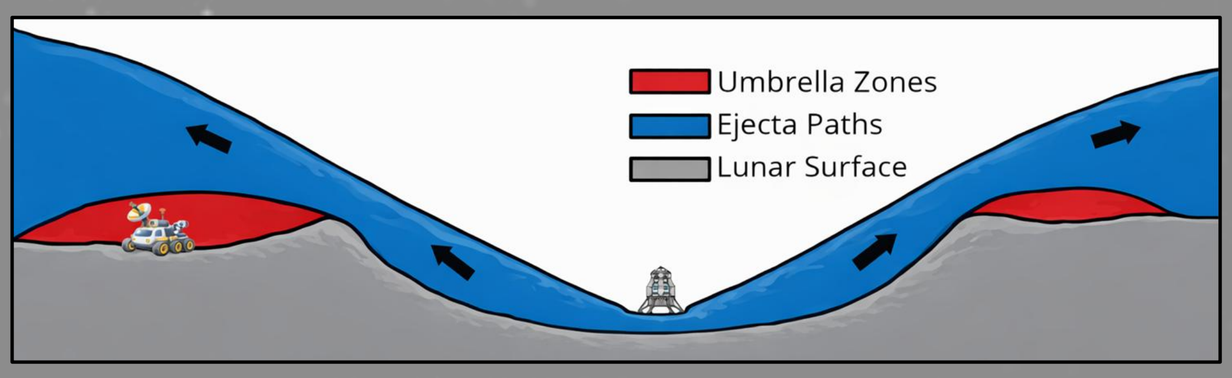
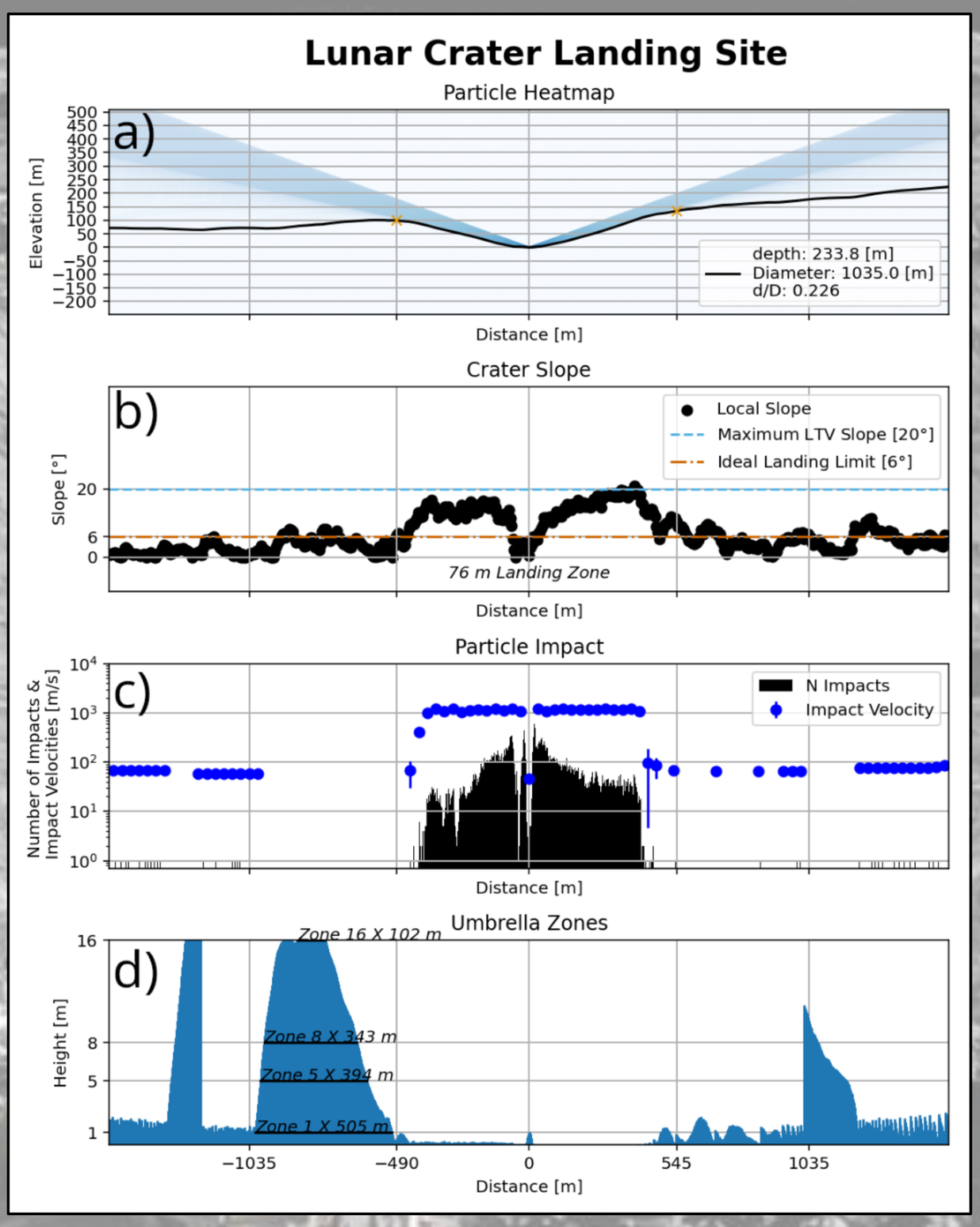
Lunar Craters as Unprepared Landing Sites

Seamus L. Anderson[1]*, Prabal Saxena[1], Phil Metzger[2]
[1]NASA Goddard Space Flight Center, [2]University of Central Florida
*seamus.anderson@nasa.gov





Landing inside lunar craters could provide protection to nearby objects located outside the crater's rim, which we call "Umbrella Zones"

Results of PSI-Ejecta Simulation for One Crater

- This single simulation (left) shows that lunar crater topography could reduce PSI hazards in the vicinity of the landing zone
- Umbrella Zones outside this crater could protect objects as tall as 16 m for 102 m wide
- Ejecta impact density and average impact velocities just outside the crater are significantly lower than inside
- Even for areas that are not within the umbrella zone, PSI-ejecta would likely be less intense, reducing the damage caused
- Many crater floors, like this one, are both large and flat (<6°) enough for spacecraft to land safely
- Crater walls are often gentle enough for Lunar Terrain Vehicle traversal (<20°)
- Future operations requiring multiple landings could make use of topography such as this to land a habitat module in an umbrella zone, followed by a crewed vehicle targeting a landing within the crater
- Sample return missions could also land at the center of a crater, deploy a rover to collect and return samples, then send the rover to an umbrella zone to shelter during return module ascent, allowing for an extended science mission afterwards

Results from 238 Crater Landing Simulations

- Both the heights and widths of umbrella zones generally increase with depth to Diameter ratio
- Although some of our sampled craters could provide protection to objects as tall as Starship HLS (53 m), most cannot
- Our initial study suggests that craters with a d/D lower than 0.077 do not produce protective umbrella zones, while umbrella zones are guaranteed for craters steeper than 0.164 (d/D)
- The ideal crater landing site candidates appear to have d/D ratios between ~0.14 – 0.17 since they have large, flat landing areas as well as large umbrella zones
- Simulations assume gravity as the only force acting on PSI-ejecta, initial velocities range from 10 – 2380 m/s and 0 – 20° above horizontal
- Sampled craters were between 60 – 1500 m in diameter
- Future work will incorporate modelling of PSI ejecta impacting the surface to constrain the hazard posed y secondary ejecta
- Possible landing sites may also be inappropriate due to poor illumination conditions