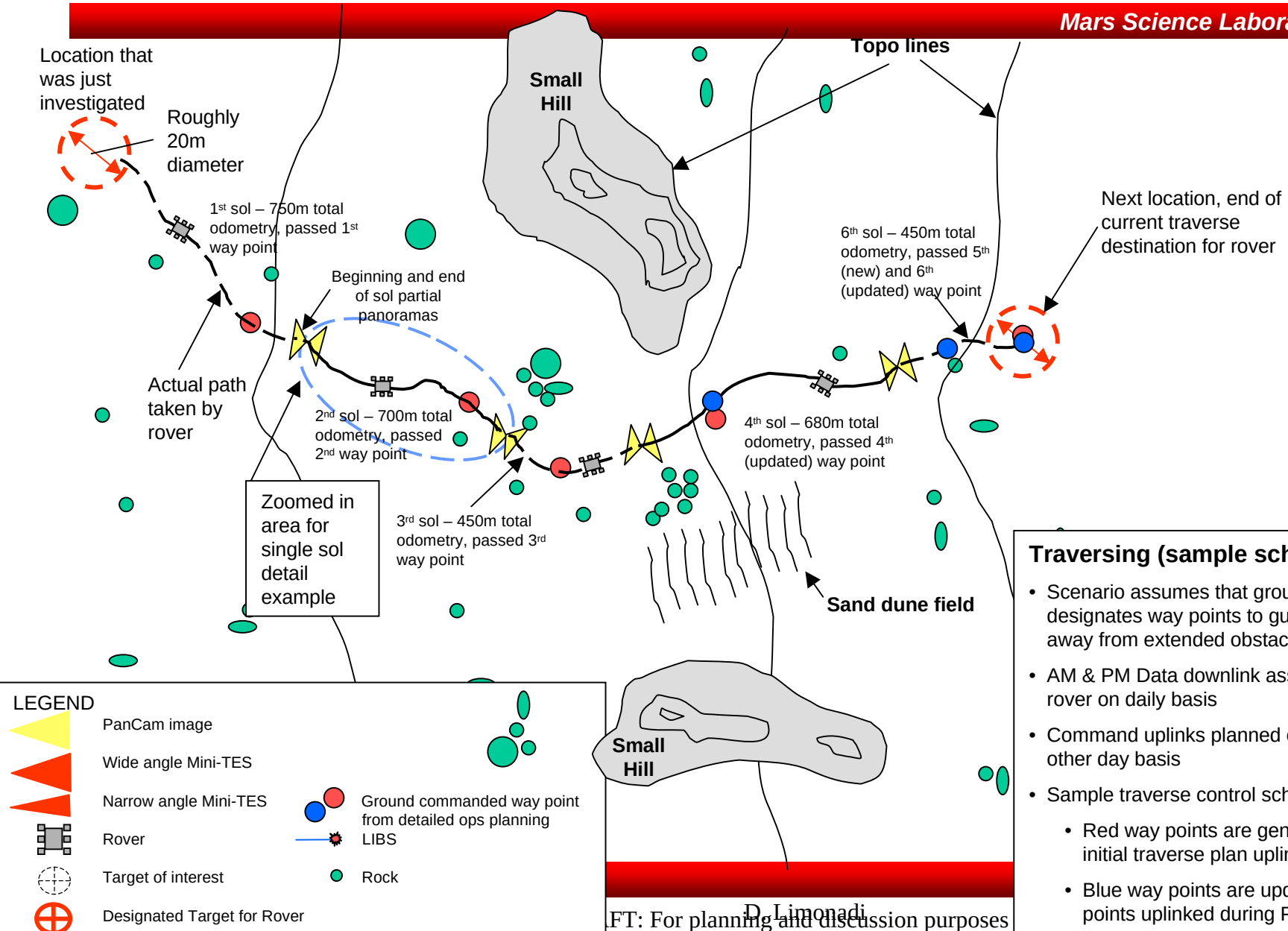
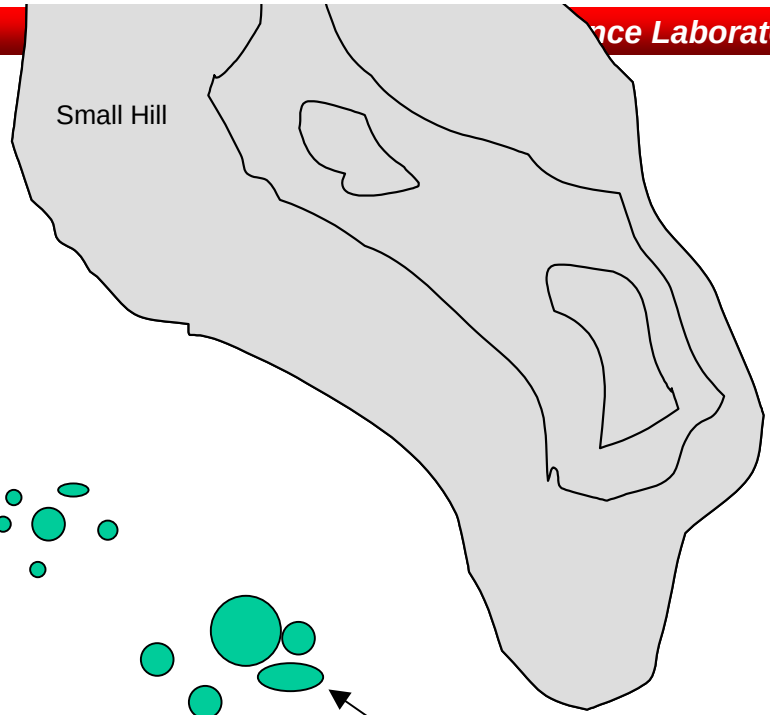


Traversing (sample scheme only)

- Scenario assumes that ground designates way points to guide rover away from extended obstacles
- AM & PM Data downlink assumed from rover on daily basis
- Command uplinks planned on every other day basis
- Sample traverse control scheme:
  - Red way points are generated during initial traverse plan uplinked on Sol 1
  - Blue way points are updated or new points uplinked during PM of sol 3

Traverse Operations
Single-sol View

Detail View of Sol 2 Activities



Beginning of Sol panorama – Looking back toward last sols traverse, may be done at same time as AM communications session

Every 20-30m (TBR), Navcam panoramas are acquired in order to help on board medium scale path planning. At same time science pancam and Mini-TES data may be acquired on "non-interference basis (see inset). There MAY BE on board analysis of science data which is comparing data to pre-defined signatures of carbonates or other targets of interest. If detected, traverse may be halted and information relayed back to Earth

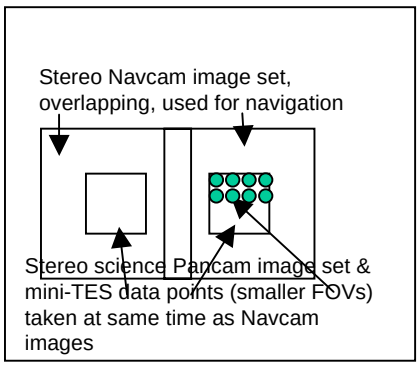
Obstacles visible in orbital imagery

Possible planned OR autonomous traverse science – Science pancam and mini-TES imaging of distant hill, looking for evidence of layering, etc

Obstacles NOT visible in orbital imagery

End of Sol panorama – Looking forward toward next sols traverse, may be done at same time as PM communications session

INSERT Example of low-impact traverse science data collection:



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