INTEGRATING LRO DATA PRODUCTS FOR PRELIMINARY NORTH POLE ROVER MISSION PLANNING

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Overview of a Notional Telepresence Rover Traverse at the Lunar North Pole

The purpose of this work will be to describe a methodology for using recently acquired Lunar Reconnaissance Orbiter data sets to identify potential rover driving routes from high-illumination regions on the rim of Peary/Whipple crater to candidate small, low-illumination craters on the floor of Peary. This preliminary work will be utilized to derive baseline design requirements for a rover to perform a traverse over the identified terrain. Mission planning will include very short duration sorties to collect samples from within permanently shadowed areas of small craters on the floor of Peary.

Rationale for the North Pole vs. Other Potential Locations

The authors believe that the selection of future sites for unmanned exploration of the Lunar surface should be driven by several short and long term objectives to maximize not only the scientific value of the selected site, but also the applicability of ground-truth data obtained from the surface to the longer term goal of Lunar resource utilization. Sites selected for unmanned surface science missions, such as the one being proposed in this document, will be a natural location of future outposts both unmanned and manned. Those outposts, in turn, become the natural beginnings for the economic development of the Moon's resources. The criteria related to these longer-term goals are identified below:

- •Cost
  - Without cost control and local resource leverage, it is unlikely to go beyond paper studies.
- •Global Surface Access
  - Whether science or industrial development is the driver for exploration, global surface access is a must.
- •Access to Resources
  - Long term presence and economic development require access to resources, including sunlight, water and other volatiles.
- •Power
  - Success of lunar activities is directly proportional to power available.
- •Cislunar Access
  - Anytime launches are highly desired

The polar regions were subjectively ranked on a scale of one to five (see table 1 at right). While the terrain of both polar regions is within the capabilities of historical and proposed rover designs, the terrain features of the north polar region have approximately half the topographic prominence of features near the south pole (demonstrated in figure 1 below). Additionally, the north pole enjoys relative proximity to the nearside mare with Mare Frigoris approximately 428 kilometers to the south of Peary. Contrast the south pole's nearest, Mare Nubium, at approximately 1400 kilometers to the north.

Table 1: Polar Regions Ranking (N = North, S = South) 1 to 5 in descending value

Ranking	1	2	3	4	5
Power	N/S				
Terrain			N		S
Resources		N/S			
Accessibility			N	S	
Cost		N/S			
Cislunar Access	N/S				

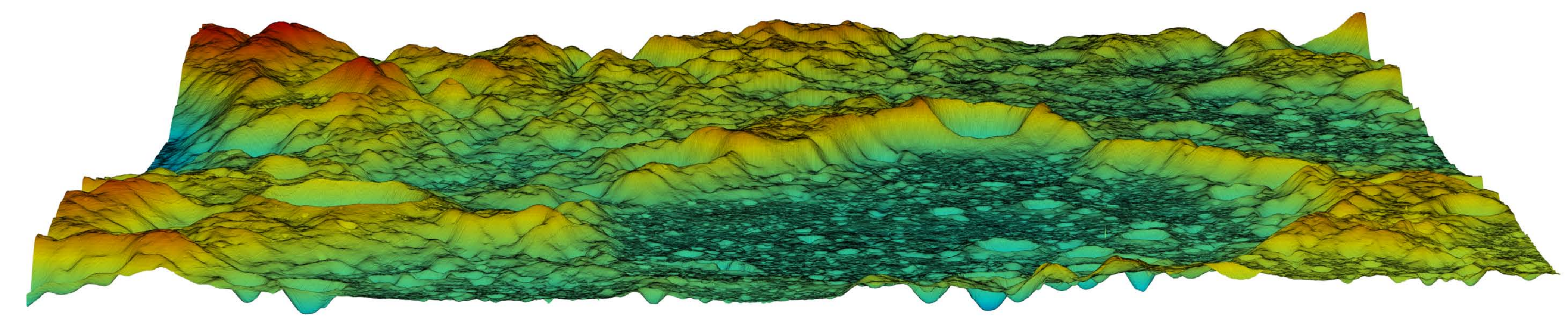

Figure 1a: LOLA 10 Meter Gridded Data Record Terrain from 87.5° North to the North Pole (3x vertical exaggeration)

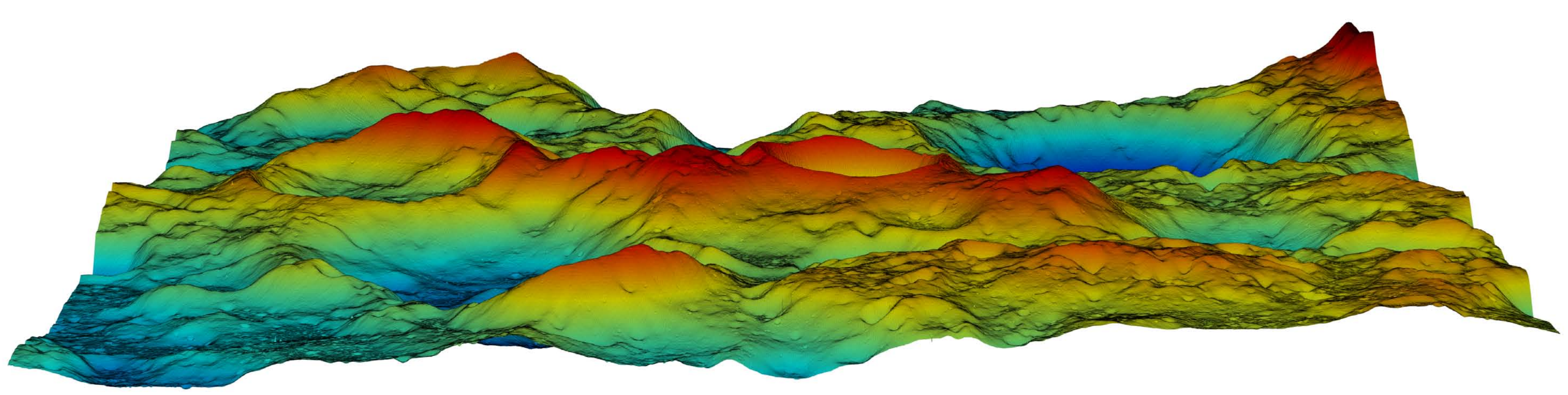

Figure 1b: LOLA 10 Meter Gridded Data Record Terrain from 87.5° South to the South Pole (3x vertical exaggeration)

Applicable LRO Data Products

The primary data products being utilized from LRO are from the Lunar Orbiter Laser Altimeter (LOLA), specifically the Gridded Data Record (GDR) polar stereographic projection. Additionally the WAC-derived illumination mosaics and the NAC visible light images (both the NAC polar stereographic mosaic and individual NAC images projected as necessary to provide context in areas poorly illuminated in the mosaic).

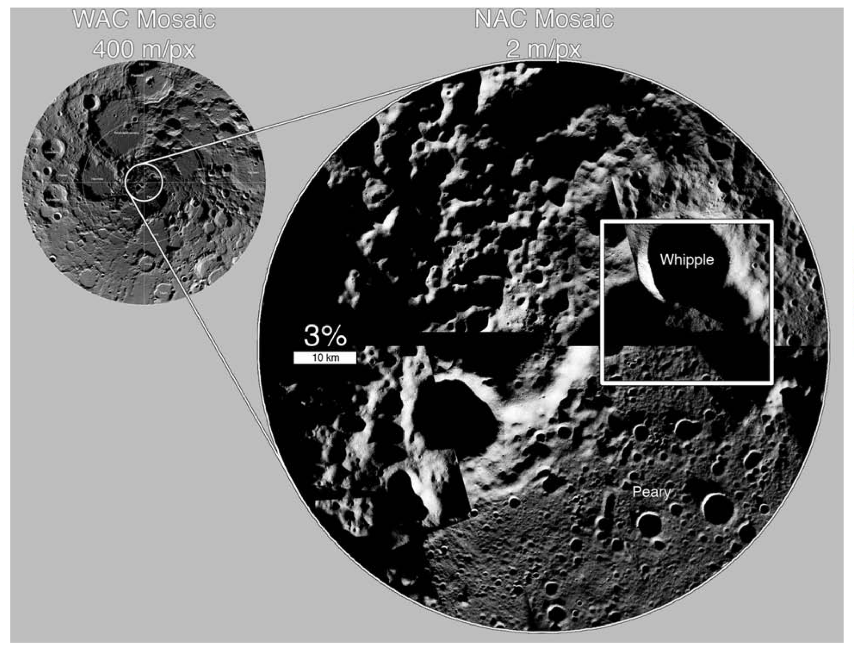

Figure 2: Area of focus is indicated by white box in NAC mosaic inset. Whipple and Peary craters are labeled. NAC and WAC mosaics by NASA/GSFC/Arizona State University[2].

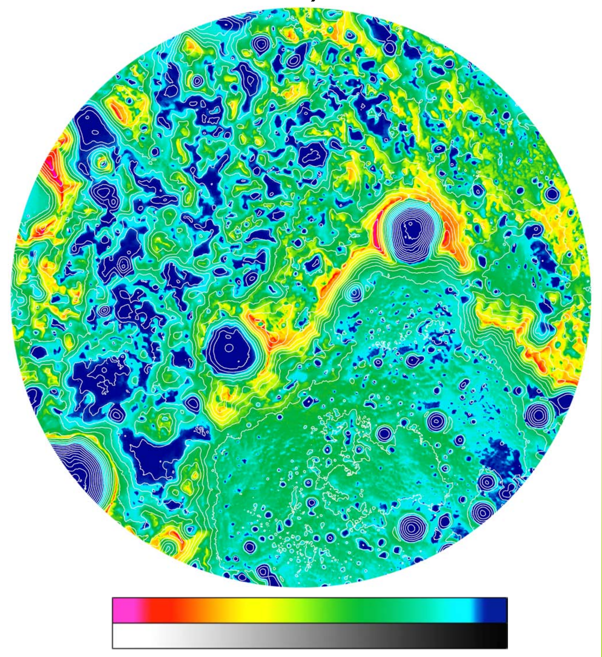

Figure 3: WAC illumination mosaic[2] with LOLA GDR contours. Contour lines are at 200 meter vertical spacing.

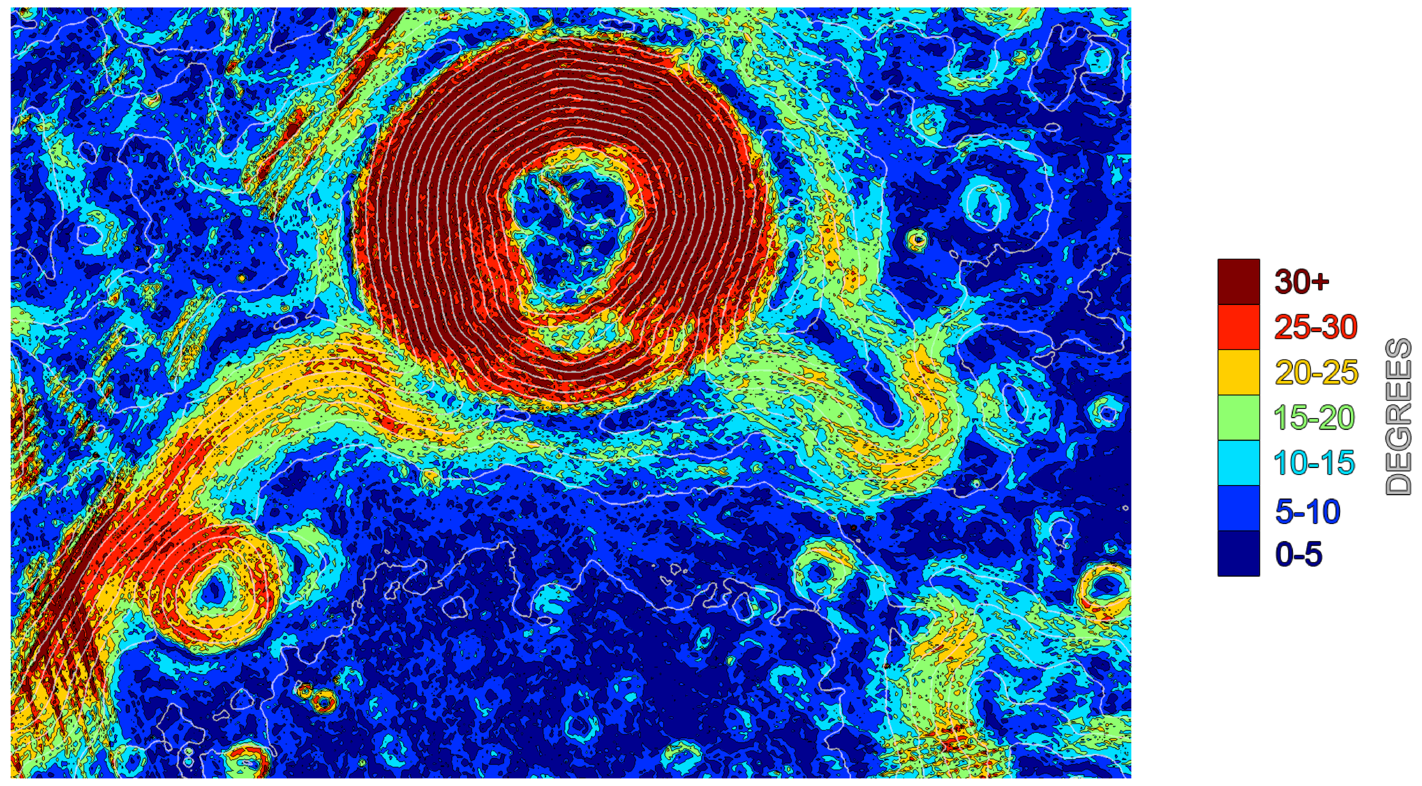

Figure 4: Slopes in the area of Peary/Whipple craters with overlaid elevation contours at 200 meter vertical spacing. Slopes are derived from LOLA GDR.

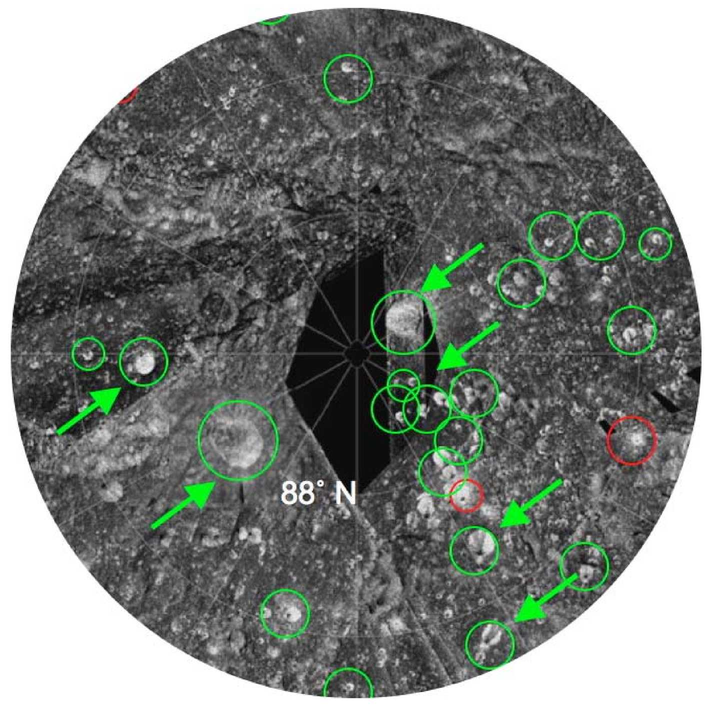

Figure 5: Circular Polarization Ratio map from the Mini-SAR instrument on Chandrayaan-1 cropped to show the area from approximately 85°N to the pole. Anomalous craters suspected of containing volatiles, including several craters on the floor of Peary, are circled in green [see reference 1].

Rover Performance Requirements

Rover baseline design requirements will depend on a variety of parameters, both for the topology of the terrain and also for the physical properties of the regolith which govern the interactions between the vehicle and the surface. Models developed by Pavlics[3] include slope, slip coefficient, soil density, exponent of sinkage, cohesive modulus of deformation, friction modulus of deformation, cohesion, and angle of friction. Many of these parameters can be accurately estimated from remote sensing data or by direct comparison to the mechanical properties of regolith samples obtained from other highlands areas such as the Apollo 16 Descartes Highlands region and Lunar Roving Vehicle performance.

With the availability of highly accurate digital elevation models for the polar areas it should be possible to accurately plan traverses which avoid problematic terrain such as steep slopes. Very high resolution (1-2 meters/px) visible images allow for traverse planning that is cognizant of potential smaller-scale hazards, for example high surface roughness near recent impacts associated with bright-rayed craters.

Candidate routes can be initialized by visual inspection of co-registered datasets based on their proximity to locations of interest, avoidance of hazards, and predicted rover capabilities. Three candidate routes are shown superimposed on figure 6 below. Route 1 is a relatively short distance, high slope angle route to a pair of low-illumination craters on the northern floor of Peary. Route 2 is a slightly longer, moderate slope route. Route 3 is an example of a significantly longer minimal slope route to the floor of Peary, however it passes near several small low-illumination craters outside of Peary.

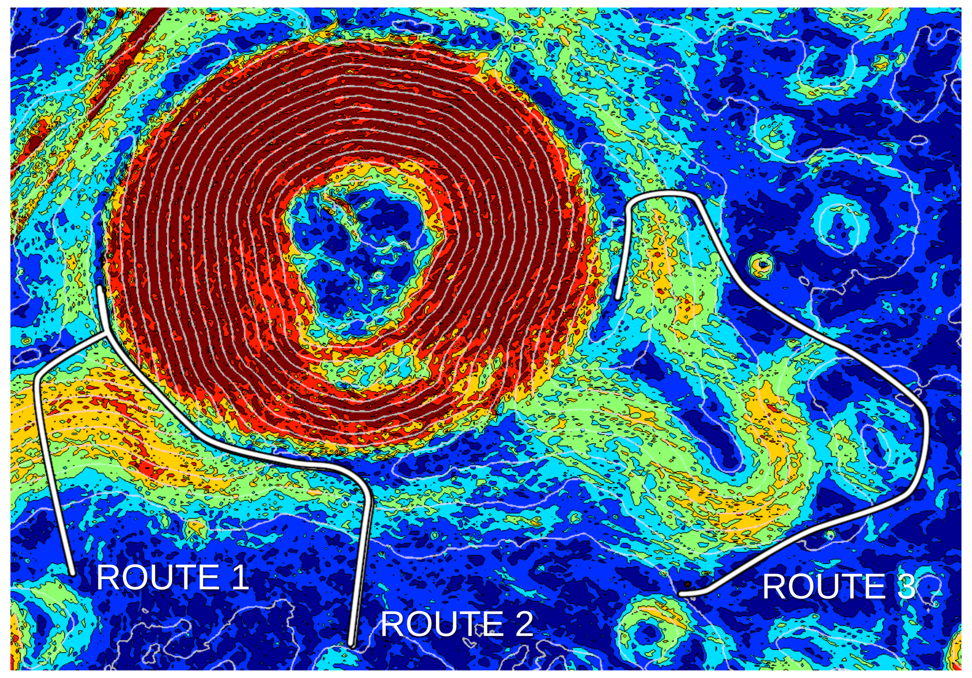

Figure 6a: Slopes with overlaid elevation contours and examples of candidate rover driving routes from high-illumination regions on the rim of Whipple crater to the floor of Peary.

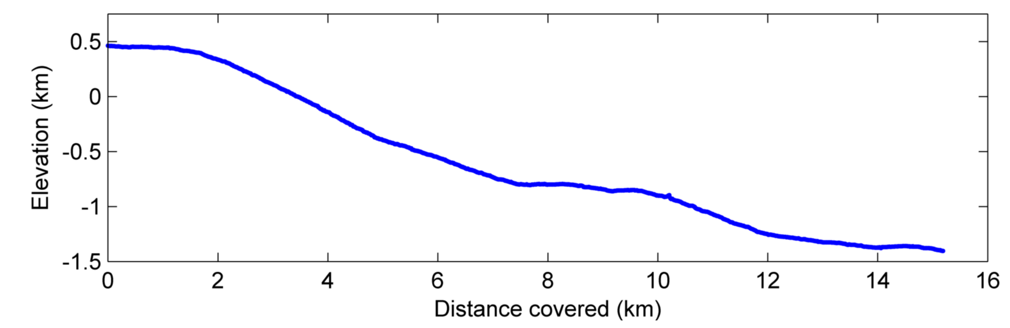

Figure 6b: Plot of elevation vs. traverse distance for route 2 shown in figure 5a.

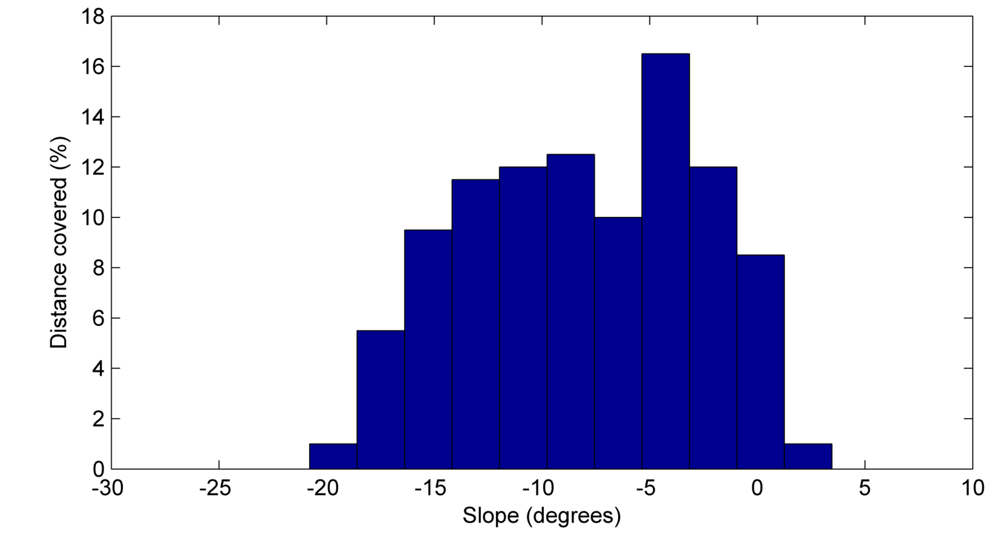

Figure 6c: Slope histogram for route 2 shown in figure 5a.

References:
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