Landing Targets and Technical Subjects for SELENE-2

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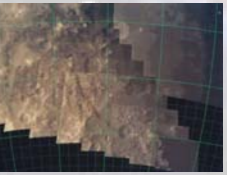
JAXA / JSPEC

JAXA's Lunar Exploration



SELENE-B

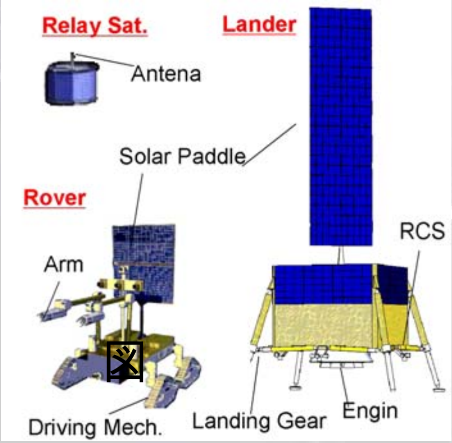
Hiten & Hagoromo 1990 → SELENE ~ 2007.9 → SELENE-2 (Early 2010) → SELENE-X → Human Lunar Explo.

JAXA 2025

NASA VSE

SAC- -Lunar Explo. WG

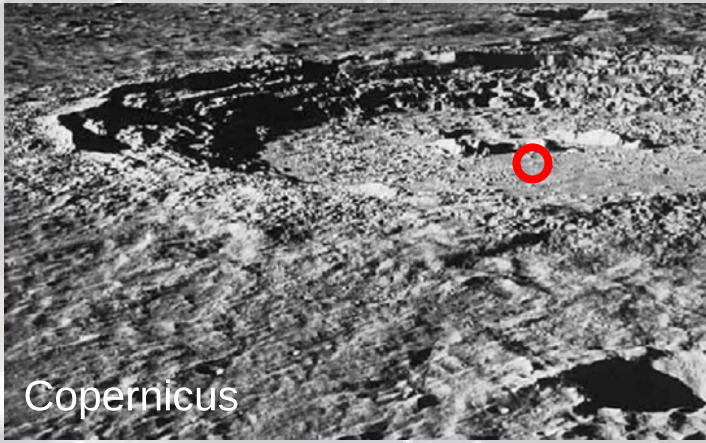
Lunar-A → Int' Coop.



SELENE-2

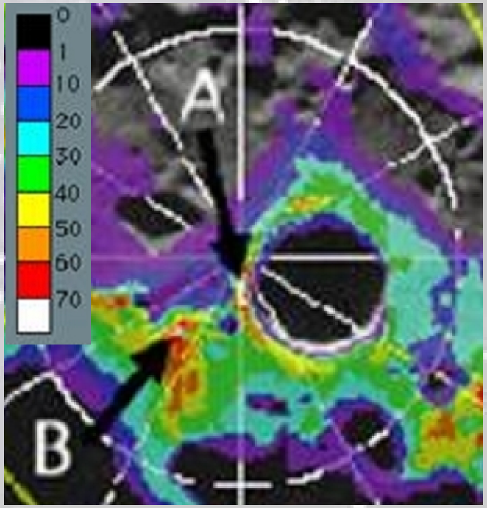
Japanese Lander Concepts : SELENE-B to SELENE-2

- SELENE-B
  - Mission
    - Lunar science
  - Landing
    - Central peak of a large crater



Central Peak

- SELENE-2
  - Mission
    - Lunar science
    - Technology development
    - International cooperation
  - Landing :
    - Primary : ELR (Eternal Light Region) of polar region
    - Sub : Equatorial, or high latitudes



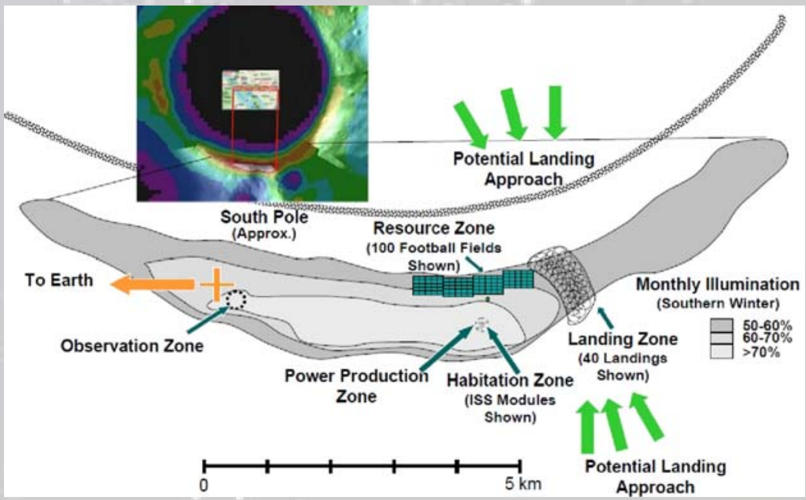
South Pole & Shackleton Crator (D.B.J.Bussey et al)

Characteristics of new Landing Target
-- Quasi-ELR(eternal light region) –

- for long term lunar activity
  - Long term scientific observation
    - Seismology, libration, . . .
  - Future lunar activities
    - Outpost, Observatory

- Science
  - By : Long Term Seismometric Observation
  - of : Geology & Chronology, SPA
  - : Origin of Water/Ice
  - from : Astronomy

- Utilization
  - PSR is very close for water/ice ISRU



Landing Targets for SELENE-2

	Polar Region (ELR)	Mid Lattitude (Crater Central Hill)
Tech. merits	*Long term mission by solar power *Low temperature change	*Direct link from ground *Optical image role for Hazard Avoidance *Hot temperature during day time
Science	*Water/Ice possibility at PSR *Samples from SPA	*Material from lunar inside *SPA and far side
Social	*Inter. human lunar exploration & outpost	*Science driven
Subjects to be solved	*Narrow Landing site *Low sun angle *Difficulty of direct comm. →Data relay Sat.	*Night survival for long Moon nights

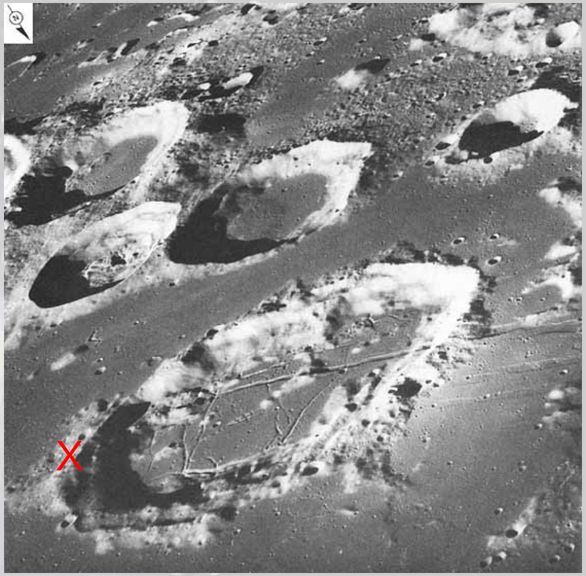
ELR -- what ELR is, for technology?

- Mountain top
  - Pin-point & Safe landing
    - Narrow(<1km) & Long(3,4km)
  - Rough terain mobility
    - Slope with 15^{o} Average
- Very low temperature thermal control
    - 100K (estimated)
- Long day time
- Low & sun angle (< 5^{o})
-

- Safe & precise landing
- Exploration around lander by rover
  - Slope Climbing
  - Survival in very low temperature
- Utilization of longer day time at ELR
  - Long term activities at landing site

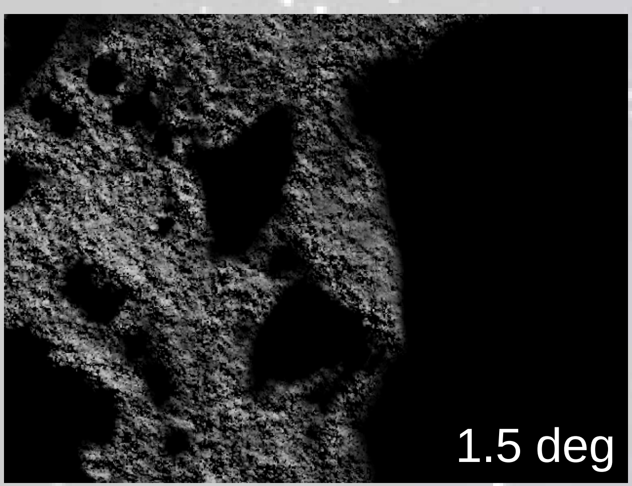
For Safe & precise landing

- Safe
  - Autonomous Obstacle Avoidance
    - Obstacle identification / recognition
      - Active image recognition
        - » Rader altimeter & velocity meter
        - » LRF
        - » Flash, Star shell
  - Supervised landing control from ground



- Precise -- Navigation & Guidance
  - Advanced N&G sensors
    - Image tracking
    - Altitude trace tracking
  - Pin Point Control
    - Image tracking control
    - Sensors: Radio A&V

Simulated Image of Polar region



Effect of Rocks

*Surveyor 7 level rock distribution

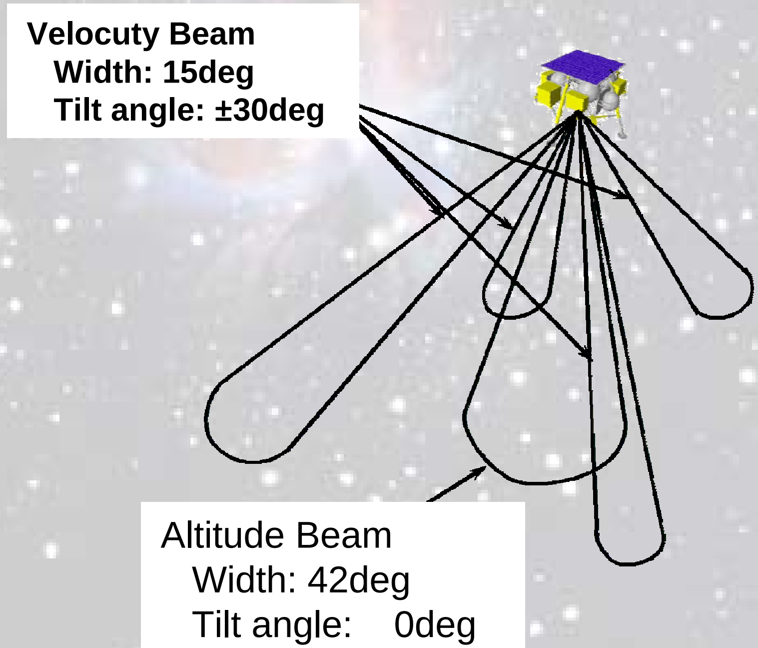
*Sun angle : 1.5 deg

→ Shadow : 91.8%

Active sensors

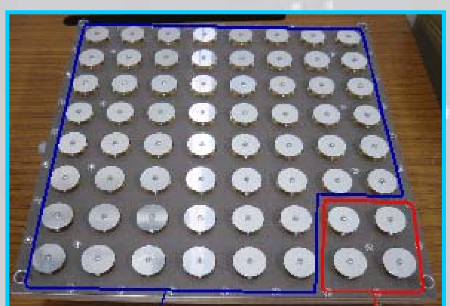
Radar, LRF, Flash, Star shell

For Safe & precise landing
-- Development of Landing RADAR



Radar Type	**Pulse radar**
Funciton	**Altimeter** **Velocitymeter** **(Doppler RADAR)**
Range	**Altitude 30 - 10000m**
	Velocity 0 - 50m/s
Accuracy	**5% for Altimeter**
	5% for Velocitymeter
Data rate	**5Hz**

RADAR BBM Field Experiment & Evaluation

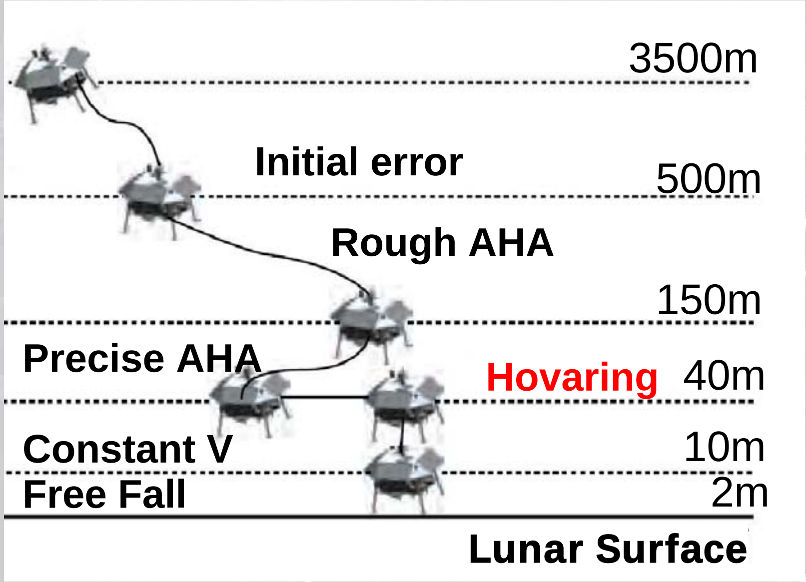


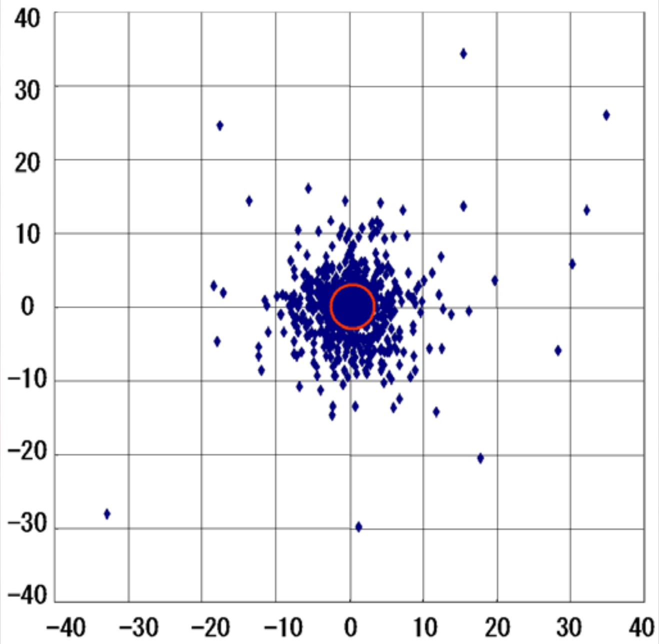
Antenna Unit

Now ready to move on to EM

For Safe & precise landing
-- Precise vertical descent control

Vertical descent scenario





Simulation

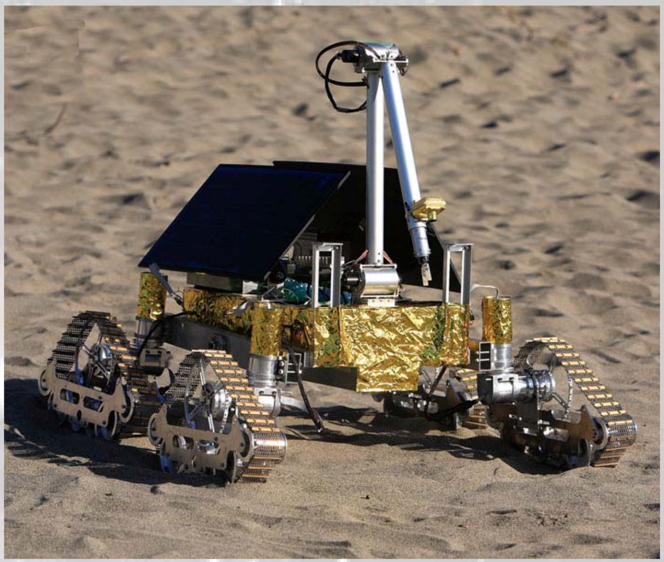
Improved vertical descent control

Results : < ±4m 3 σ

- Hovering 10 sec at 40m altitude
- N&V sensor
  - ✓Image Tracking
  - ✓Touch down sensor

Rover : Exploration around lander

- ELR area characteristic
  - Rough terrain like mountain top
    - Surface : covered by thick regolith
    - Slope : Average 15^o
    - Rock : Ejector zone of a Crater
      - Surveyer-7 level as worst case

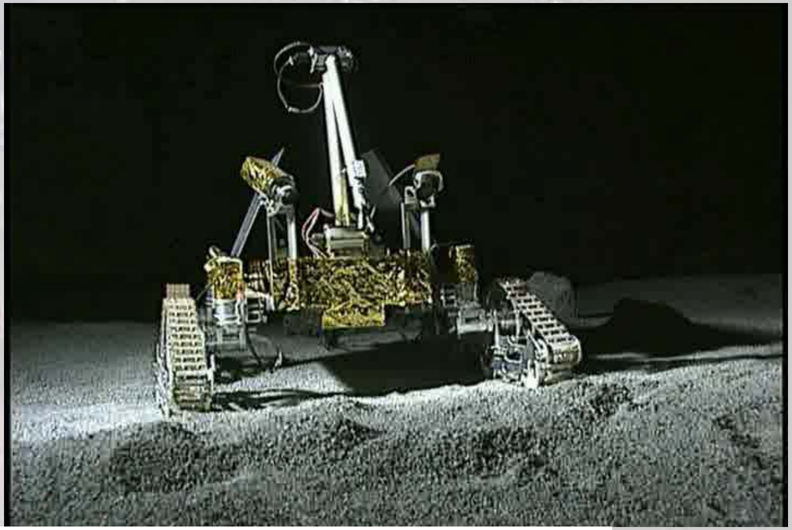


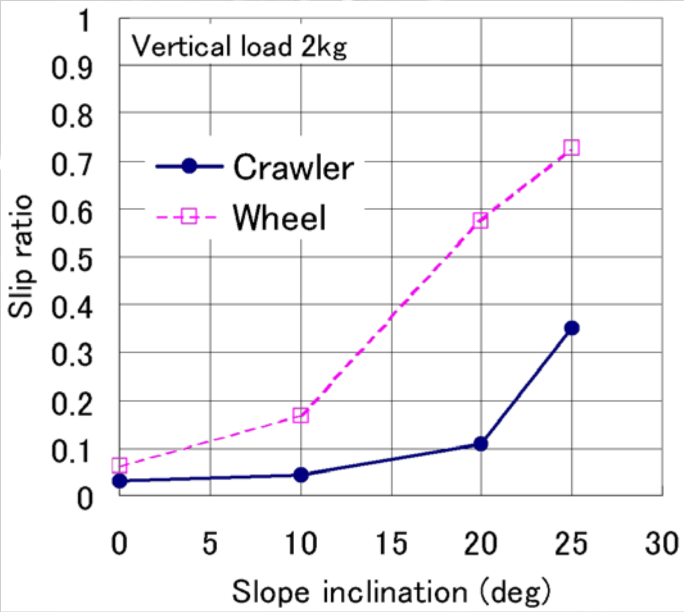
- Technical subjects of rover
  - Running mechanism
    - Crawler
    - Low pressure ring tire
  - Supervised vs Autonomy
    - Little comm. time delay
    - Technology & future planet explo.
  - Moon night survival

Rover : Exploration around lander
-- Running Mechnism--

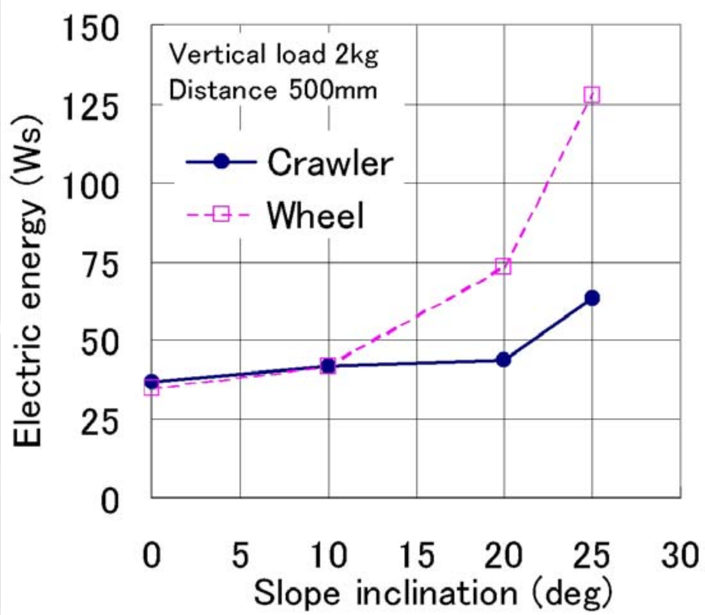
- Crawler type rover and Wheel type rover BBM is under developing

Crawler for
*next exploration
*future outpost





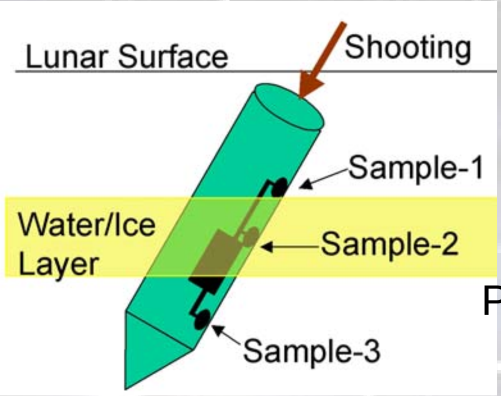
Hill Climbing



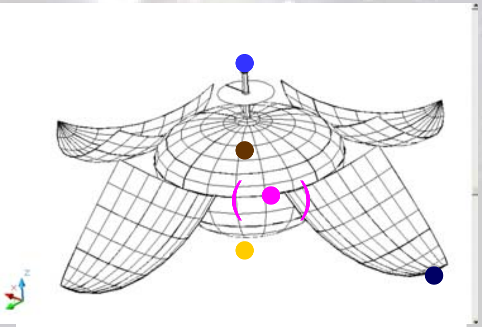
Power Req.

Explo

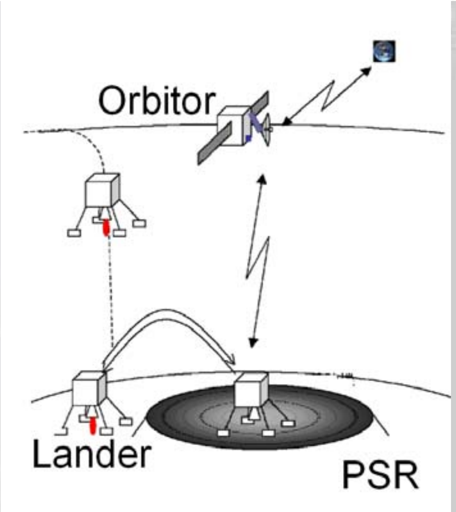
- Before landing
  - Penetrator
    - High penetrating G (>10000G)
  - Capsule with Air Bag
    - Single point of PSR surface
- After landing
  - Hopping exploration
    - Amount of fuel
  - Rover exploration in PSR
    - Survivability in PSR
  - RSIM observation from Rover on the end of Rim
    - RSIM sensor



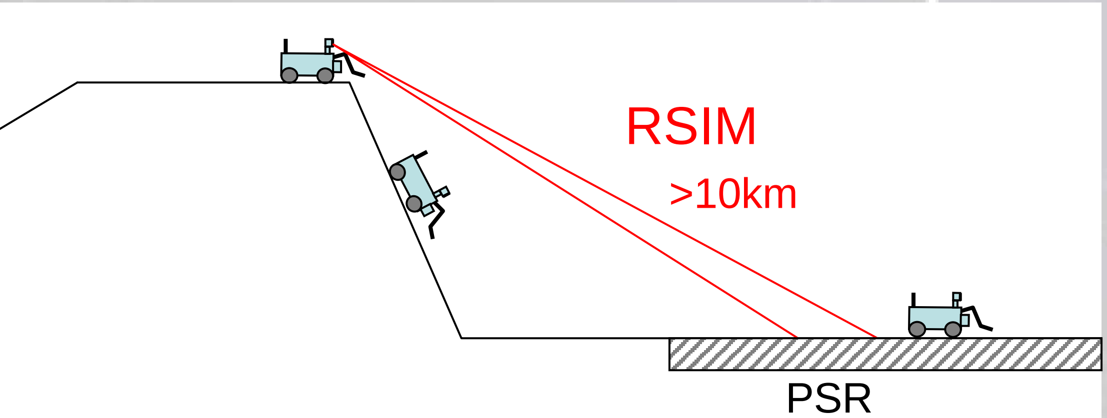
Penetrator digging by itself



Capsule Airbag landing

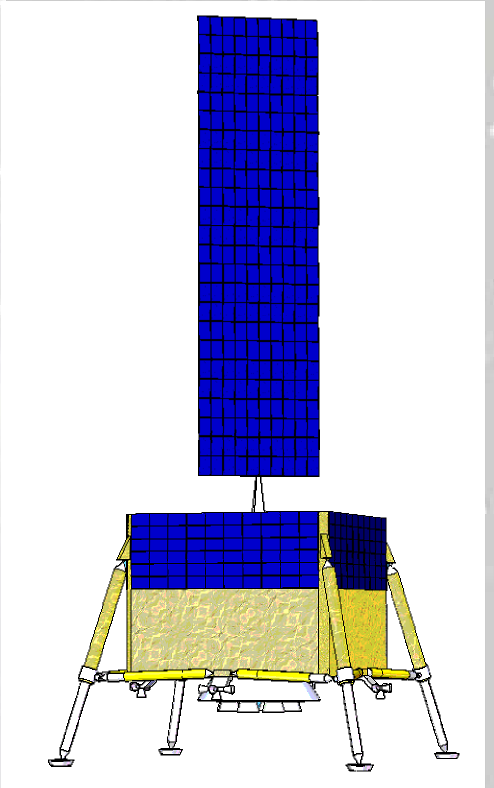


Hopping Full exploration

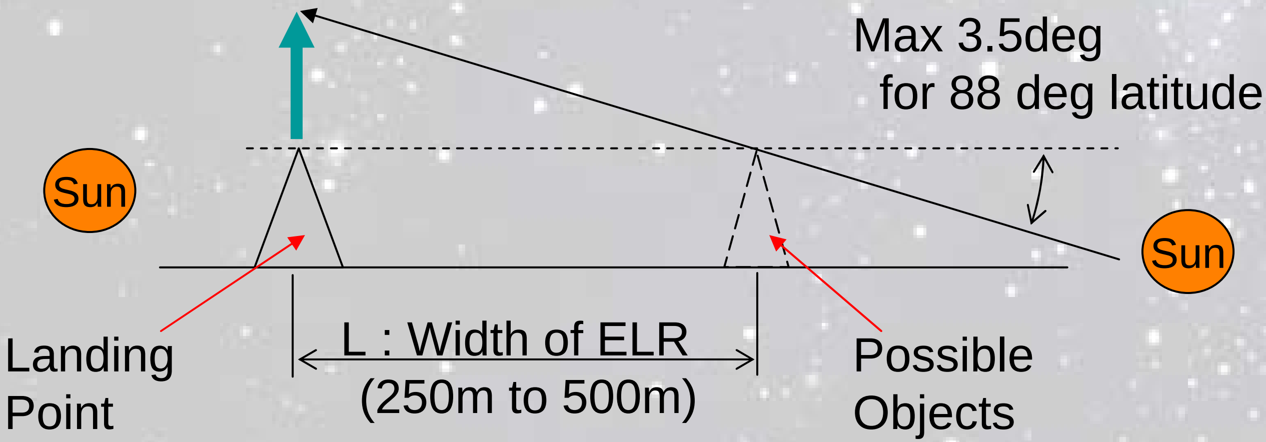


Solar Tower : Utilization of longer day time at ELR

- **Feasibility of Solar Tower Concept**
  - **Tower Height**
    - Against Ground rerief
    - (Against rock obstacles)



Tower Height
= L×tan 3.5deg



15 to 30m Tower Height

Power system : Utilization of longer day time at ELR

	Power Req. kw/h	Total Power for a Night kw/h	Fuel Cell (kg)	RTG (kg)	Nuclear (kg)	Solar Paddle on Lunar Pole (kg)
Electrical Specification			400 WH/kg			11w/kg ～150w/kg
Unmanned Explorer (No activities in Night)	0.1	36	200	20	-	10
Unmanned Explorer (Active in Night)	0.5	180	400	100	-	50
Manned Outpost (JEM Size)	21	7560	(18900)	(4200)	1000 ～ 4000	280 ～1900
Manned Base (ISS Level)	75	27000	(67500)	(15000)	1000 ～ 4000	1000 ～7000

Promissing Solar Paddle Tower

-- Major technological subjects to be solved – as Concluding Remarks

- Safe & Precise
  - – Active sensors for Obstacle recognition
  - – Reliable N&G algorithm/software
- Rover
  - – Night survival without RTG
  - – Activities under very low temperature
- Night survival
  - – Parts development & verification for $–200^{o}C$ to $–240^{o}C$
  - – Effective power resource for lunar exploration

Rover : Exploration around Lander
-- Survivability in PSR --

- **PSR is close to landing zone**
  - Long traverse from lander to PSR
    - > 10km
    - Steep slope from crater rim to floor > 30º
  - Survivability of Small rover in PSR
    - Thermal Control in ELR & PSR
    - 2 to 5 hours survival in PSR
      - with 40W continuous power consumption