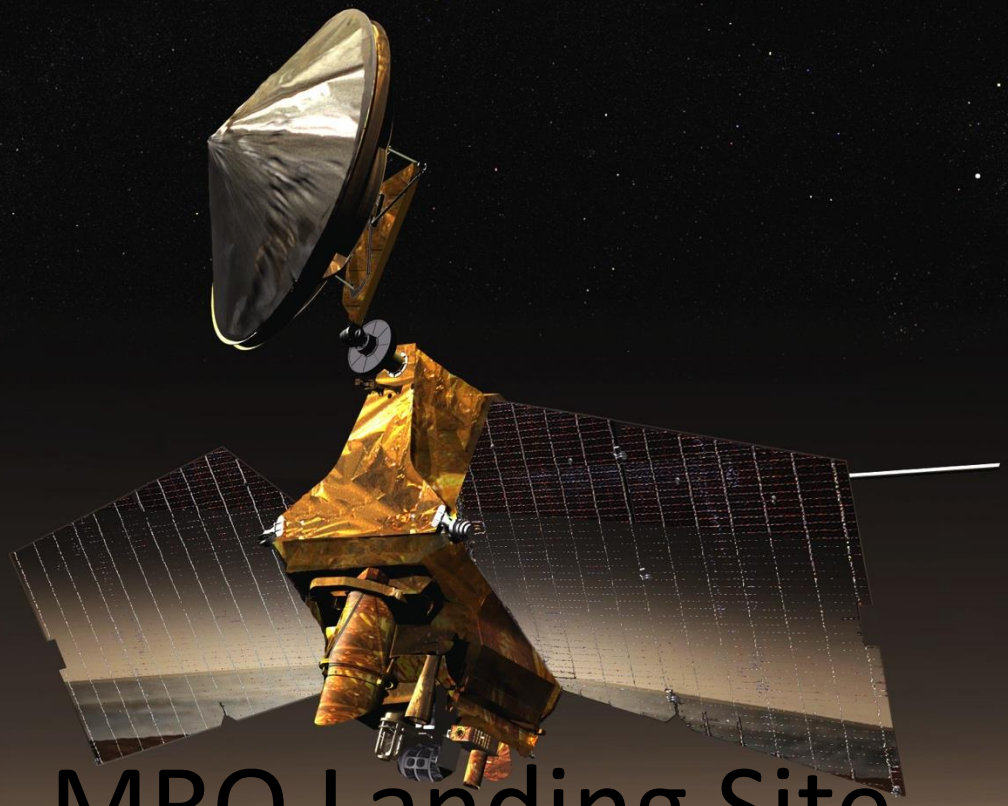

MRO Landing Site Reconnaissance Capability

Martin Brennan

Jet Propulsion Laboratory,
California Institute of Technology

March 6, 2017

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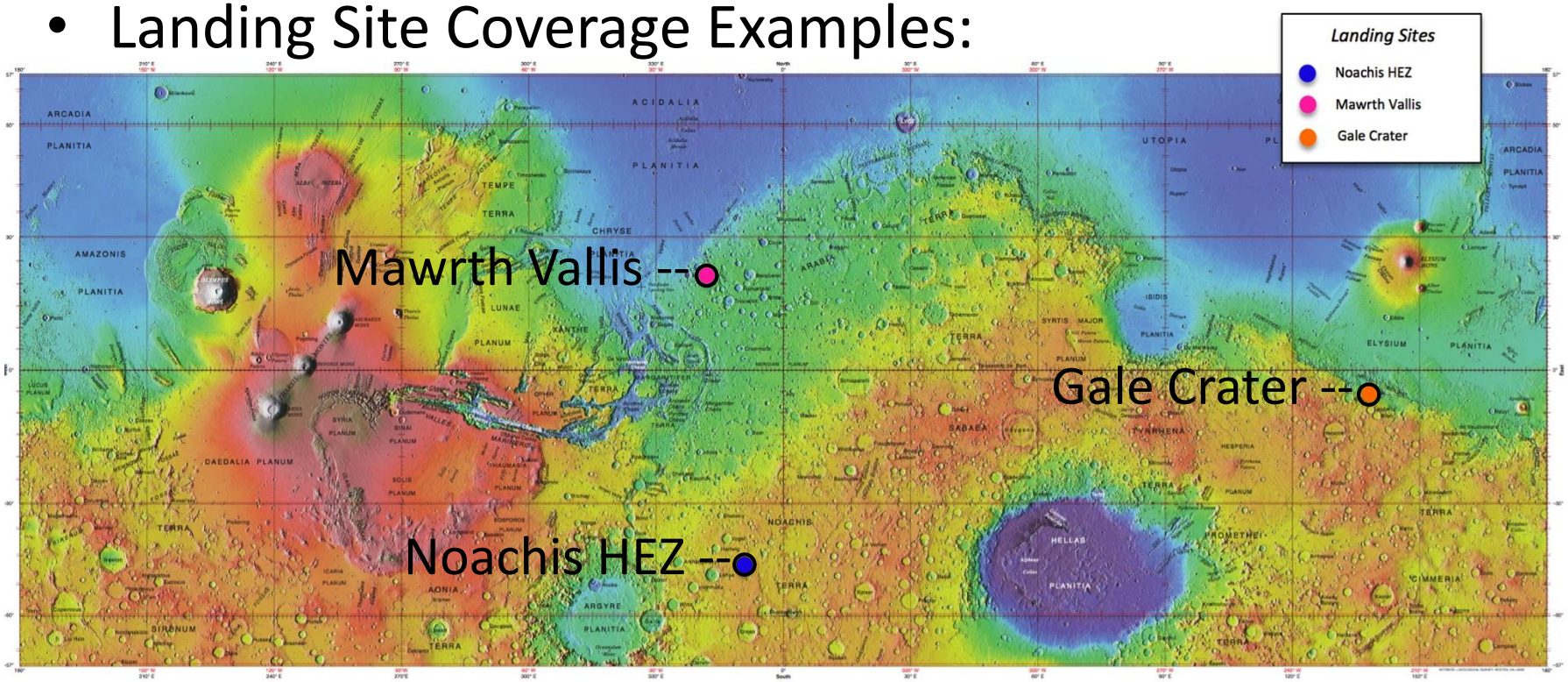
Government sponsorship acknowledged.

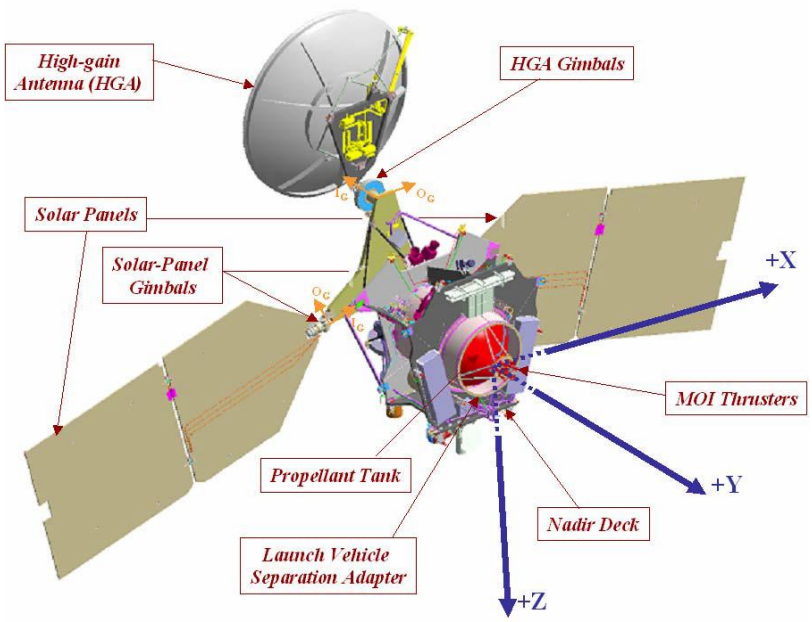
Overview

- MRO Mission Background
- MRO Imager / Ground Site Coverage
- MRO Orbital Characteristics
- MRO Targeted Roll Capability
- Landing Site Coverage Examples:



MRO Mission Background

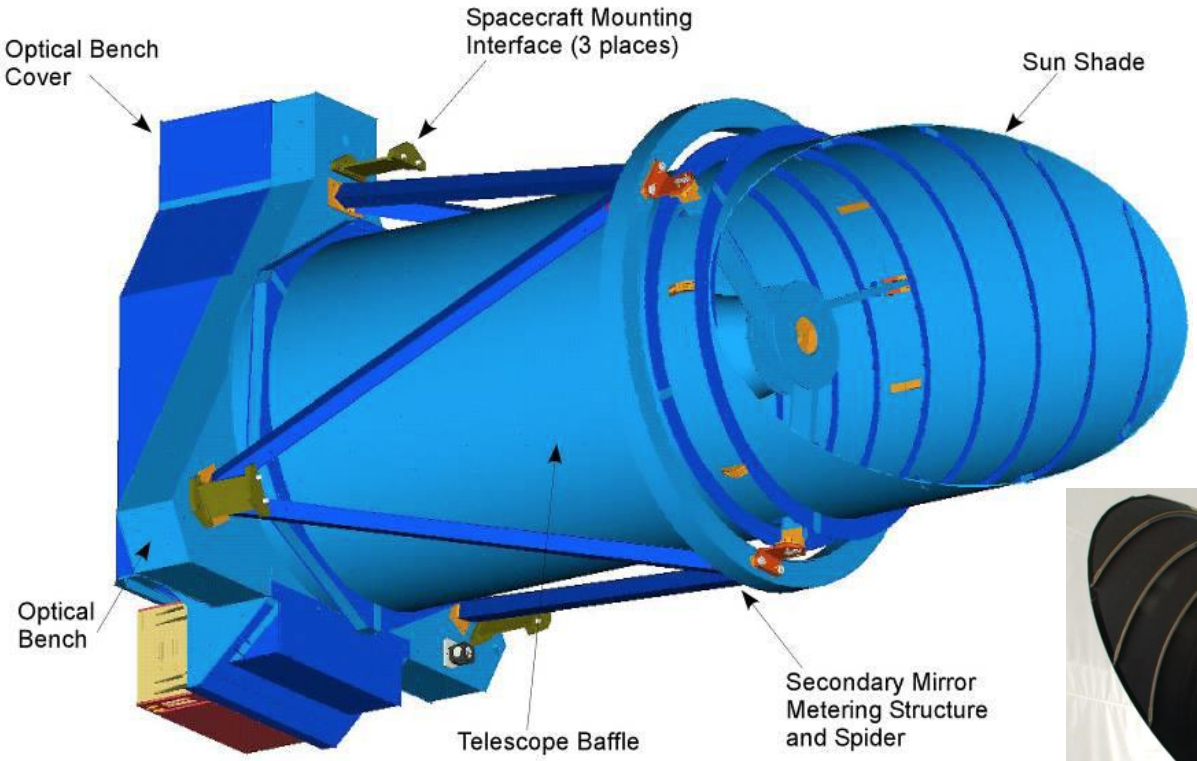
- Mars polar orbit insertion March 10, 2006
- Aerobraking to shape orbit
- Roles at Mars
  - Scientific Investigation
    - Geology and surface mapping
    - Monitor atmosphere / climate
    - Search for evidence of water
  - Telecom relay for rovers
  - Landing site reconnaissance for future Mars missions



Ground Site Coverage

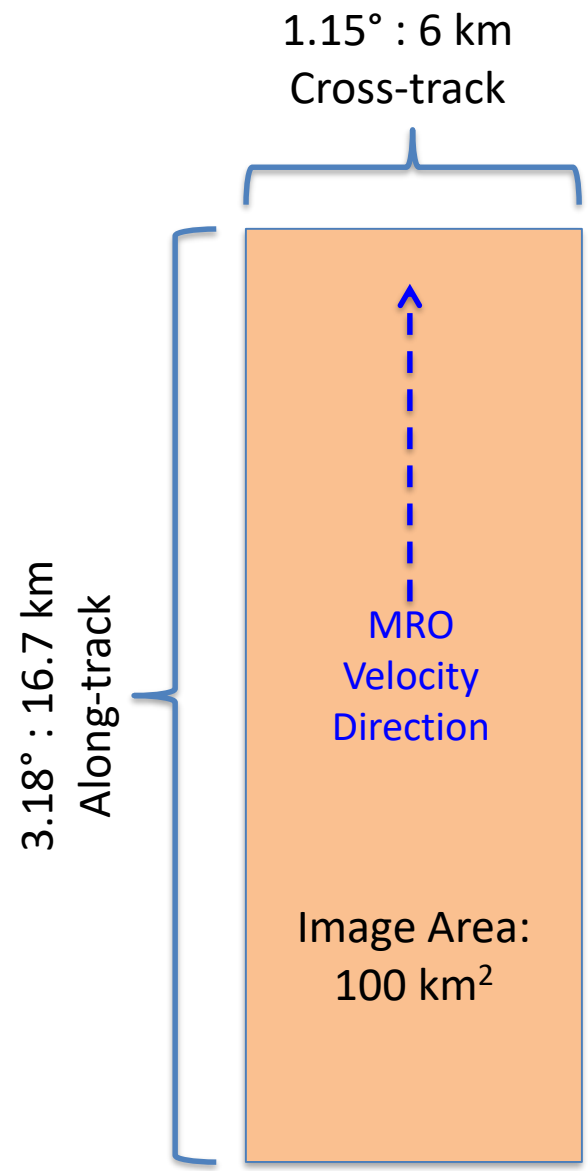
- MRO Imager: **HiRISE**

  High **R**esolution **I**maging **S**cience **E**xperiment



Ground Site Coverage

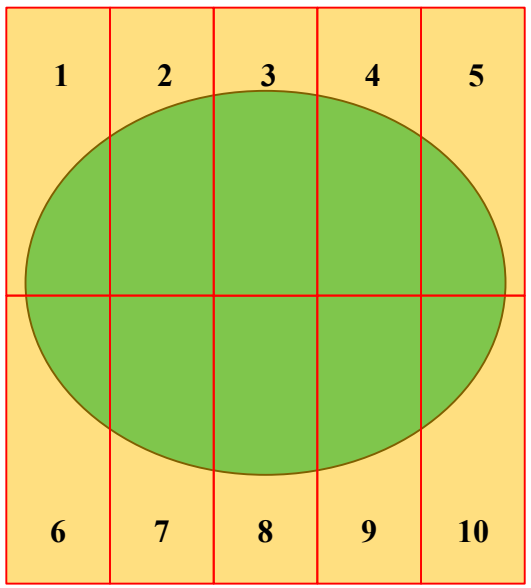
- MRO Imager: **HiRISE**
  - FOV: 1.15° × 3.18°
  - Swath: 6km @300km altitude
    - Min: 5.1km @ 255km (periapse)
    - Max: 6.4km @ 320km (apoapse)
  - Single image size(Nadir pointing):
    - 6 × 16.7 km at 300 km Alt
    - 5.4 × 15 km at 265 km Alt



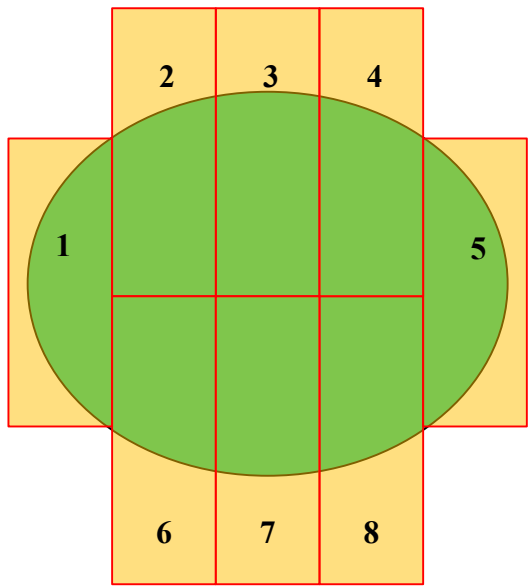
Landing Site Coverage

Subdividing 25 x 20 km Landing Ellipse (MSL) with 5.4 x 15 km HiRISE swaths

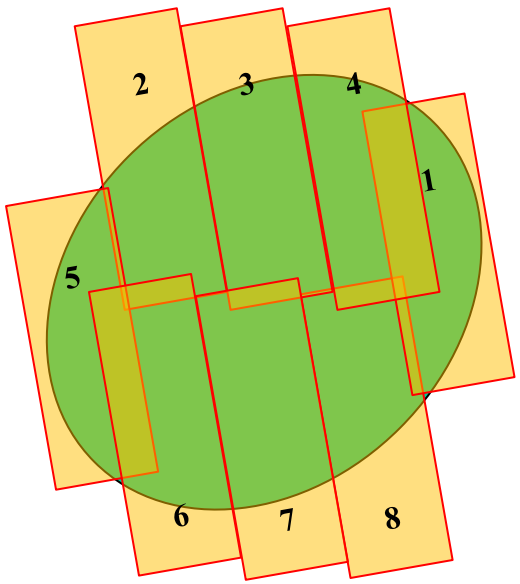
Conservative 10 Passes



Minimum of 8 Passes



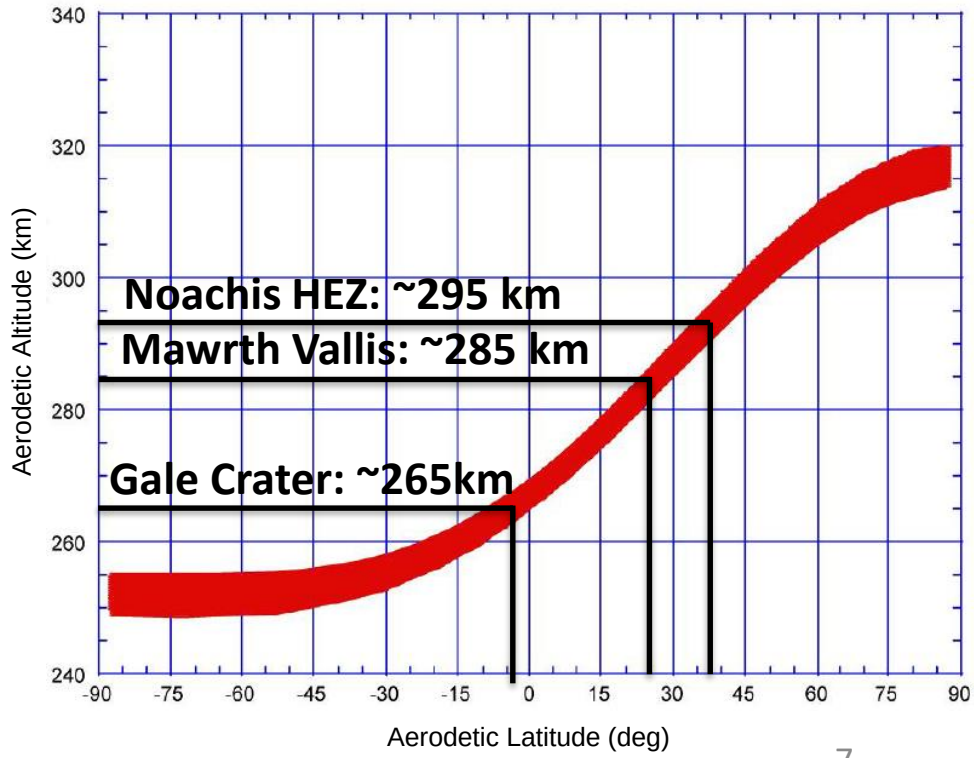
Angled Passes

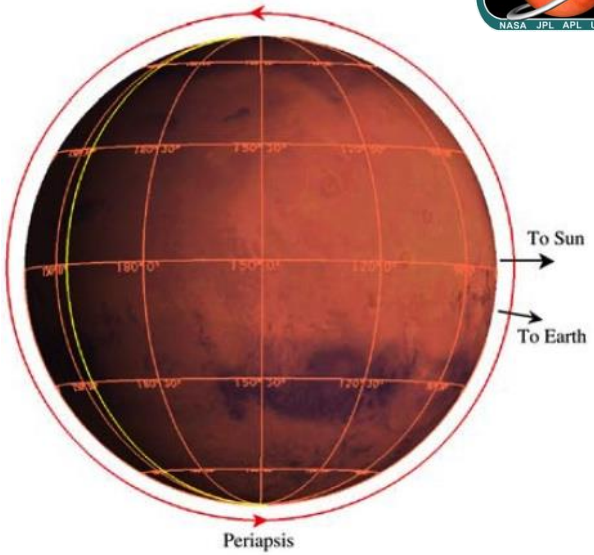


Average Coverage Time = (Average Revisit Time) × (# of Passes)

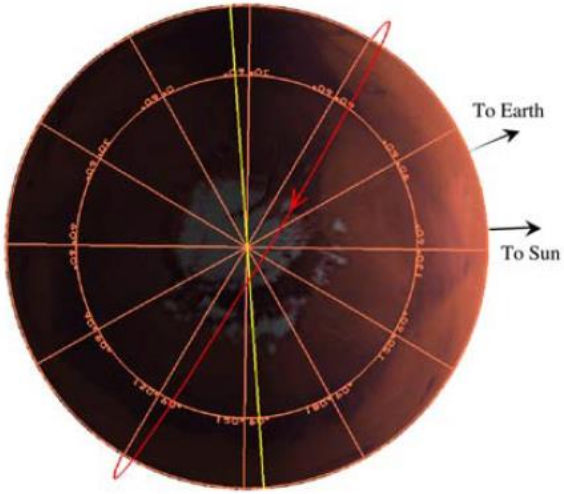
MRO Orbital Characteristics

- Sun Synchronous Polar orbit:
  - Periapse frozen over S-pole
  - Apoapse/Periapse: 320/255 km alt
  - Equator: ~268km alt





View from Trajectory North



View from Mars North Pole

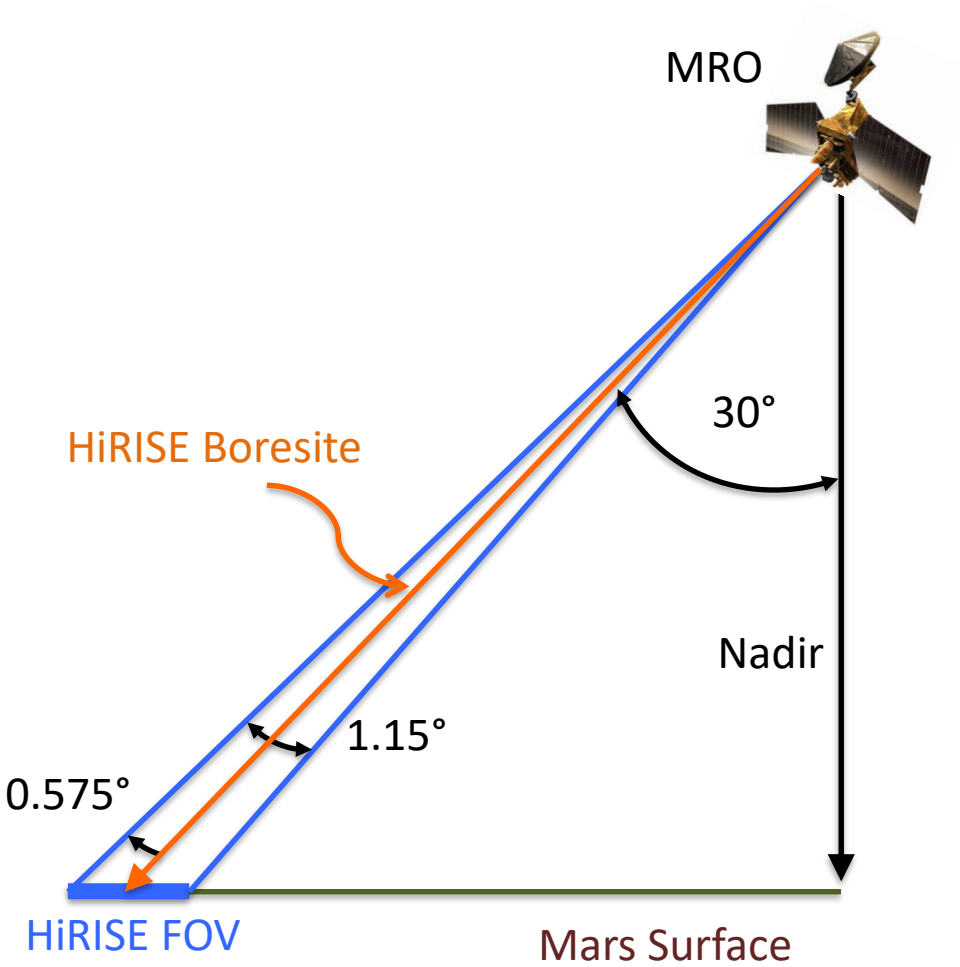
MRO Orbital Characteristics

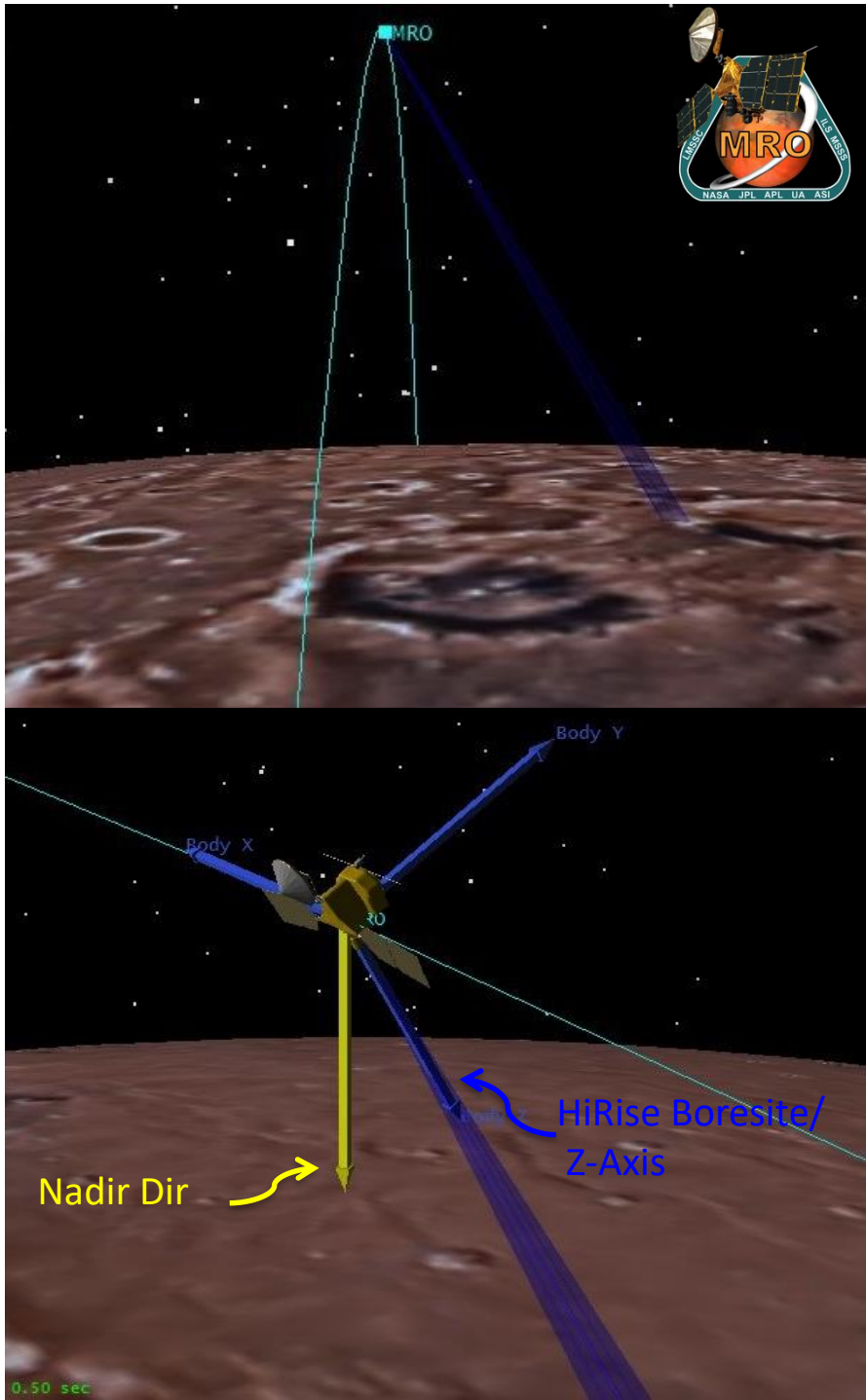
- Orbit period: 112 min (12.8 revs/day)
  - Each orbit “walks” westward 1618.2km (27.3° longitude) at Equator

- Exact repeat ground track: 358.6 days (349 sols) : 4602 revs
  - <5km spacing between ground track traces
  - Complete Mars coverage assuming Nadir pointing

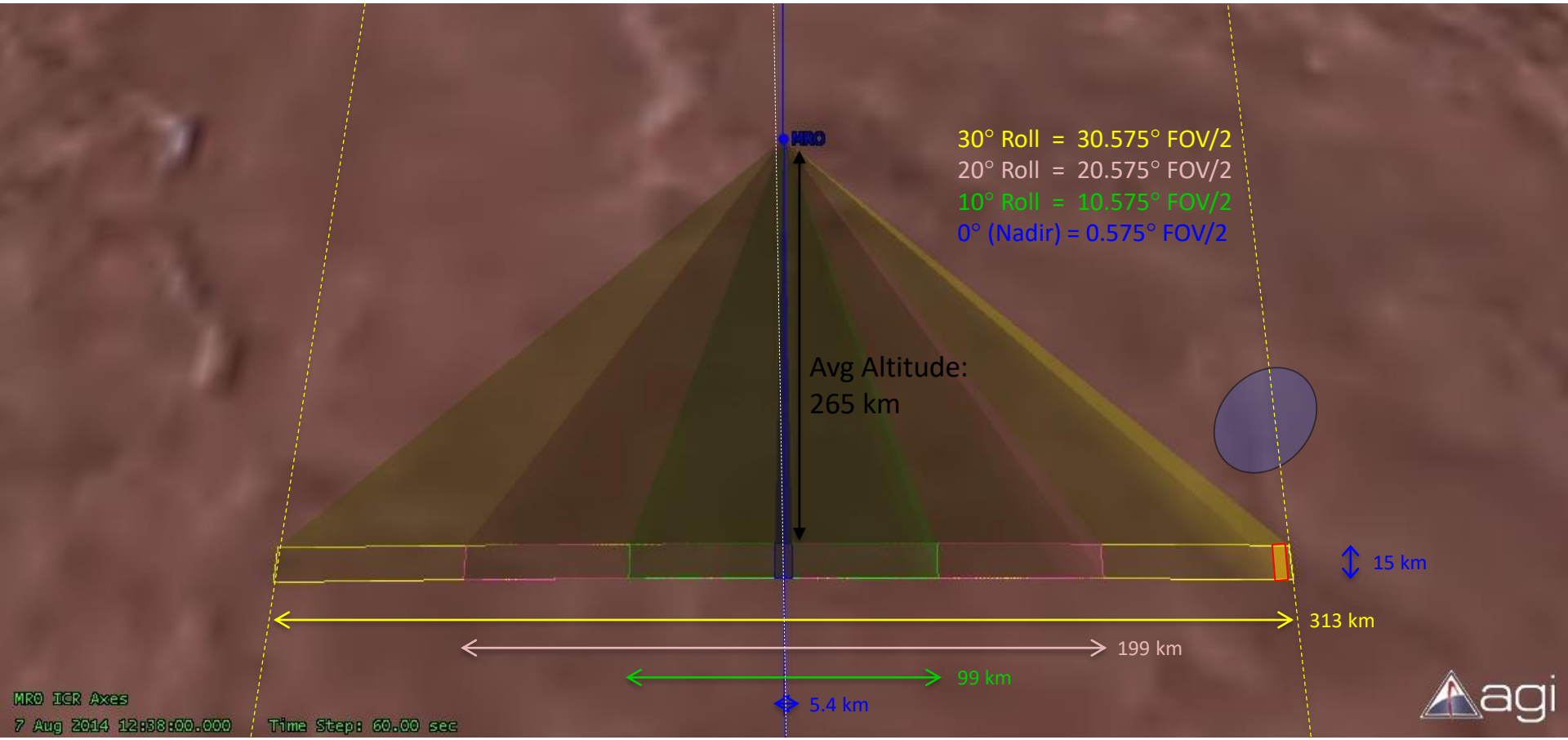
- Short-term targeted site revisit using rolling
  - 17 Day targeted revisit cycle w/ 20°
  - Max roll of ±30° from Nadir

MRO Roll Capability



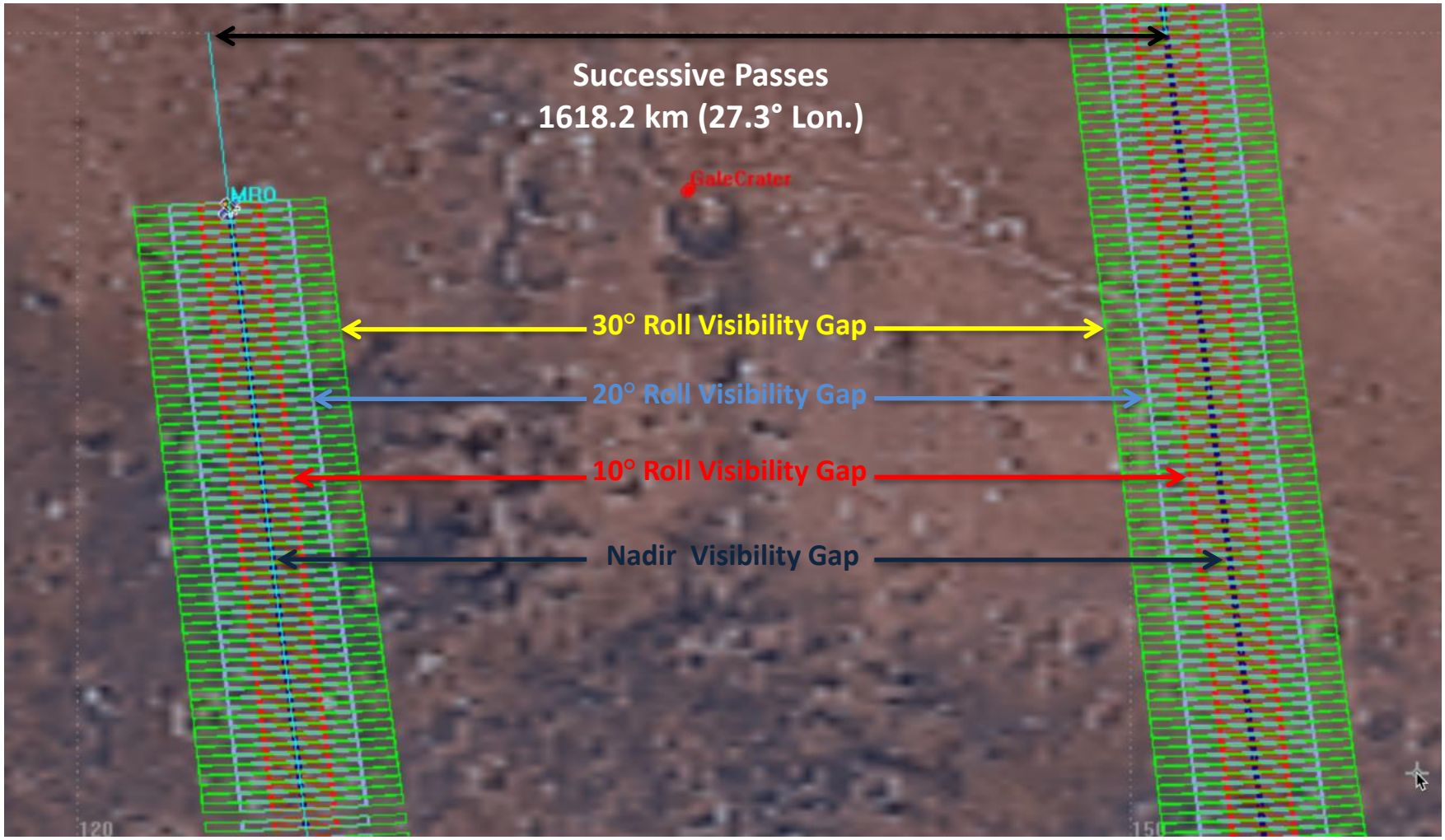


General Visibility with Roll:

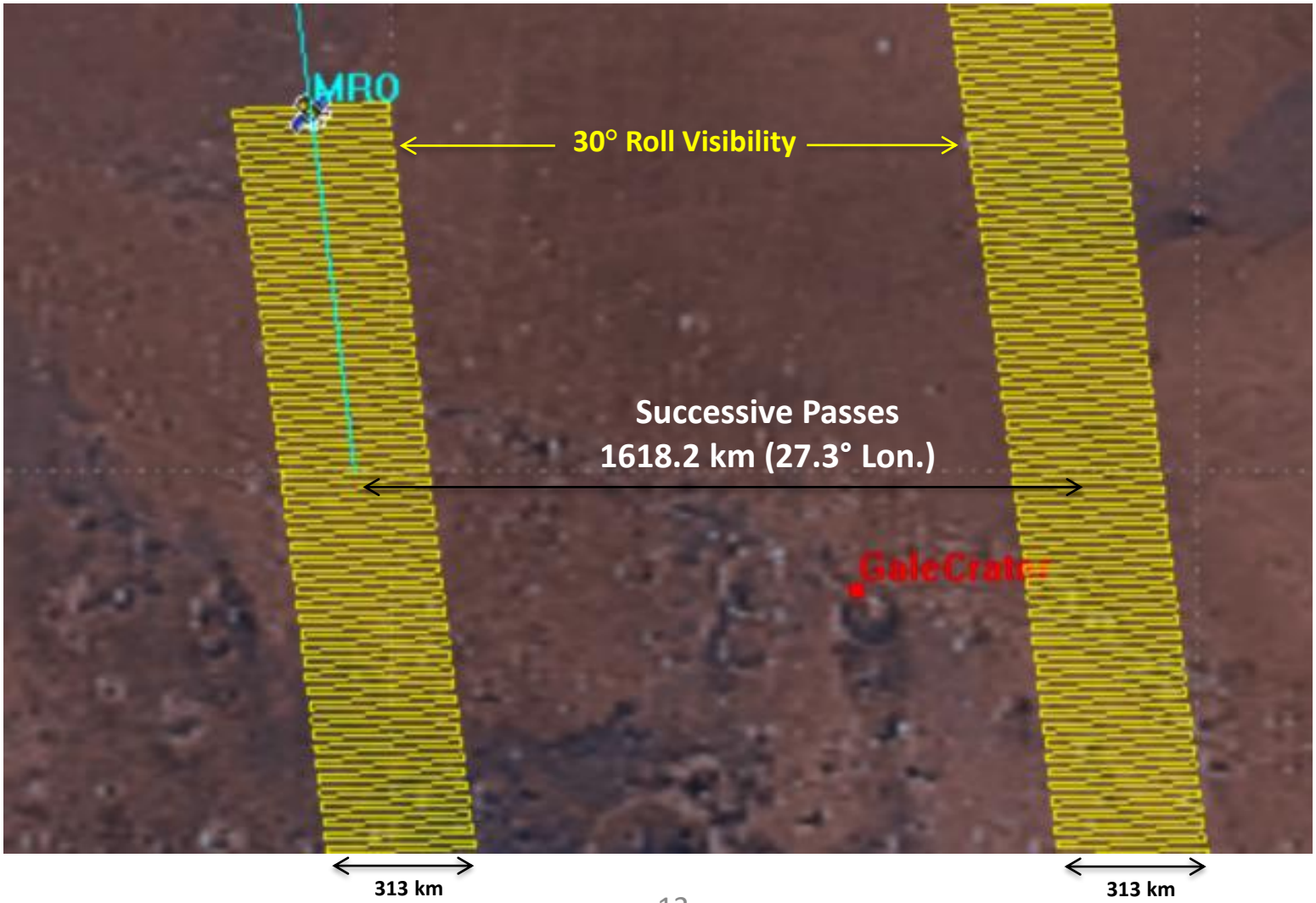


Swath widths are from 265 km altitude

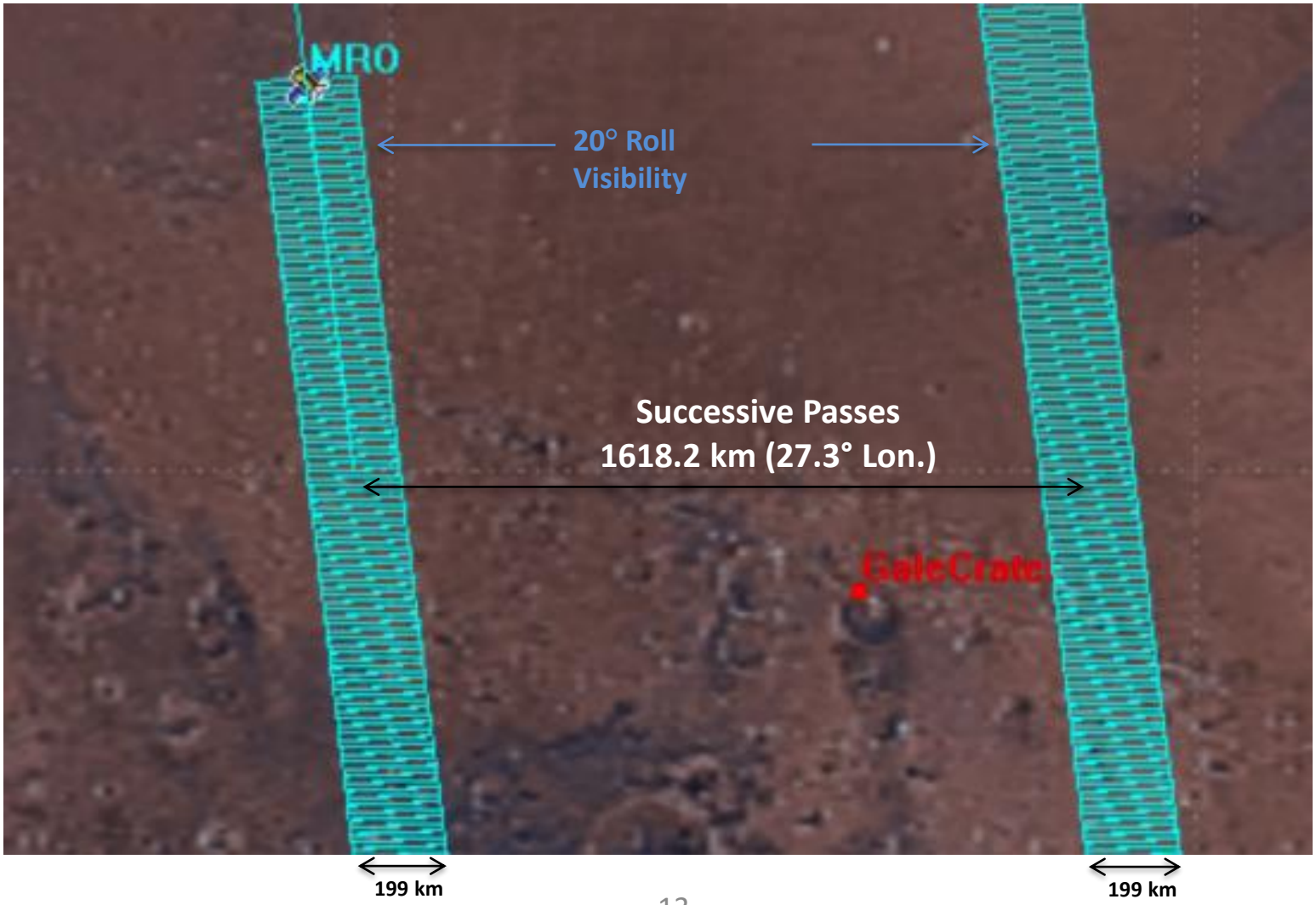
General Visibility with Roll:



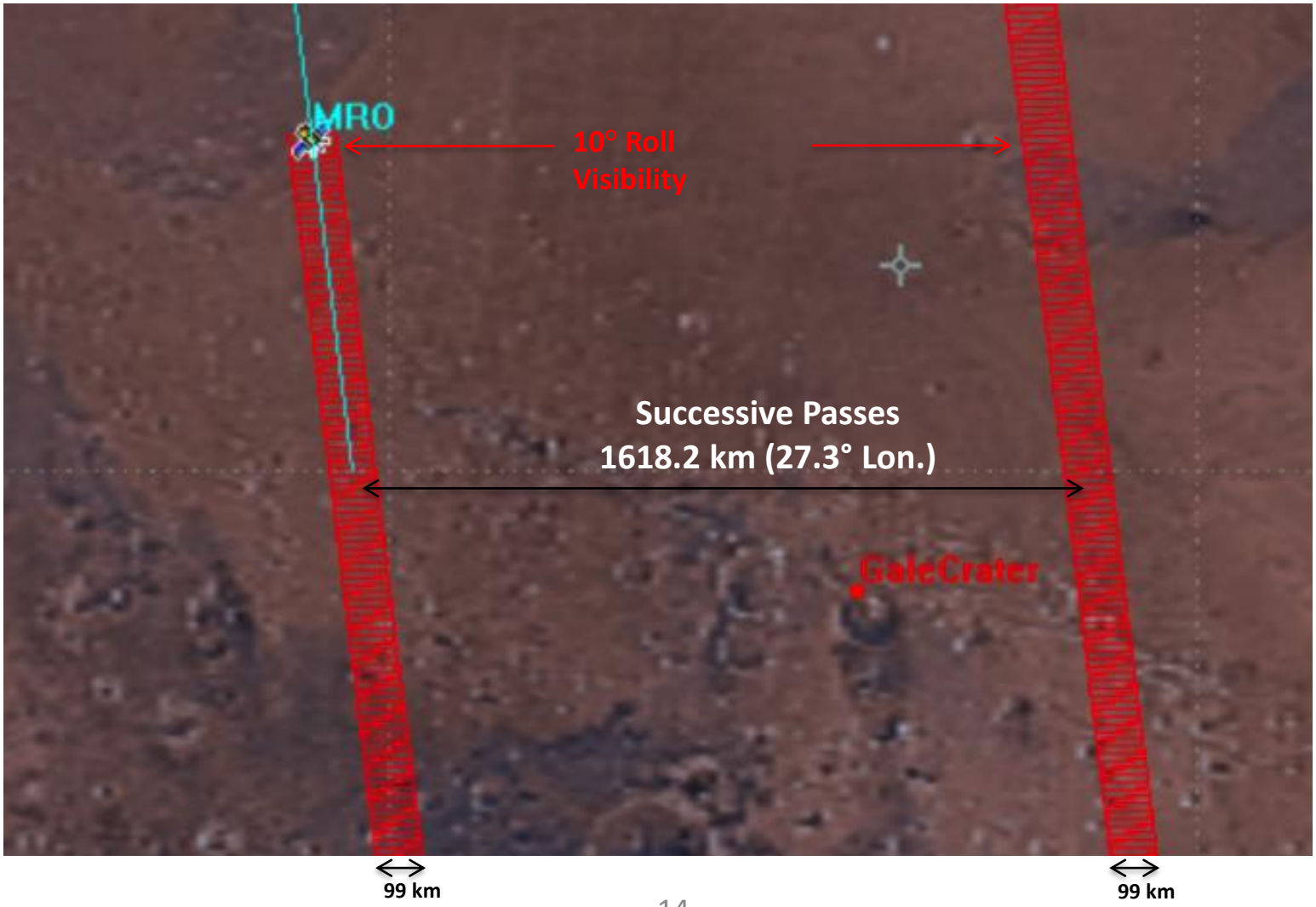
General Visibility: 30° Roll



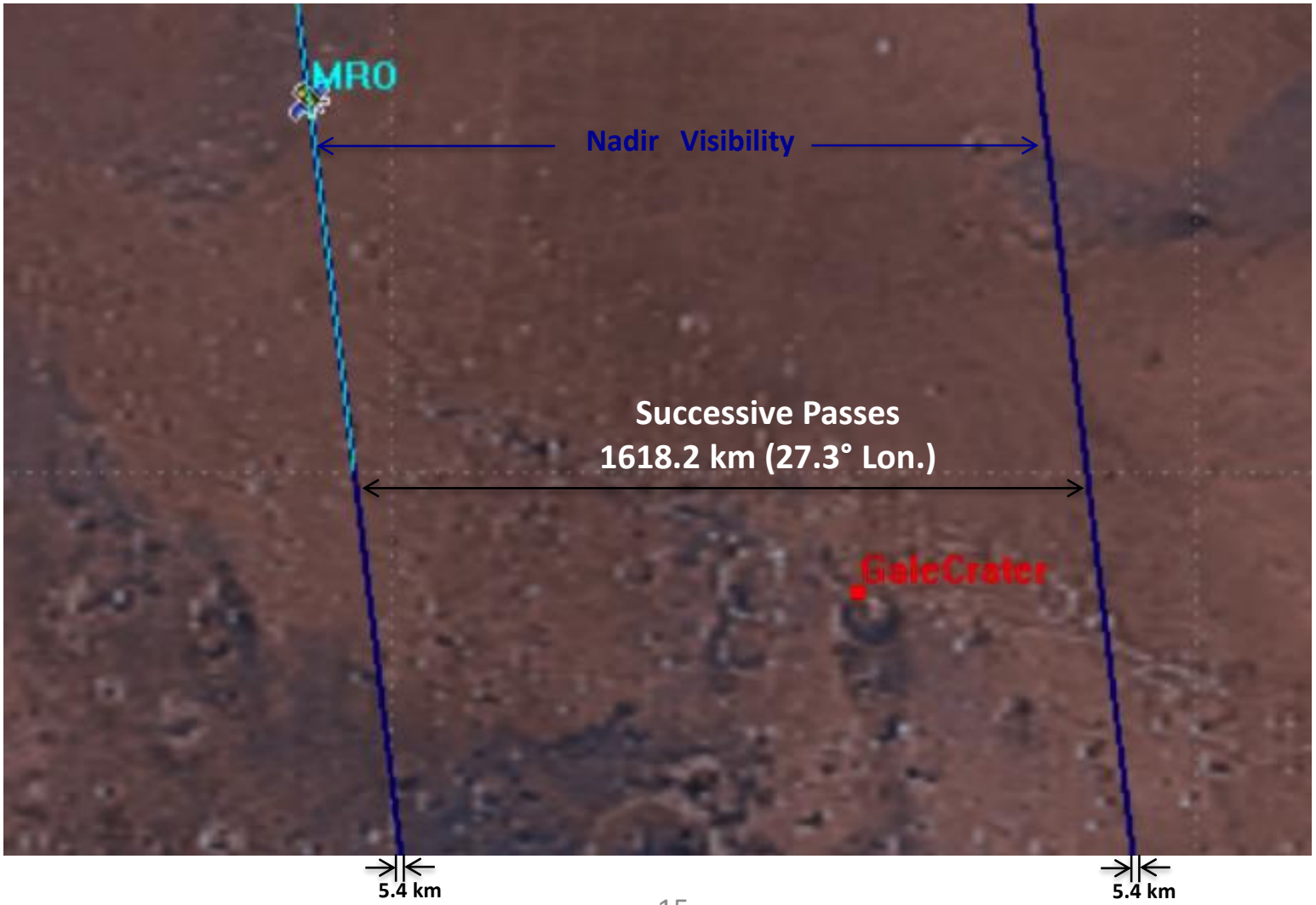
General Visibility: 20° Roll



General Visibility: 10° Roll

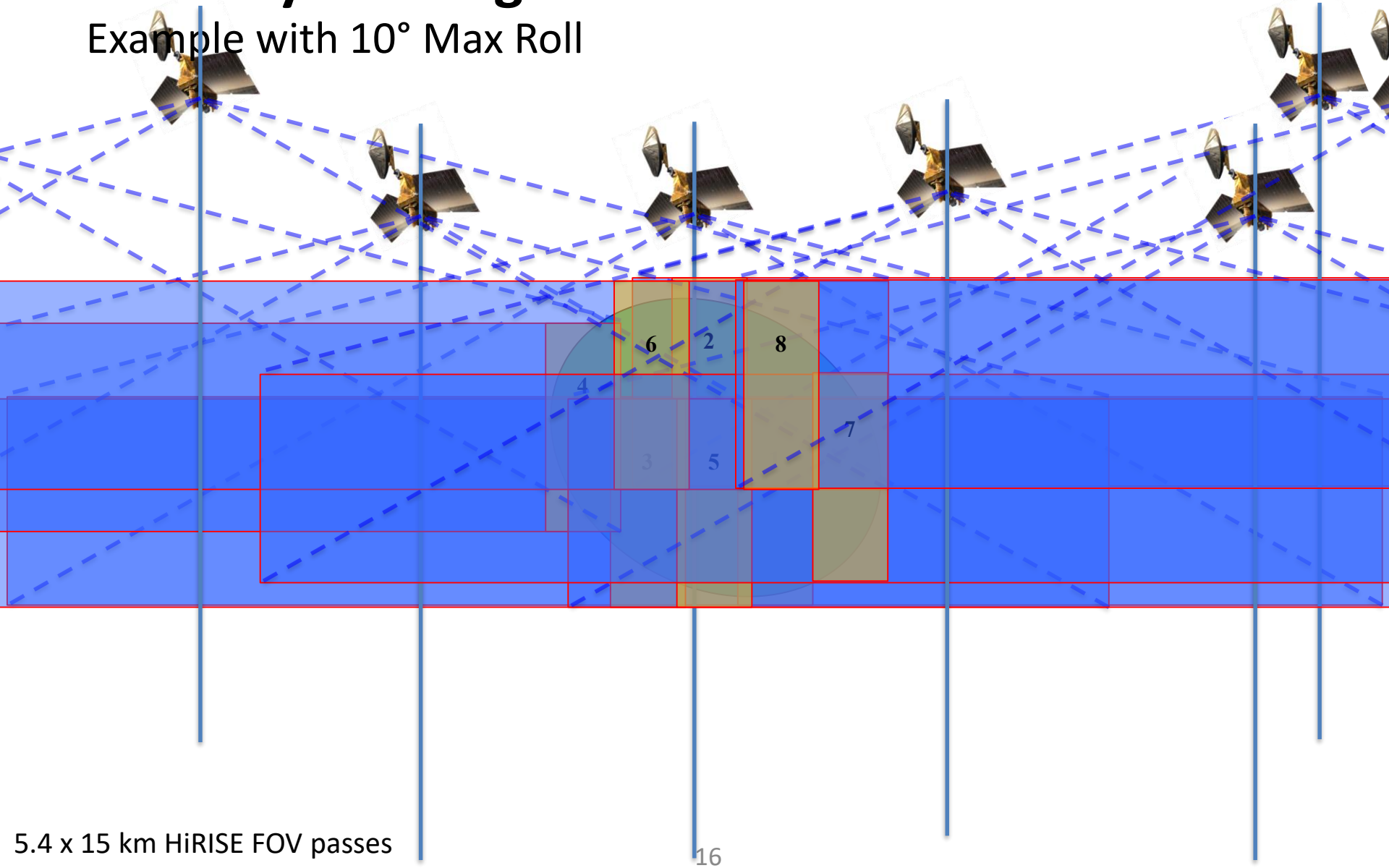


General Visibility: 0° Roll (Nadir)



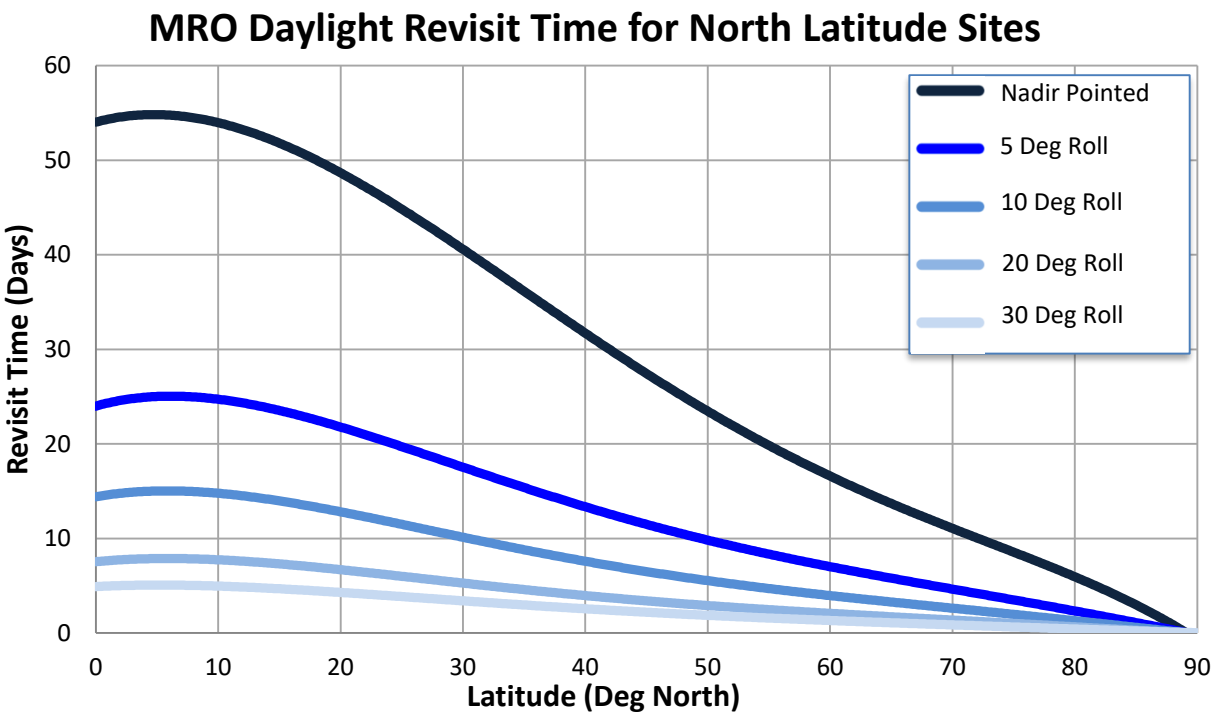
Visibility Coverage Method

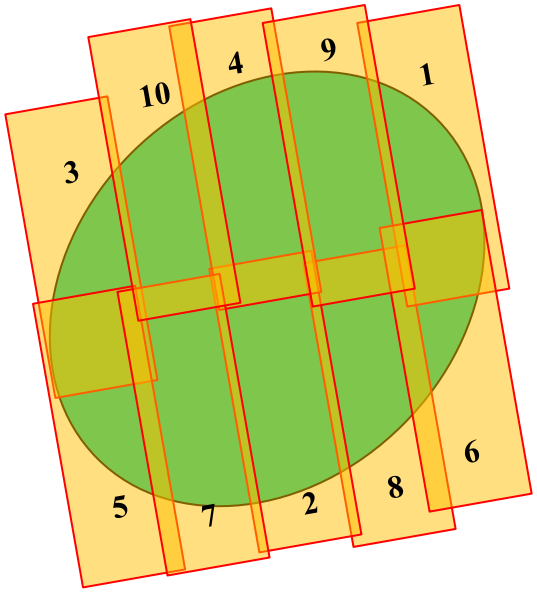
Example with 10° Max Roll



5.4 x 15 km HiRISE FOV passes overlaid on 25 x 20 km landing ellipse

Landing Site Revisit Factors:

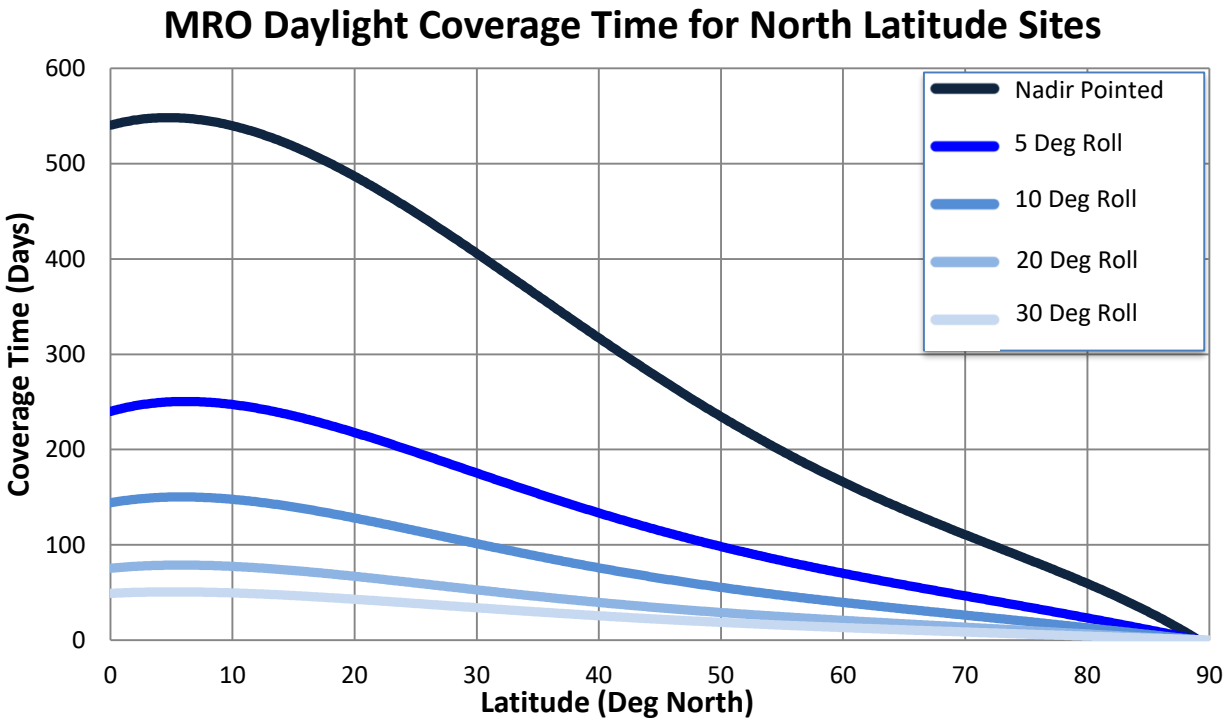


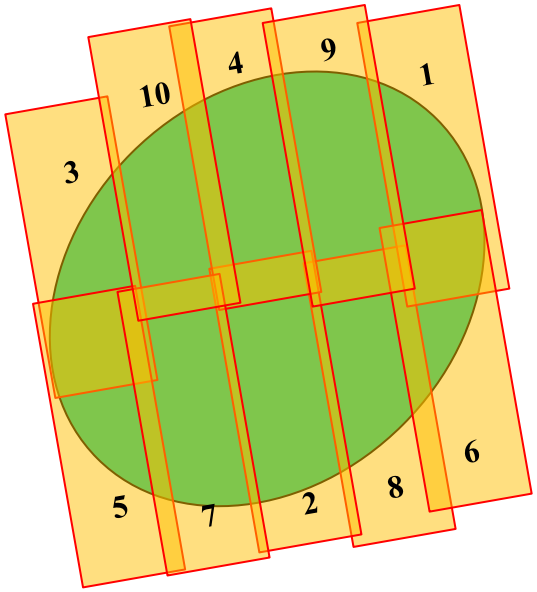


HiRISE FOV passes overlaid on 25 x 20 km landing ellipse

	Average Revisit Time (Days)				
Ground Site	**Nadir**	**5° Roll**	**10° Roll**	**20° Roll**	**30° Roll**
Gale Crater (4.5° S, 137.4° E)	44.4	24.1	14.9	7.7	5.1
Mawrth Vallis (24.9° N, 339.4° E)	51.2	20.8	12.3	6.4	4.1
Noachis HEZ (37.2° S, 350.5° E)	36.8	17.8	10.4	5.5	3.6

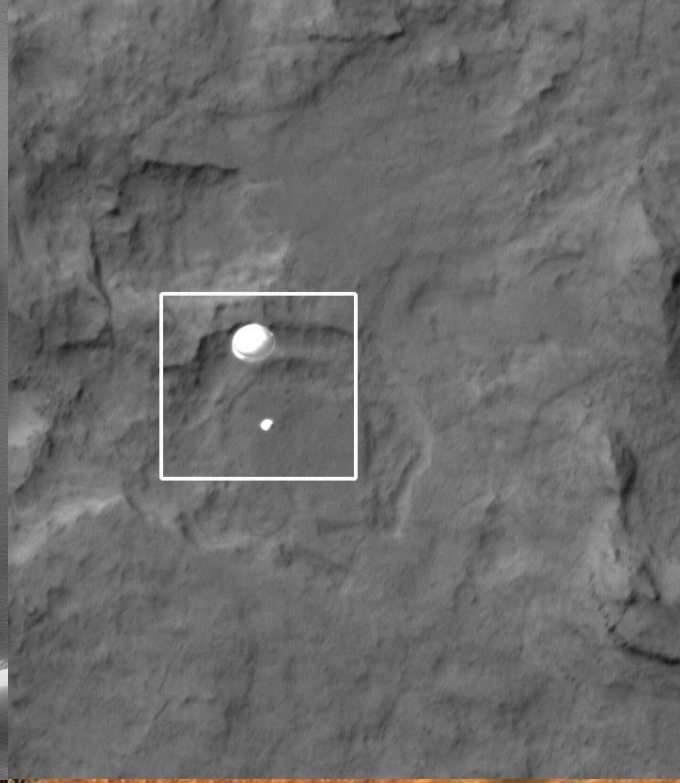
Landing Site Coverage Factors:





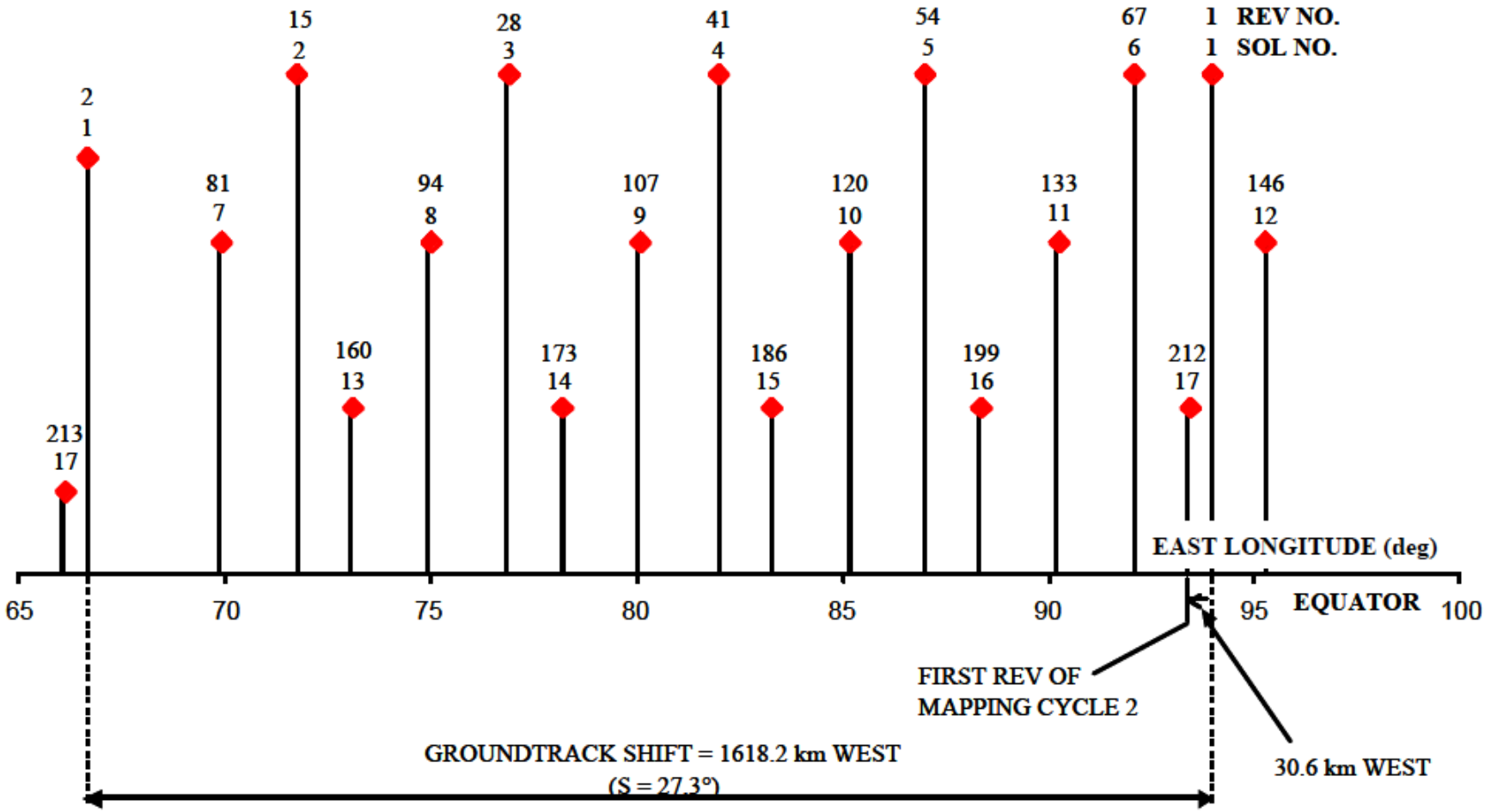
HiRISE FOV passes overlaid on 25 x 20 km landing ellipse

	Average Coverage Time (Days)				
Ground Site	**Nadir**	**5° Roll**	**10° Roll**	**20° Roll**	**30° Roll**
Gale Crater (4.5° S, 137.4° E)	443.9	240.9	149.0	77.3	50.8
Mawrth Vallis (24.9° N, 339.4° E)	512.2	207.6	123.1	63.7	40.8
Noachis HEZ (37.2° S, 350.5° E)	368.0	177.5	104.4	55.0	36.3



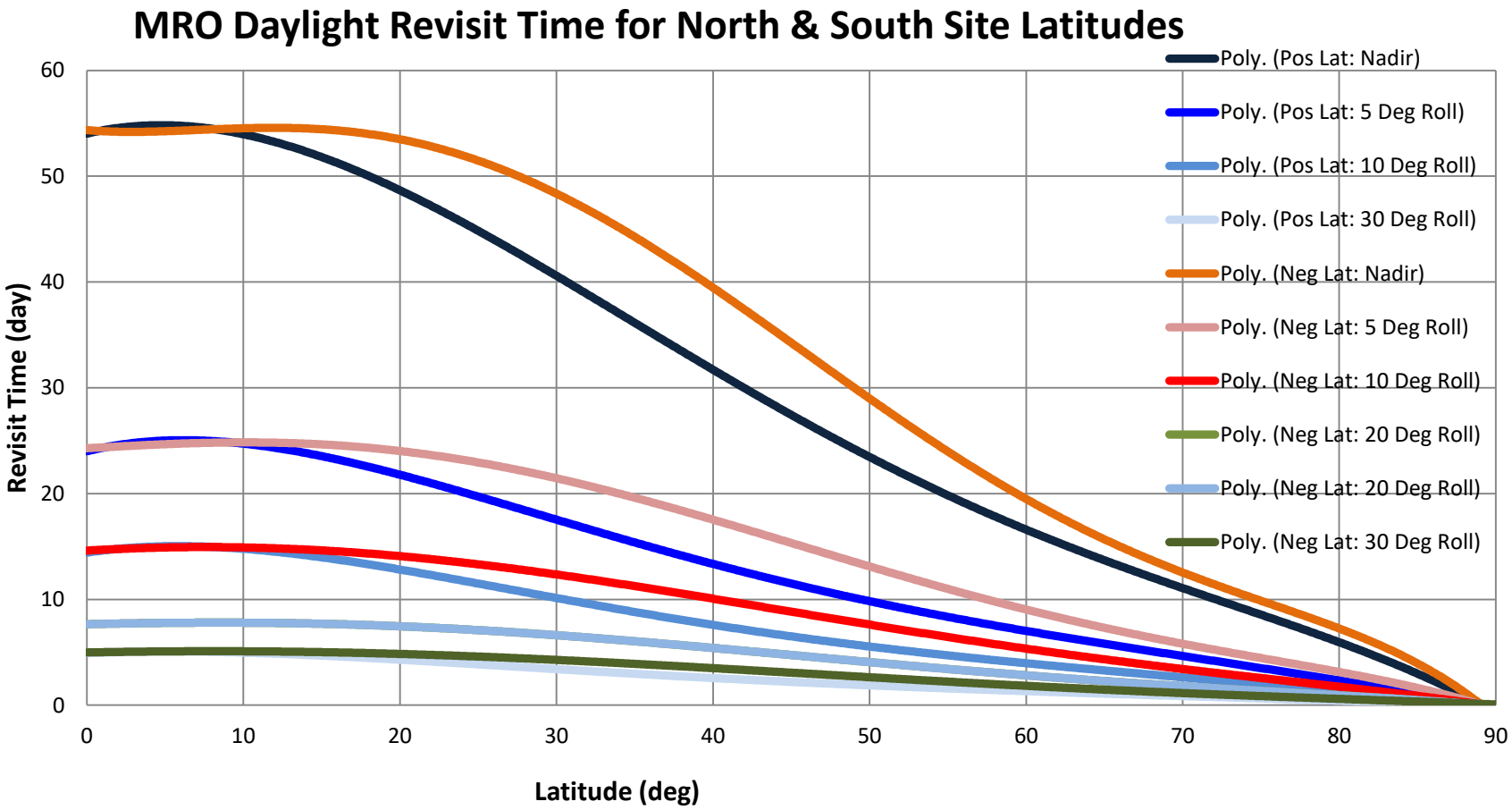
Questions ?

MRO 17 day Targeted Revisit Cycle



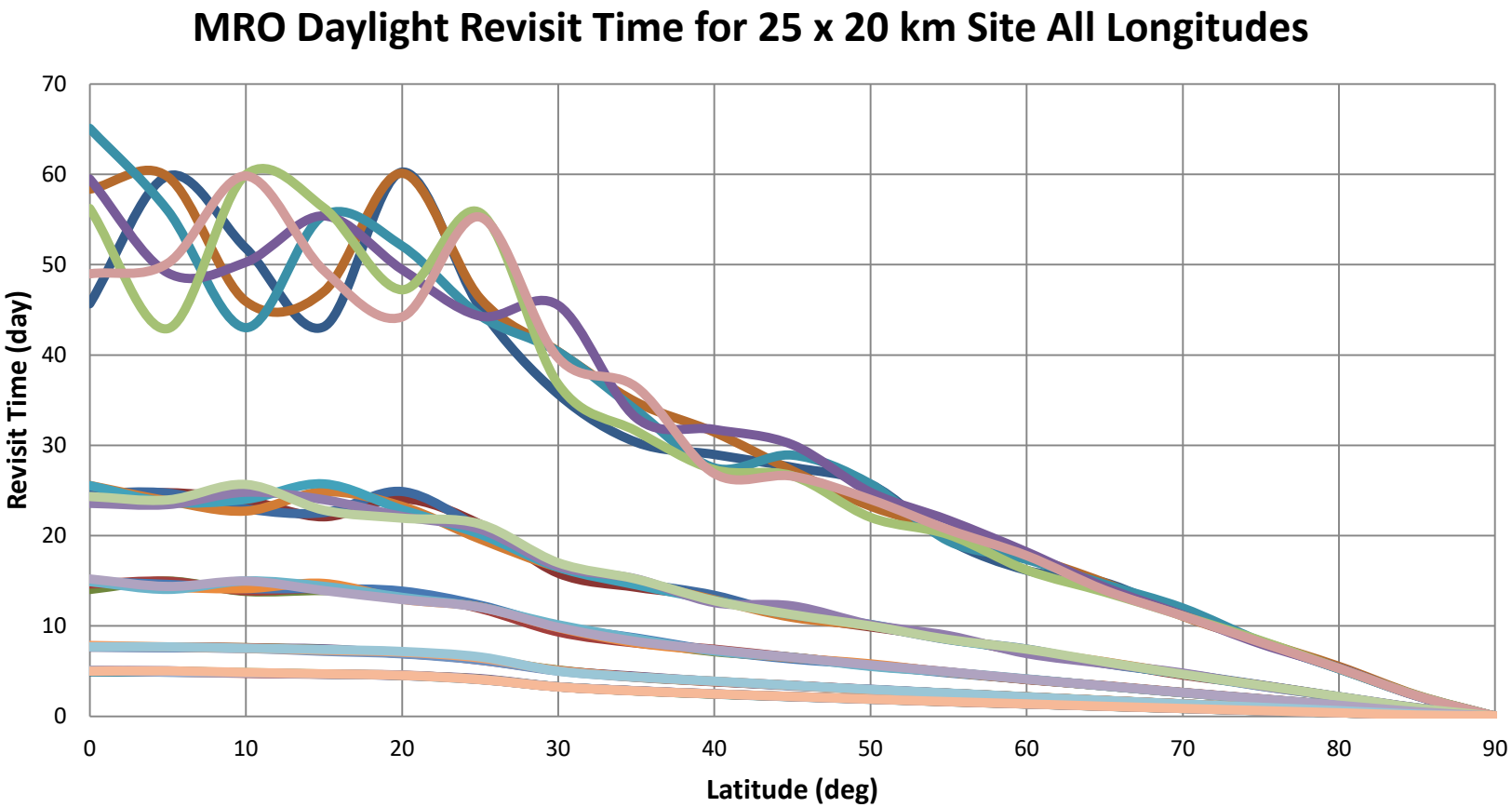
Site Revisit vs. Latitude:

25 x 20 km Landing Site Geometry



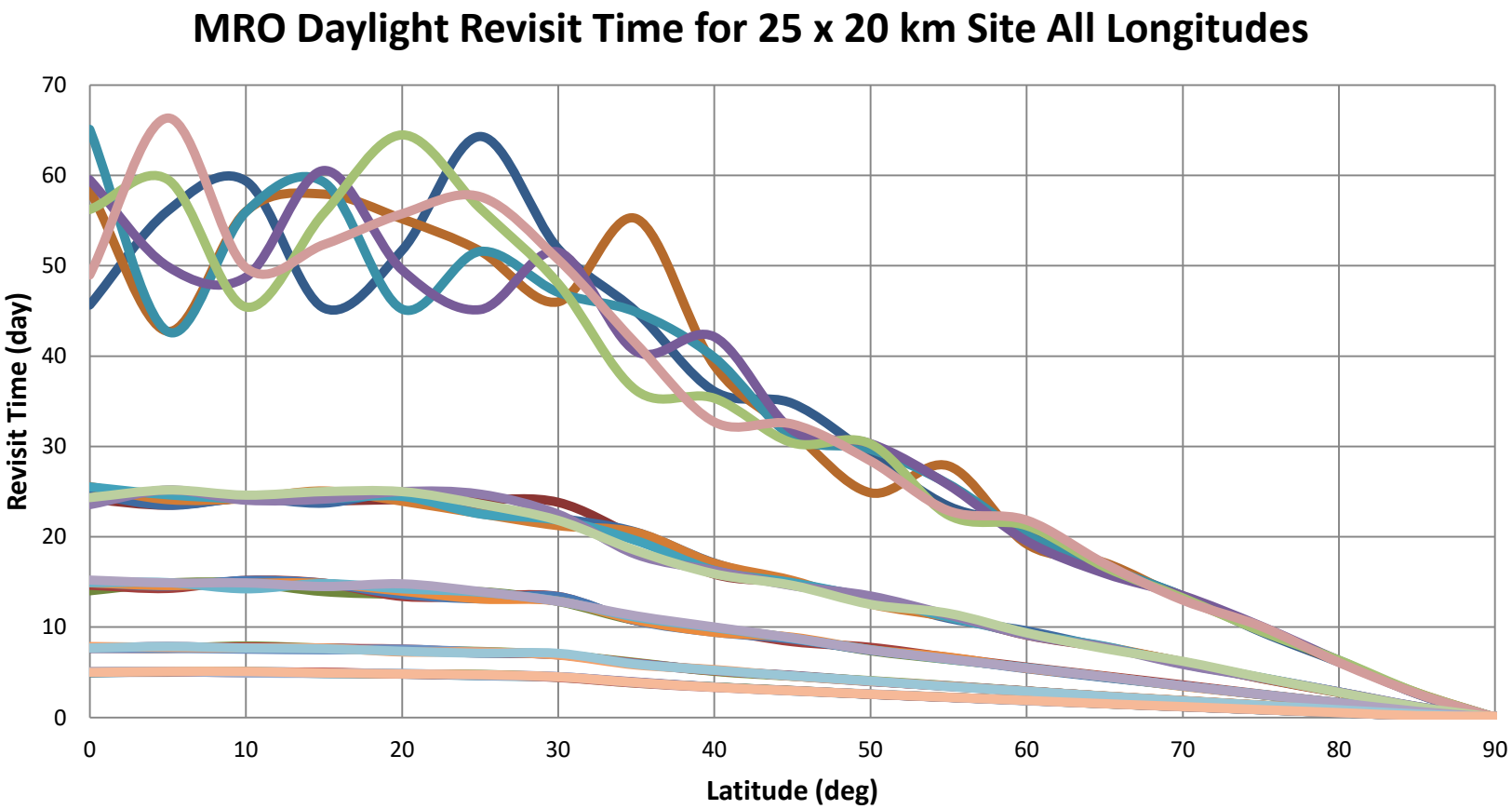
Site Revisit vs. North Latitude:

25 x 20 km Landing Site Geometry at Lon: 0, 60, 120, 180, 240, 300 deg



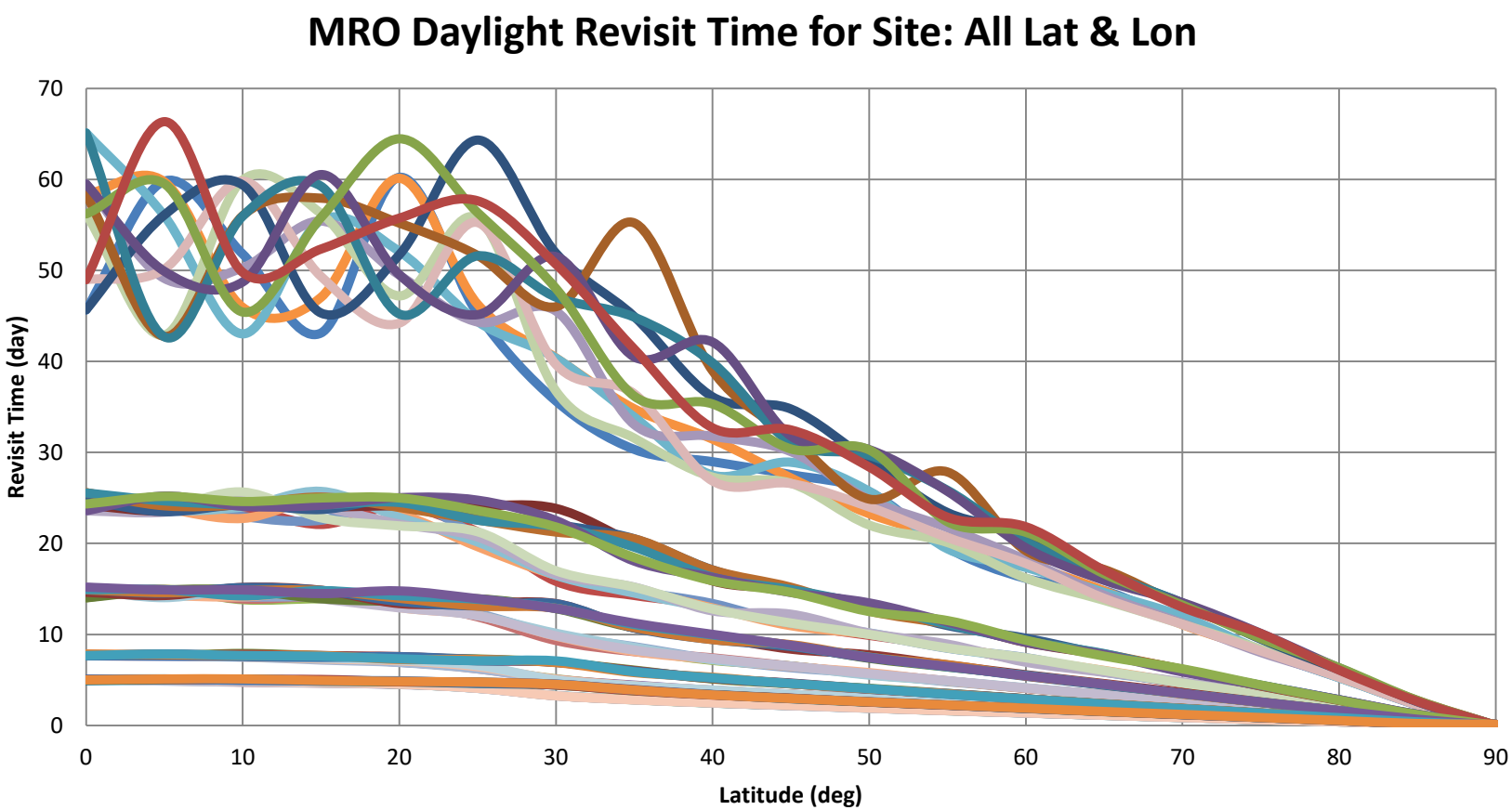
Site Revisit vs. South Latitude:

25 x 20 km Landing Site Geometry at Lon: 0, 60, 120, 180, 240, 300 deg



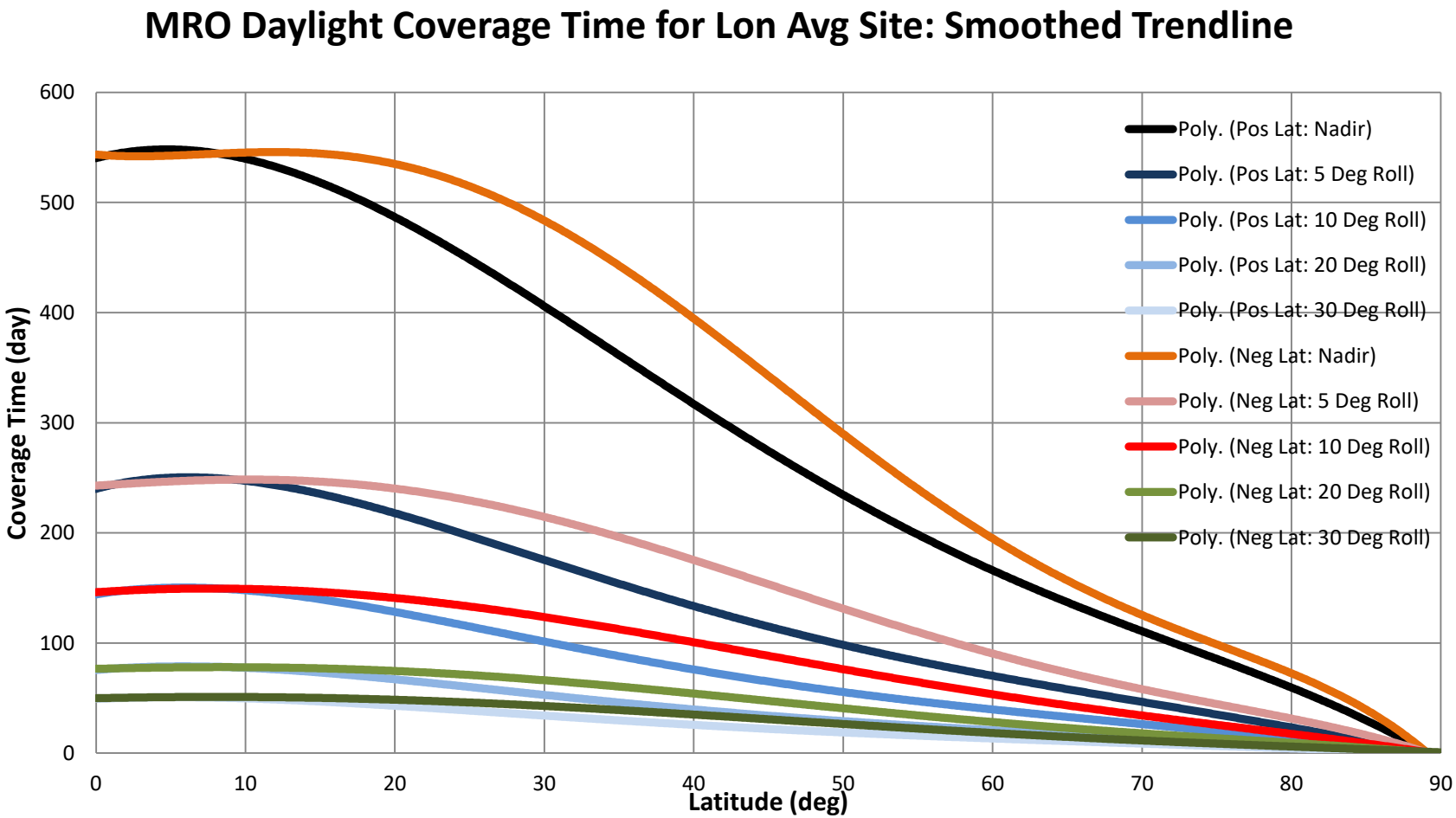
Site Revisit vs. N & S Latitude:

25 x 20 km Landing Site Geometry at Lon: 0, 60, 120, 180, 240, 300 deg



Site Coverage vs. Latitude:

25 x 20 km Landing Site Geometry using 10 Passes



Landing Site Revisit statistics

Gale Crater (4.5° S, 137.4° E):	Average Revisit Time (days)				
Revisit (days)	Nadir	5° Roll	10° Roll	20° Roll	30° Roll
Avg	44.4	24.1	14.9	7.7	5.1
Min	16.4	16.4	5.1	5.1	1.0
Max	77.1	60.6	16.4	11.3	6.2
1-σ	27.8	13.4	2.9	3.0	1.3

Mawrth Vallis (24.9° N, 339.4° E):	Average Revisit Time (days)				
Revisit (days)	Nadir	5° Roll	10° Roll	20° Roll	30° Roll
Avg	51.2	20.8	12.3	6.4	4.1
Min	6.7	6.7	1.5	0.5	0.5
Max	93.5	44.2	16.4	11.3	6.2
1-σ	31.8	10.8	4.6	2.7	1.9

Noachis HEZ (37.2° S, 350.5° E):	Average Revisit Time (days)				
Revisit (days)	Nadir	5° Roll	10° Roll	20° Roll	30° Roll
Avg	36.8	17.8	10.4	5.5	3.6
Min	3.6	3.6	1.5	1.5	1.0
Max	77.1	44.2	16.4	11.3	6.2
1-σ	28.6	10.1	4.9	2.5	1.9

Gale Crater Site Coverage / Revisit Examples

Gale Crater (4.5° S, 137.4° E):	Site Revisit Time (days)				
Revisit #	**Nadir**	**5° Roll**	**10° Roll**	**20° Roll**	**30° Roll**
1	16.4	16.4	5.1	6.2	6.2
2	60.6	16.4	11.3	5.1	5.1
3	16.4	27.7	16.4	11.3	5.1
4	77.1	16.4	16.4	5.1	6.2
5	77.1	16.4	16.4	11.3	5.1
6	16.4	44.2	11.3	5.1	5.1
7	77.1	16.4	16.4	11.3	6.2
8	16.4	16.4	16.4	5.1	5.1
9	77.1	60.6	16.4	11.3	5.1
10	16.4	16.4	16.4	5.1	1.0
Coverage Time:	451.1	247.6	142.8	77.1	50.3

Gale Crater (4.5° S, 137.4° E):	Site Coverage Time (days)				
Coverage	**Nadir**	**5° Roll**	**10° Roll**	**20° Roll**	**30° Roll**
Average	456.7	250.9	147.3	77.4	50.5
Minimum	418.2	219.9	137.7	77.1	44.2
Maximum	495.3	291.8	159.3	82.2	55.5
1-σ	28.3	19.8	8.5	1.3	3.4

Mawrth Site Coverage / Revisit Examples

Mawrth Vallis (24.9° N, 339.4° E): Site Revisit Time (days)					
Revisit #	**Nadir**	**5° Roll**	**10° Roll**	**20° Roll**	**30° Roll**
1	16.4	16.4	16.4	5.1	5.1
2	60.6	27.7	16.4	11.3	5.1
3	16.4	16.4	11.3	5.1	5.1
4	77.1	16.4	5.1	6.2	1.0
5	77.1	16.4	11.3	5.1	5.1
6	16.4	27.7	16.4	5.1	5.1
7	77.1	16.4	16.4	6.2	5.1
8	93.5	16.4	16.4	5.1	1.0
9	86.8	16.4	11.3	11.3	5.1
10	6.7	44.2	5.1	5.1	5.1
Coverage Time:	528.1	214.7	126.4	65.8	43.2

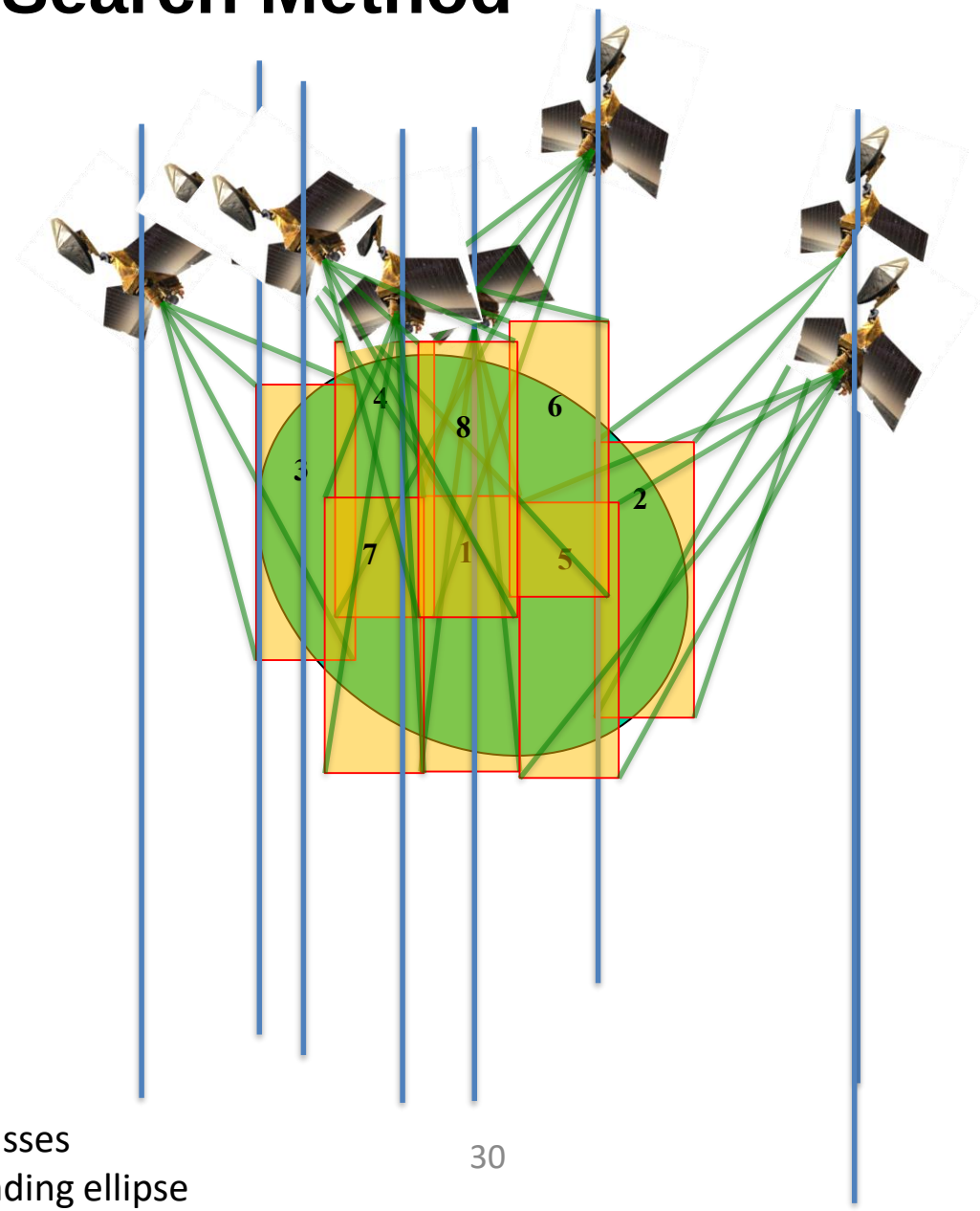
Mawrth Vallis (24.9° N, 339.4° E): Site Coverage Time (days)					
Coverage	**Nadir**	**5° Roll**	**10° Roll**	**20° Roll**	**30° Roll**
Average	525.2	212.6	126.5	64.6	41.3
Minimum	478.8	154.1	77.1	32.9	18.0
Maximum	582.1	247.6	142.8	71.9	49.3
1-σ	43.1	24.9	14.3	8.1	6.5

Noachis HEZ Site Coverage / Revisit Example

Noachis HEZ (37.2° S, 350.5° E):	Site Revisit Time (days)				
Revisit #	**Nadir**	**5° Roll**	**10° Roll**	**20° Roll**	**30° Roll**
1	16.4	16.4	5.1	5.1	5.1
2	60.6	27.7	11.3	6.2	1.0
3	12.8	16.4	5.1	5.1	5.1
4	3.6	16.4	11.3	5.1	5.1
5	57.0	16.4	16.4	6.2	5.1
6	16.4	27.7	16.4	5.1	1.0
7	3.6	16.4	11.3	5.1	5.1
8	77.1	12.8	5.1	6.2	5.1
9	16.4	3.6	11.3	5.1	5.1
10	77.1	12.8	16.4	11.3	1.0
Coverage Time:	341.1	167.0	109.9	60.6	39.0

Noachis HEZ (37.2° S, 350.5° E):	Site Coverage Time (days)				
Coverage	**Nadir**	**5° Roll**	**10° Roll**	**20° Roll**	**30° Roll**
Average	337.0	166.3	104.6	54.4	35.9
Minimum	308.3	93.5	60.6	26.7	19.0
Maximum	361.2	231.2	142.8	66.8	44.2
1-σ	19.0	40.7	25.2	13.9	9.1

Targeting Search Method



5.4 x 15 km HiRISE FOV passes
overlaid on 25 x 20 km landing ellipse