Jet Propulsion Laboratory
California Institute of Technology

Mars 2020 Project

Mars 2020 Candidate Landing Site Case Study: Evolution of an Ellipse Placement

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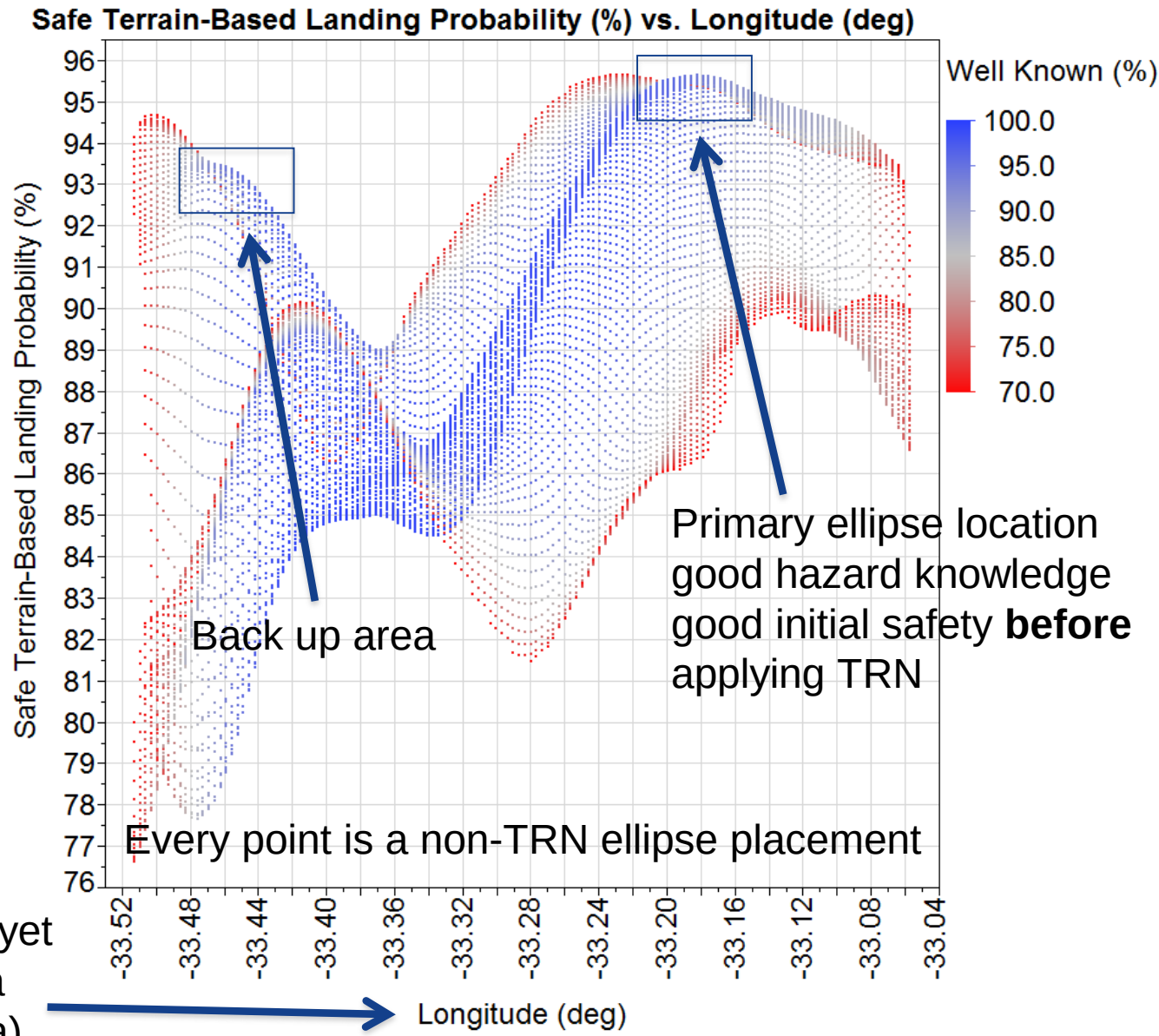
Overview

- Top-8 scientifically ranked sites undergoing an engineering feasibility analysis for M2020 mission
- This is a talk about how the engineering ellipse moved for Eberswalde as our knowledge of the site evolved
- Normally only the final ellipse placement is shown
  - This talk is meant to show the sub-products and reasoning that occurred at Eberswalde
  - Illuminate the journey from the initial ellipse to our current analysis placement

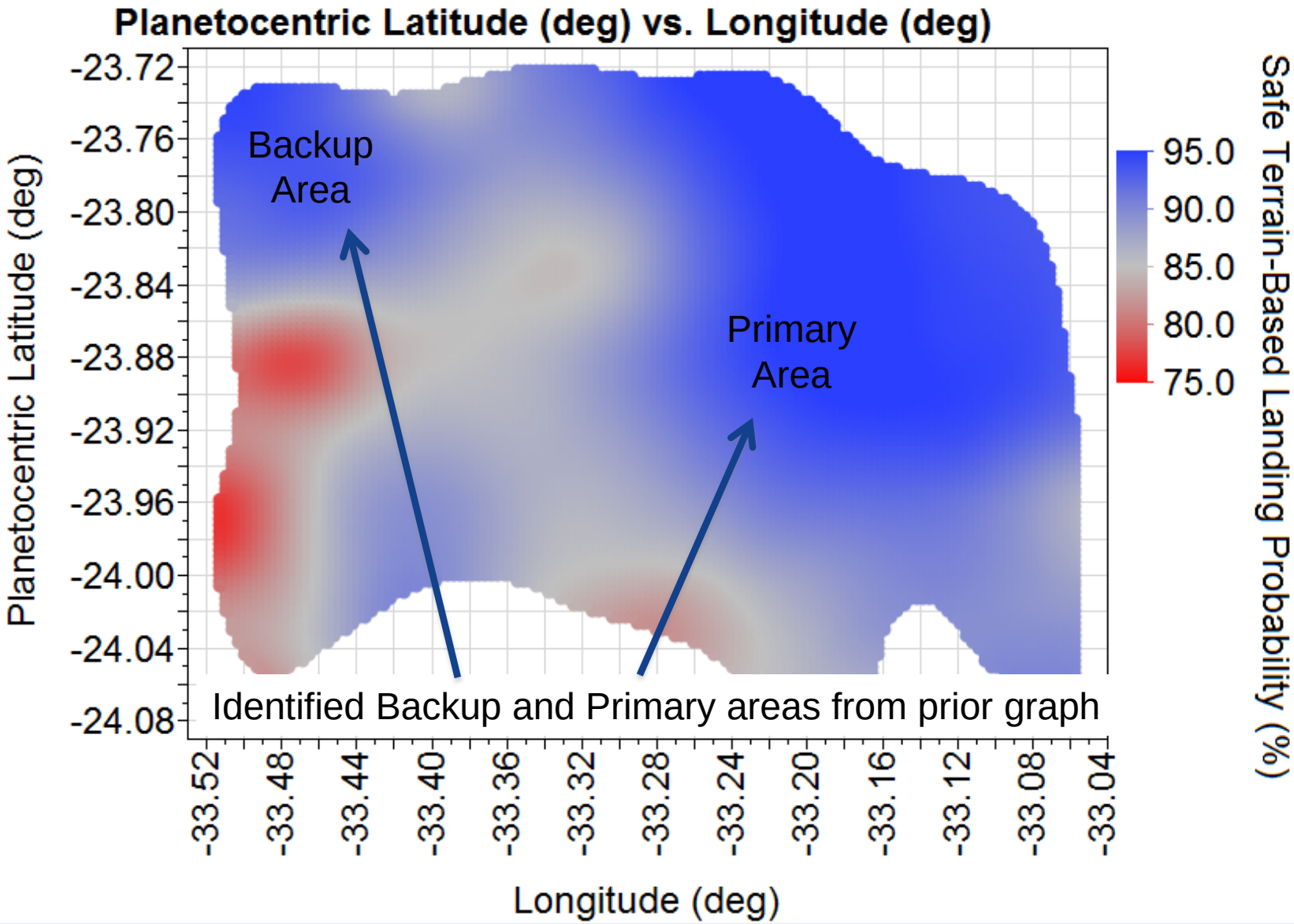
Initial Balancing of Safety and Traversal Story (weighted toward safety)

- Multi-objective plotting was very helpful to get a feel for the domain space
- The science was assumed to improve as one traveled West
- This chart can clarify more complicated traversal stories



Traversal results were not yet ready. West was used as a stand in (toward main delta)

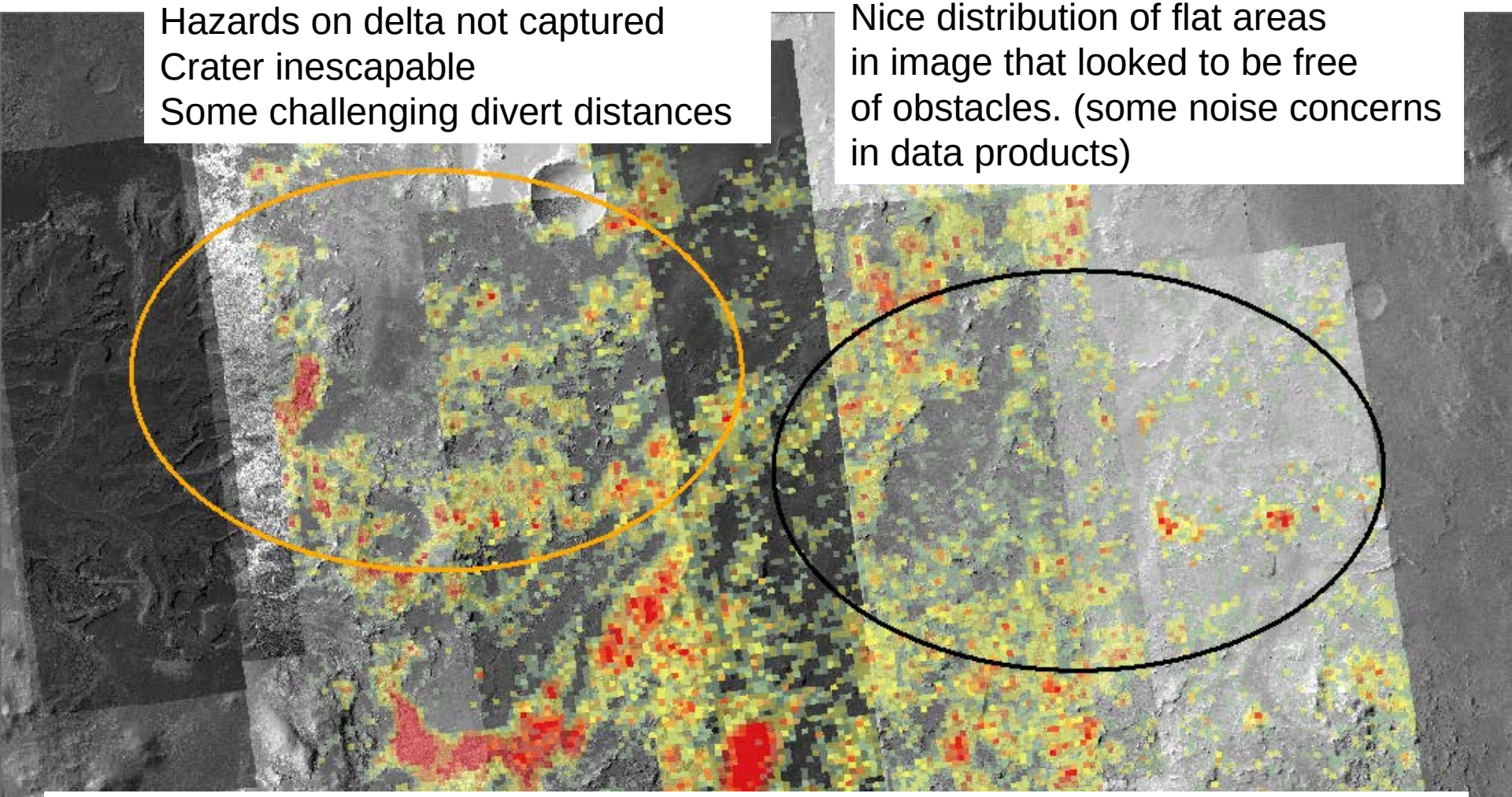
Primary and Backup Areas Identified



Visual Inspection of Terrain for Items Not Captured by the Initial Hazard Analysis

BACKUP AREA
Hazards on delta not captured
Crater inescapable
Some challenging divert distances

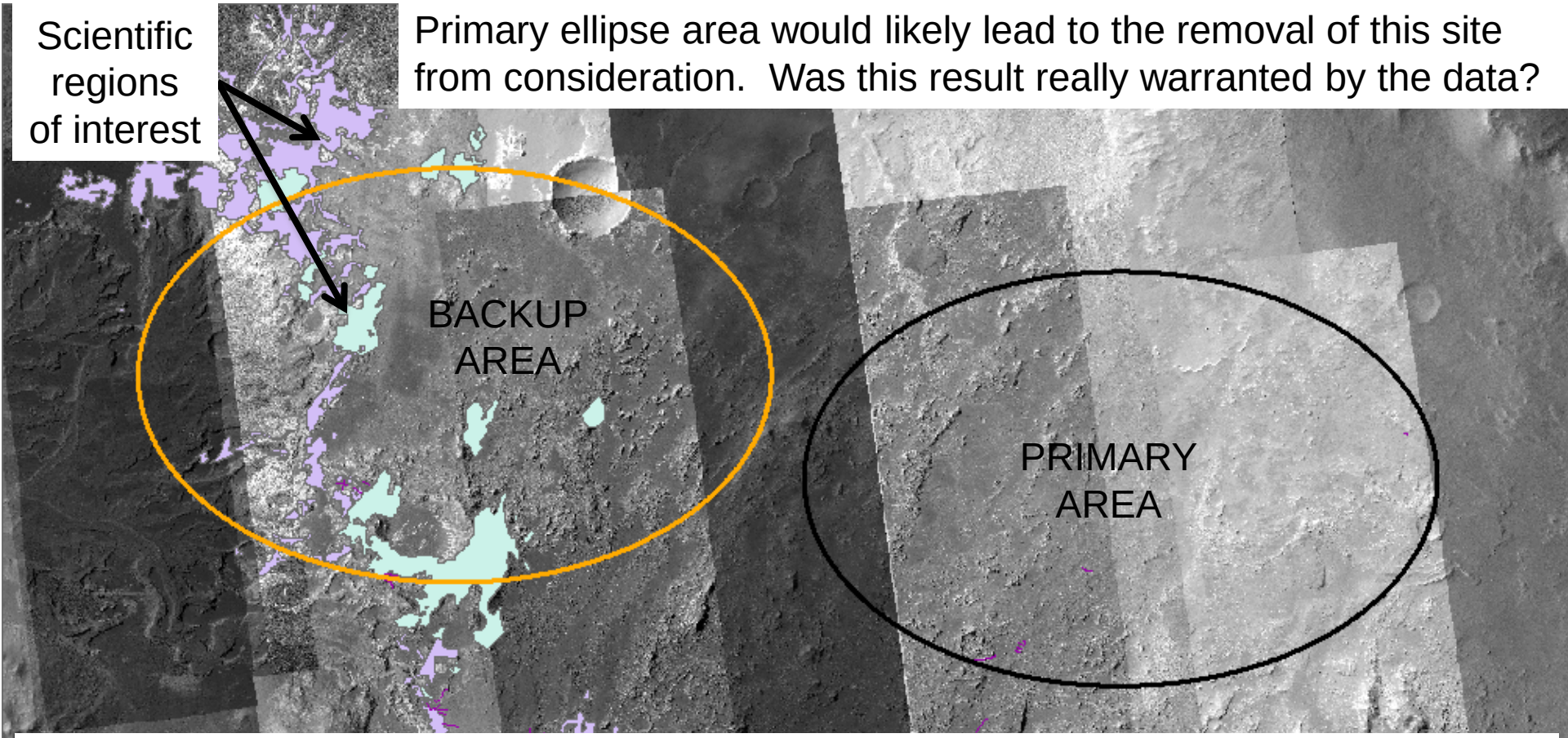
PRIMARY AREA
Nice distribution of flat areas in image that looked to be free of obstacles. (some noise concerns in data products)



Ellipse size an approximation of 50% mesoscale (physics-based) models and 50% engineering (worst case) winds [wide dist tails desired for robust placements]

Problem Discovered: Refined Science Story from Proposers (too far from science)

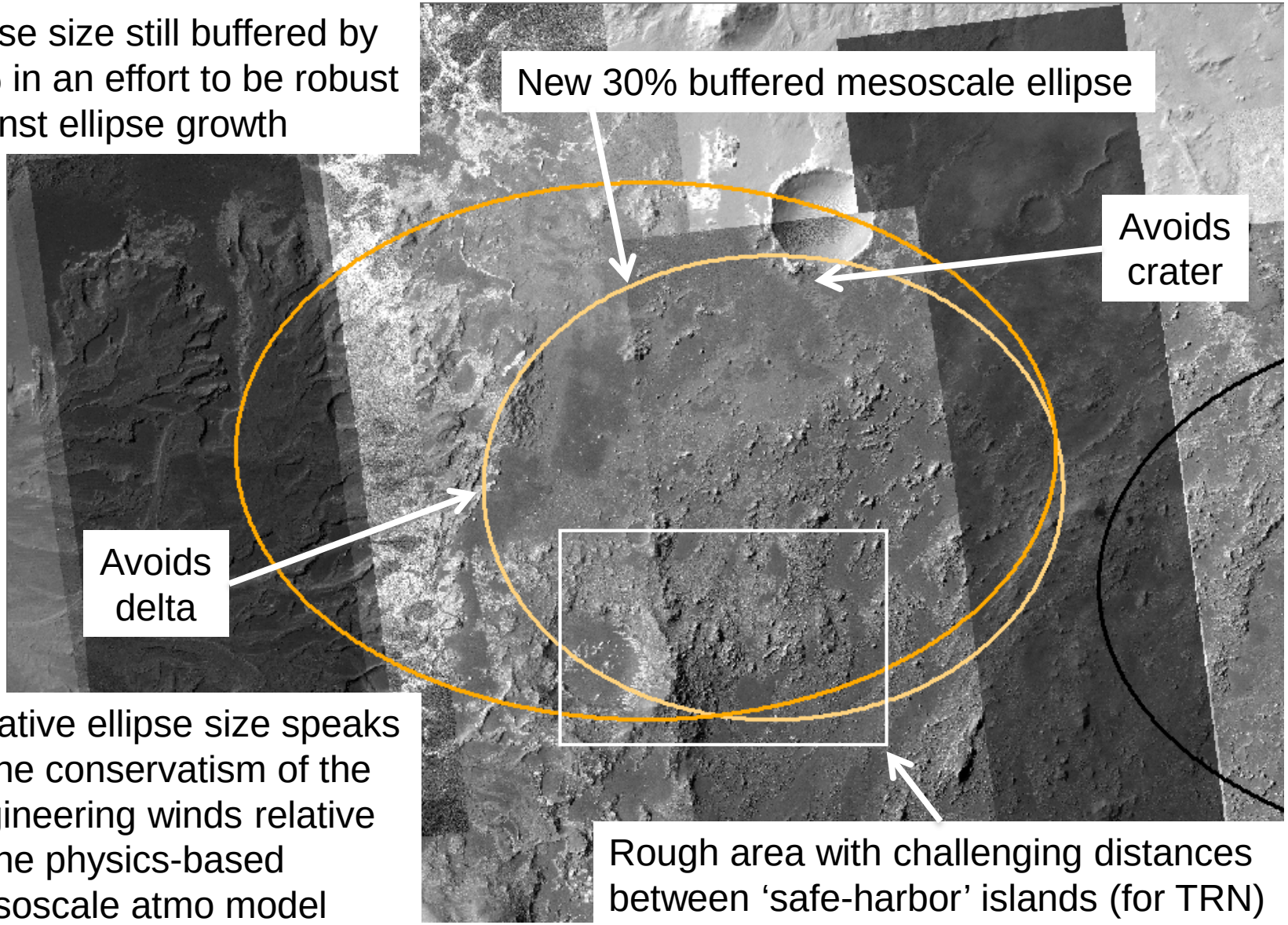
Primary ellipse area would likely lead to the removal of this site from consideration. Was this result really warranted by the data?



Elected to revisit the use of engineering winds [a system stressing assumption used in earlier stages of the EDL design before prepared mesoscale models]. They were known to be un-physically conservative [high wind + same direction + entire trajectory] The backup area still had promise.

Improvement to Fidelity: Removed Engineering Winds from Ellipse Evaluation

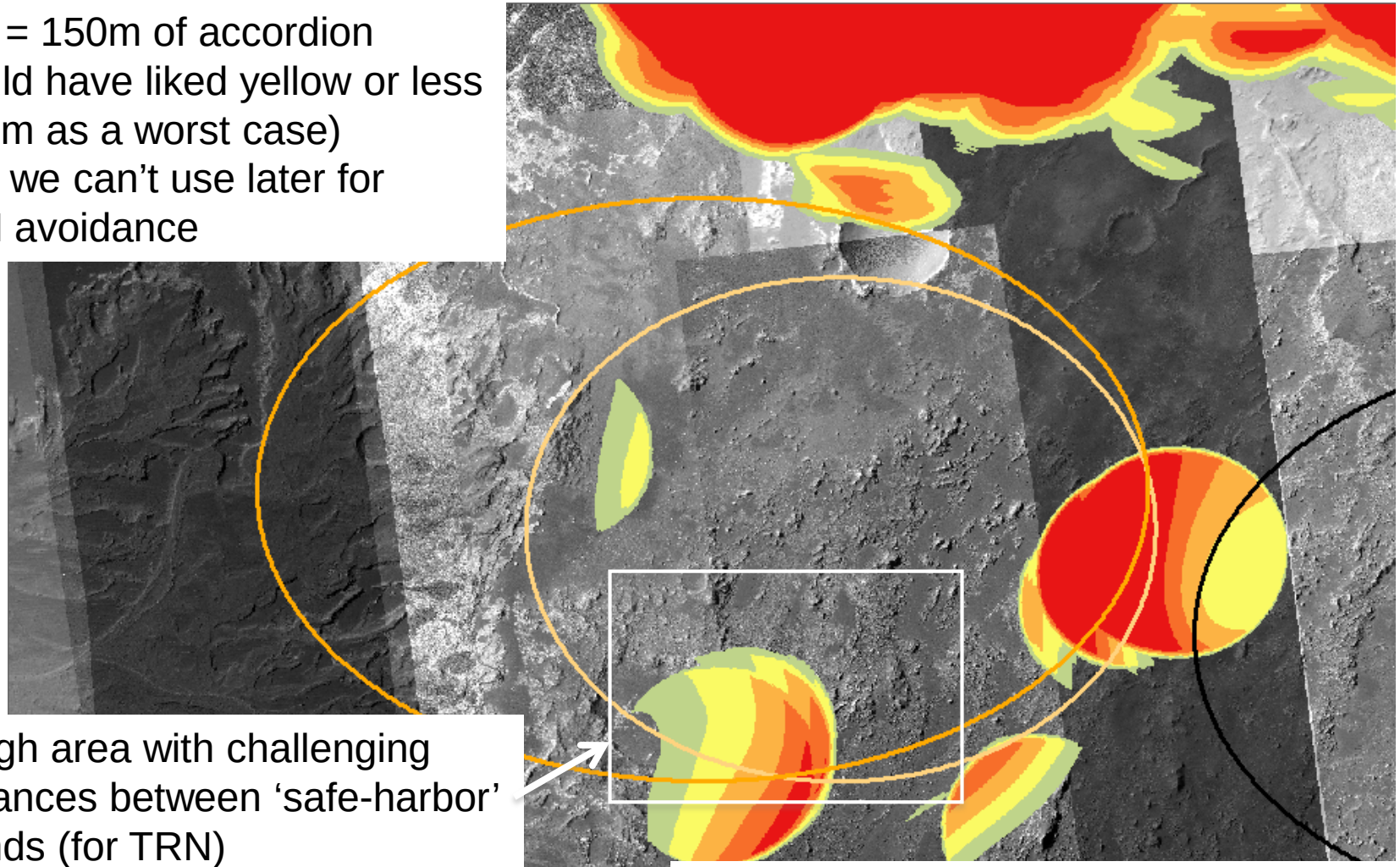
Ellipse size still buffered by 30% in an effort to be robust against ellipse growth



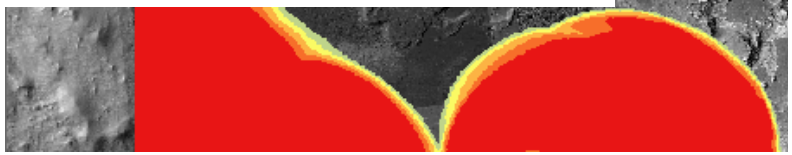
Relative ellipse size speaks to the conservatism of the engineering winds relative to the physics-based mesoscale atmo model

Problem Discovered: Updated Relief Hazard Analysis [worst case shown]

Red = 150m of accordion
Would have liked yellow or less
(130m as a worst case)
Fuel we can't use later for
TRN avoidance



Rough area with challenging
Distances between 'safe-harbor'
islands (for TRN)

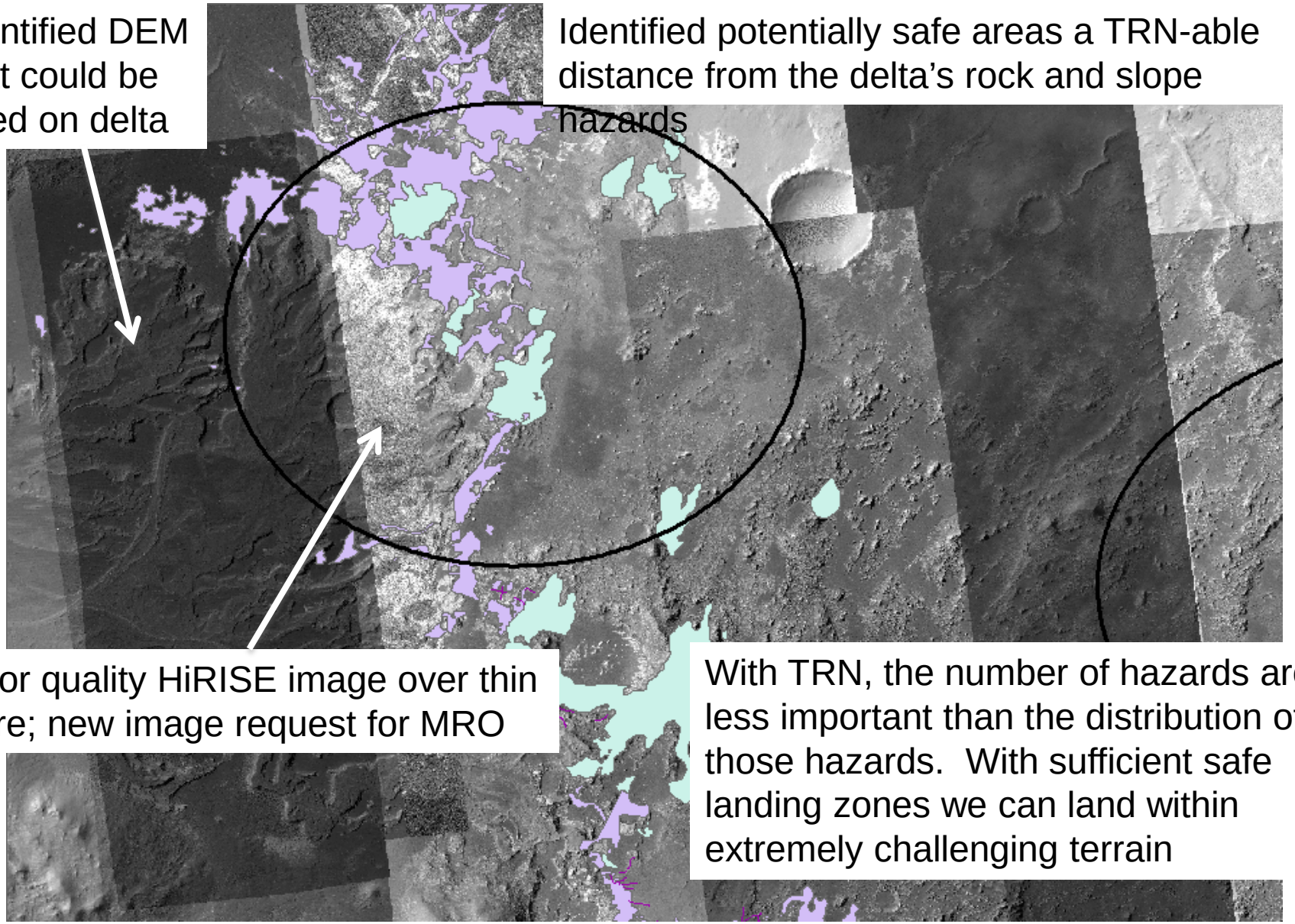


Is there a better initial placement for the ellipse? [if so, this placement here could be held in reserve as a fallback option]

New Primary Area: Move onto the Delta

Identified DEM that could be used on delta

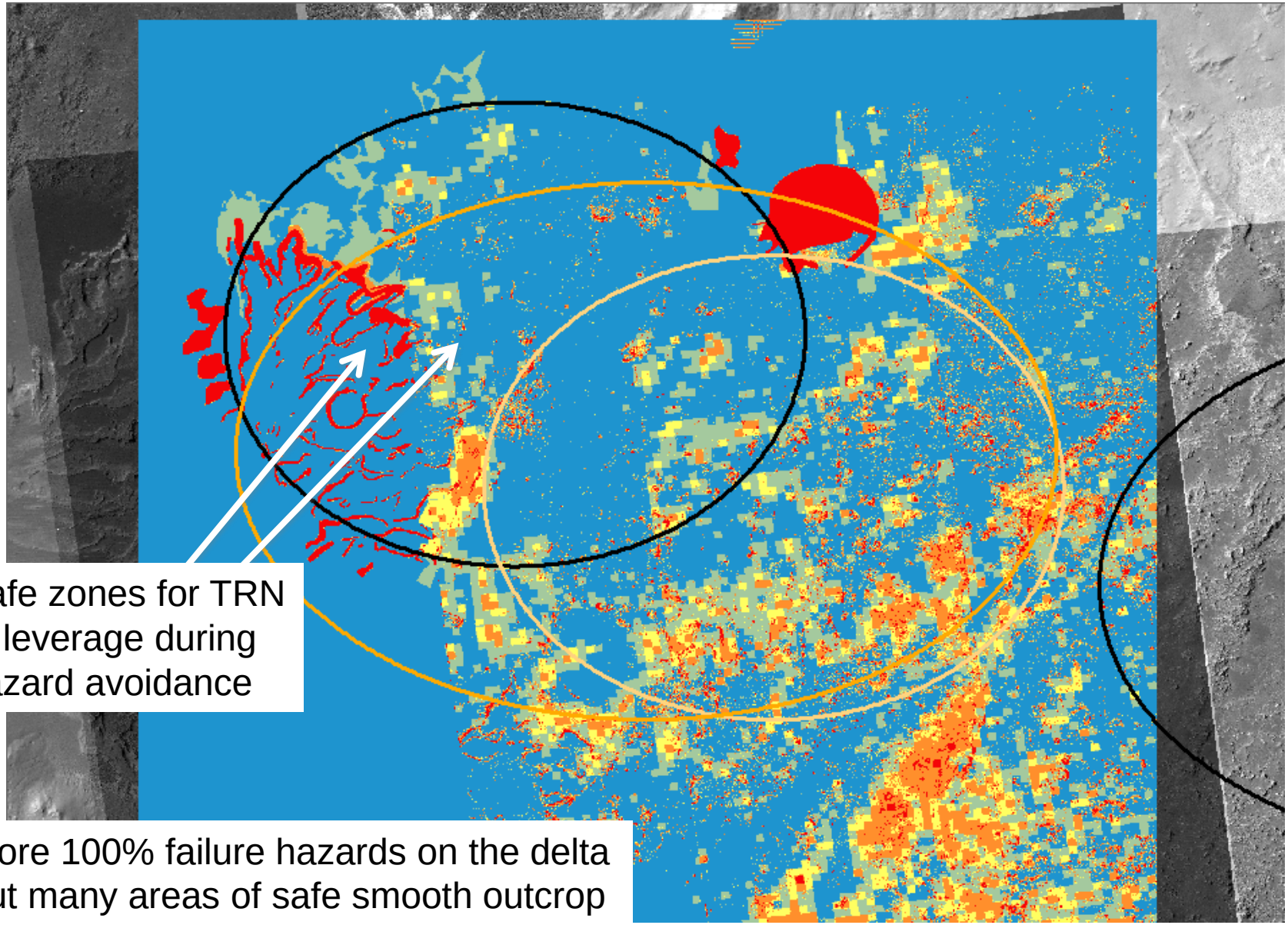
Identified potentially safe areas a TRN-able distance from the delta's rock and slope hazards



Poor quality HiRISE image over thin gore; new image request for MRO

With TRN, the number of hazards are less important than the distribution of those hazards. With sufficient safe landing zones we can land within extremely challenging terrain

Continuing to Create Representative Hazard Maps for TRN Assessments



Safe zones for TRN to leverage during hazard avoidance

More 100% failure hazards on the delta but many areas of safe smooth outcrop

Conclusions

- Only moved ellipses when placement was unworkable
  - Either due to safety or the traversal story
  - Don't fix a non-broken ellipse placement
    - A lot of work goes into each ellipse analysis
    - Each movement likely inserts uncertainty that needs to be reduced by analysis / data gathering
    - There is always another 'what if' location
- Hazard models used to inform intuition but human judgment regarding what wasn't modeled exercised
- Increased fidelity when needed for the analysis
  - Ellipse size
  - Accordion modeling
  - Cliffs on delta