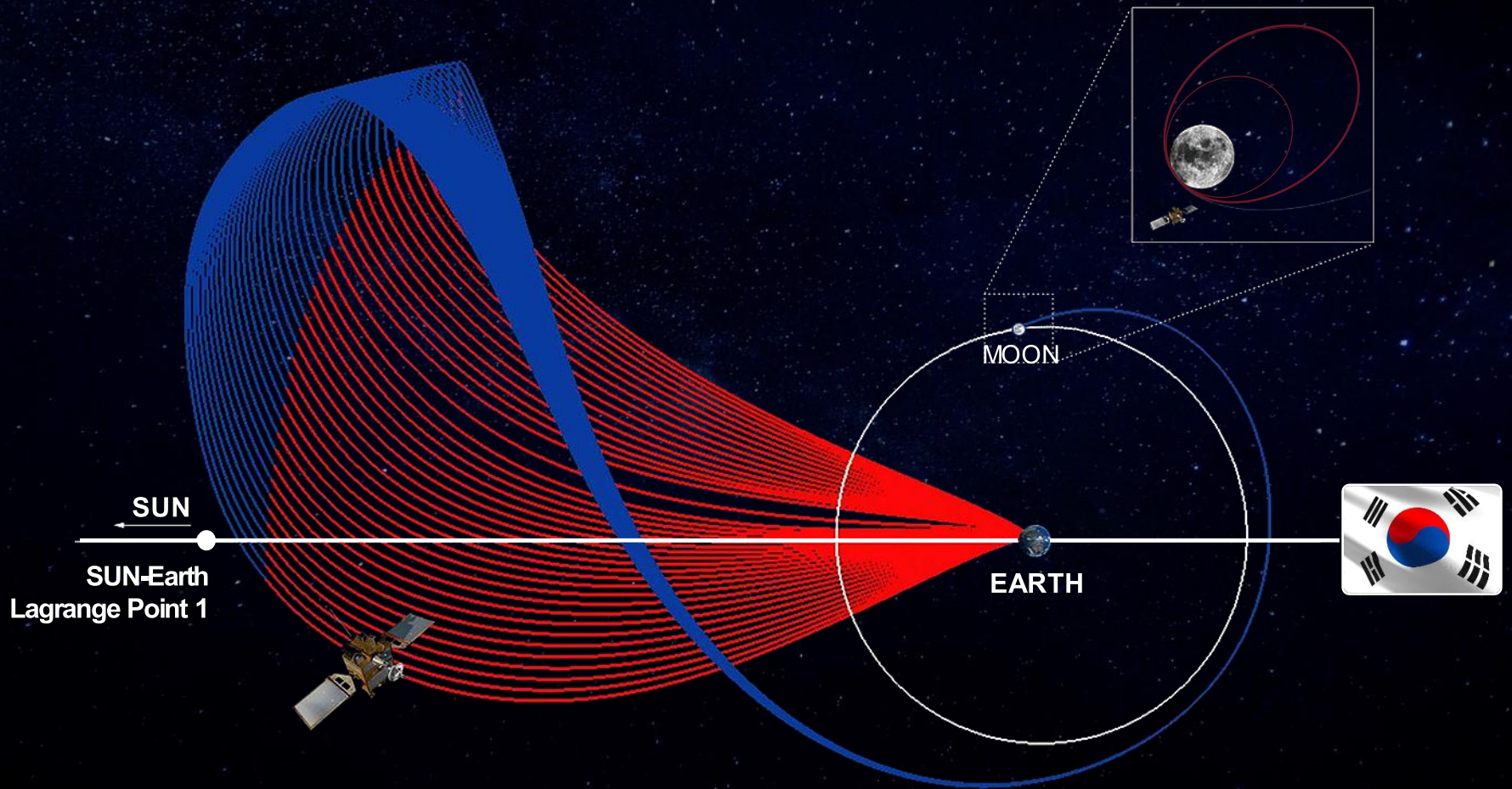
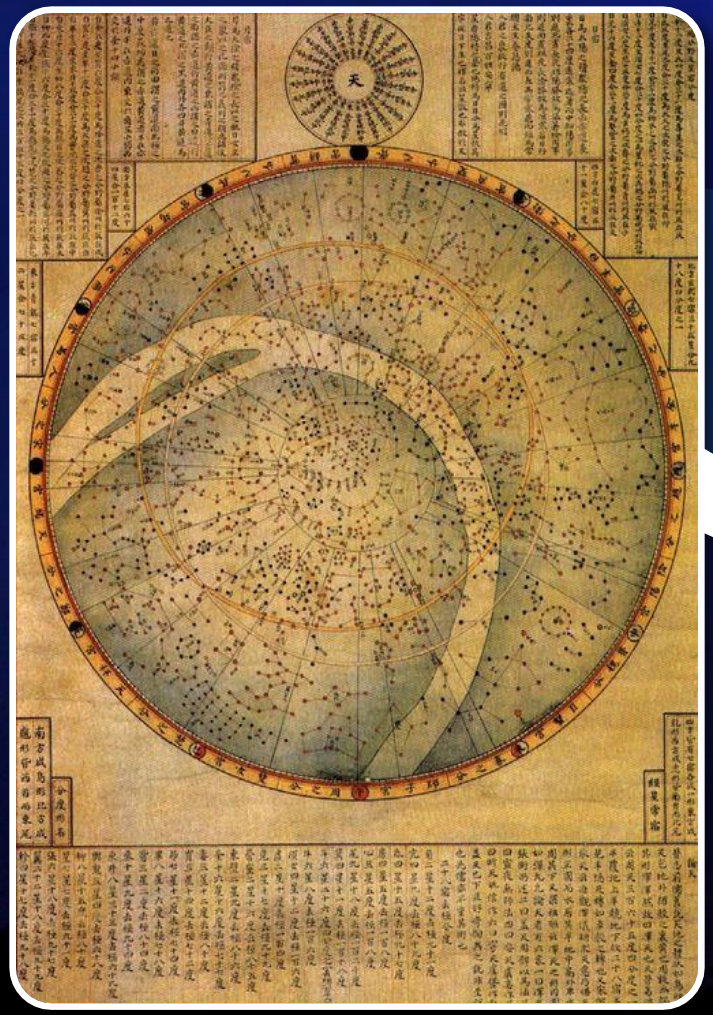
“A Journey to the Moon by Korea”



Korea Aerospace Research Institute



“ **Koreans** have been **observing stars** for **thousands of years** ”

Cheomseongdae(“Star-gazing tower”)
- Built during the 7th centry AD
- The oldest astronomical observatory in East Asia

KARI Korea Aerospace Research Institute

National Space Development Roadmap

1990 | 2000 | 2010 | 2020 | 2030 | 2040

1992 KITSAT-1

1993 KITSAT-2

1993 KSR-1

1998 KSR-3

1999 KITSAT-3

1999 KOMPSAT-1

2002 KSR-3

2003 STSAT-1

2006 KOMPSAT-2

2008 The 1st Korean astronaut

2009/2010 The 1st & 2nd Launch of KSLV-1

2009/2010 STSAT-2

2010 COMS

2012 KOMPSAT-3

2013 The 3rd launch of KSLV-I

2013 STSAT-2C

2013 KOMPSAT-5

2013 STSAT-3

2015 KOMPSAT-3A

2018 Compact Satellite 1

2018 Launch of TLV

2018 GEO- KOMPSAT-2A

2020 GEO- KOMPSAT-2B

2021 CAS500 -1

2022 KSLV-II NURI

2022 KPLO

2023 CAS500-2

2023 Compact Satellite 2

2023 KOMPSAT-6

2023 KOMPSAT-7

2023 CAS500-3

2025 CAS500-4

2025 CAS500-5

~2032 Lunar Lander

2030(TBD) Expansion of small LV platform

2035(TBD) Asteroid sample return spacecraft

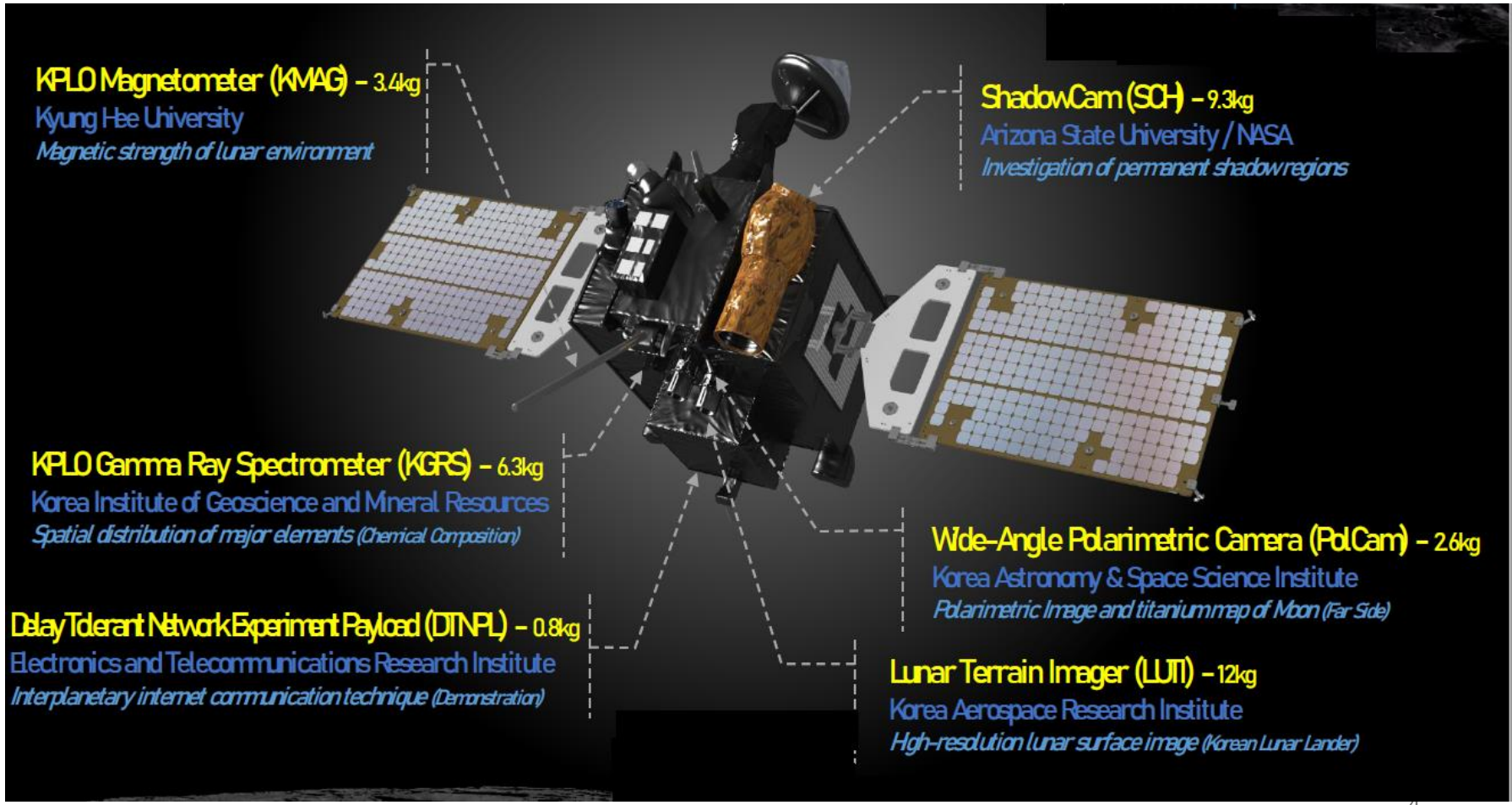
2040(TBD) Securing technology of large LV platform

Phase 1 - KPLO(Korea Pathfinder Lunar Orbiter)

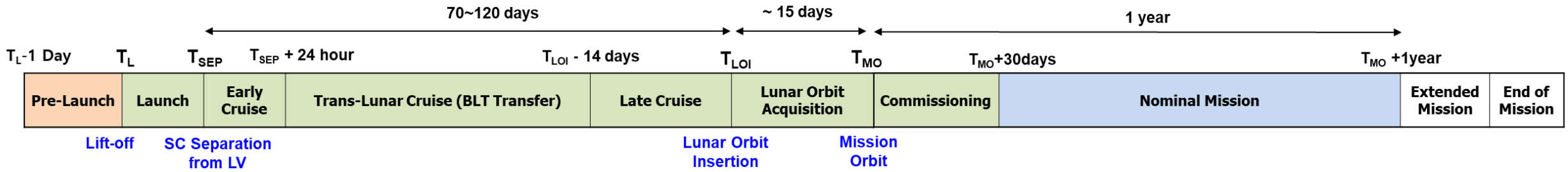
Item	Parameters
Mass	≤ 678 kg
Bus Power @ EOL	Average 760 Watt, (2-wing, 1-axis S/A)
Main Bus Voltage	26.4 ~32.8V unregulated
Mission Life	4 Months (Transfer-orbit) + 12 Months (Mission-orbit, include commissioning a month)
Lunar Transfer Trajectory	Ballistic Lunar Transfer(BLT) / Week Stability Boundary(WSB)
Mission Orbit	Altitude : 100 ±30km, Inclination : 90± 0.25deg
Propulsion System	Monopropellant System OMT : 30N Thruster (4EA) ACT : 4.45N Thruster (8EA)
Communication	S-band(Uplink) : 0.5Kbps, 1.0Kbps S-band(Downlink): 1.024Kbps, 16.384Kbps X-Band(Downlink): 8.5Mbps @HGA

KPLO = 다누리 (Danuri)

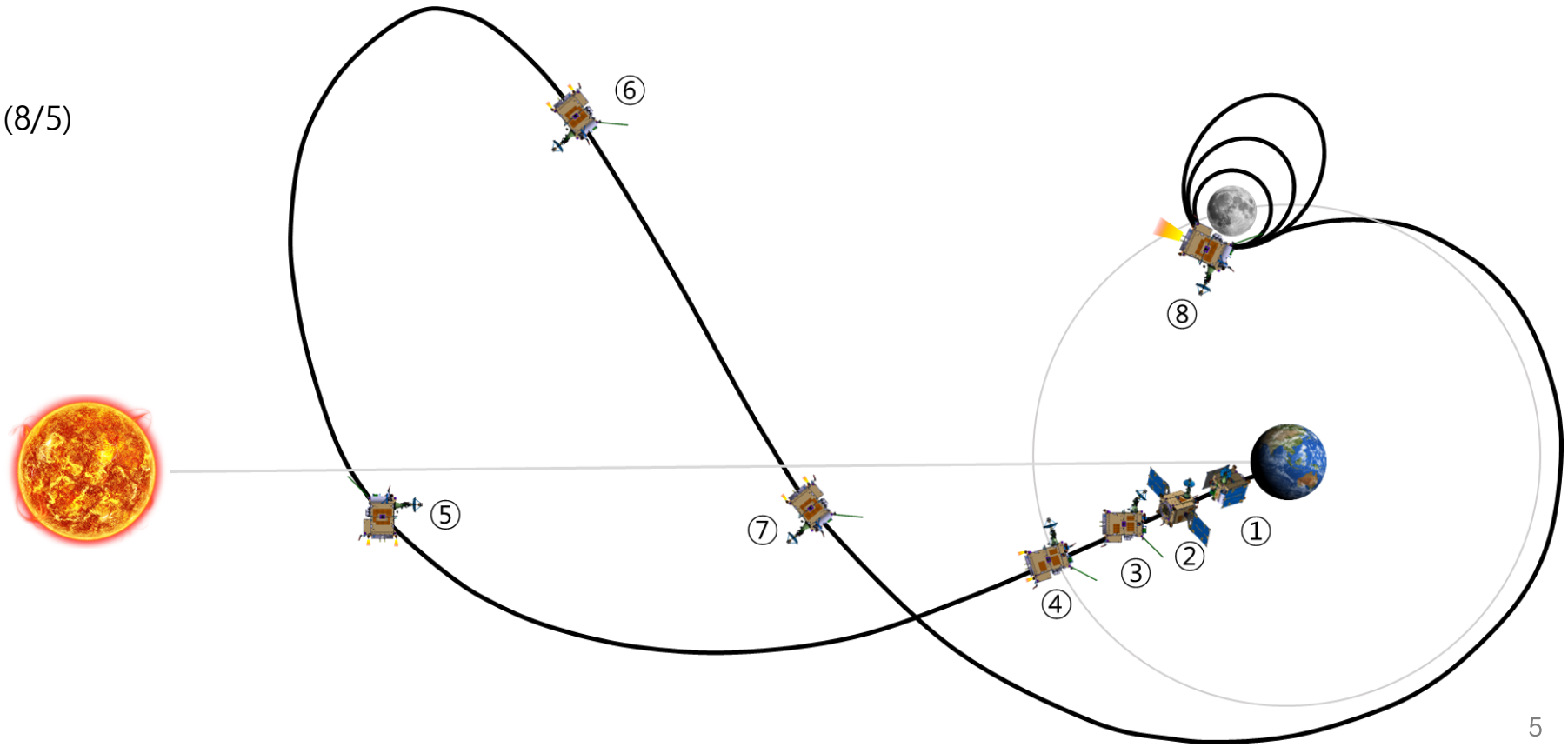
"Dal" (Moon) + "Nuri" (Enjoy)



Major Event of KPLO in BLT/WSB Trajectory



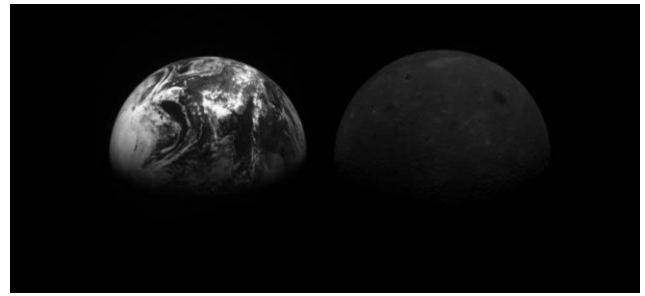
① LV Separation (8/5)
② S/A Deployment & Sun Pointing (8/5)
③ HGA Earth Pointing (8/6)
④ TCM#1 (8/7)
⑤ TCM#3 (9/2)
⑥ TCM#5 (11/2)
⑦ TCM#6 (11/16)
⑧ LOI#1, #2, #4 (12/16, 21, 26)



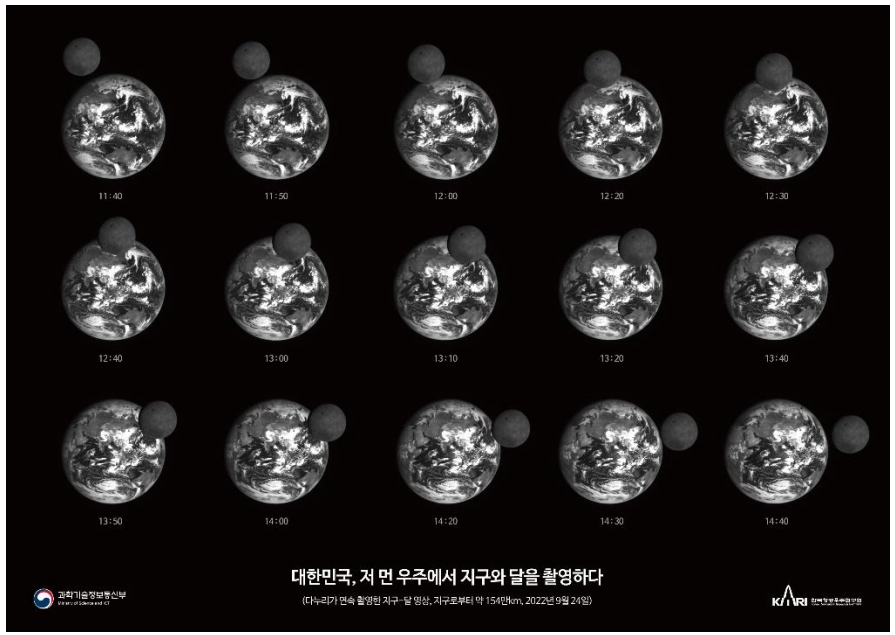
Special Images taken by Danuri during Journey to the Moon

First image taken by KPLO @ 2022/8/6

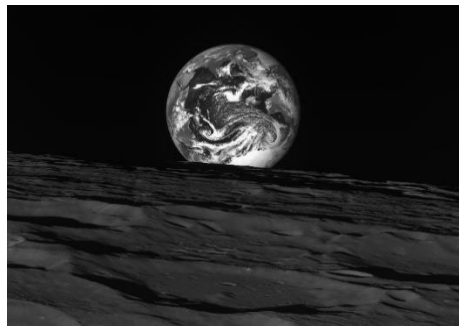
2022/11/28



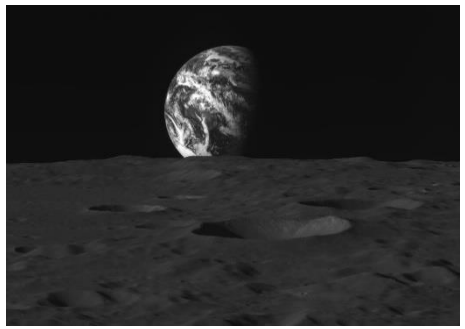
Transition to earth @ 2022/9/24



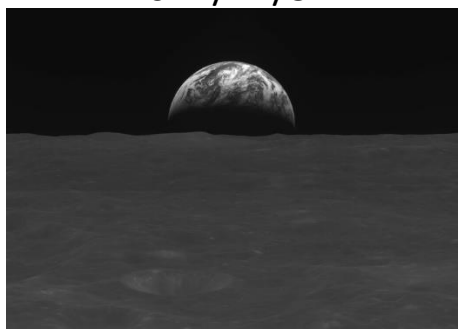
After LOI#2 @2022/12/24



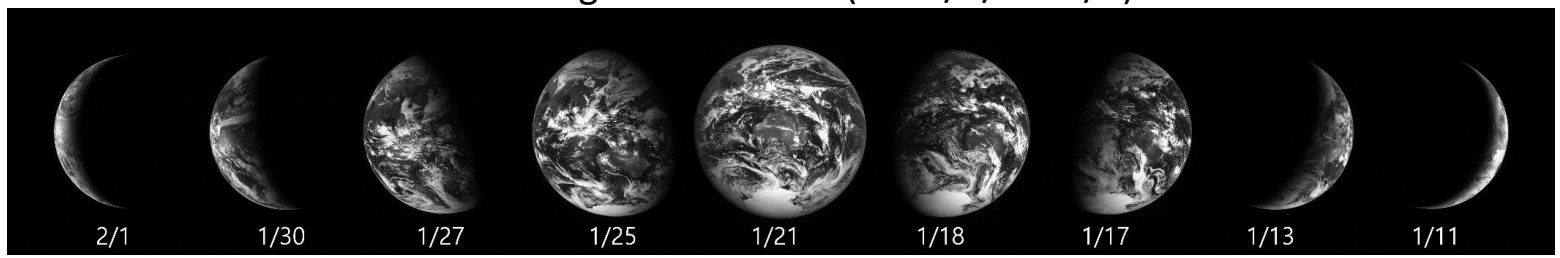
Mission Orbit @ 2022/12/28



2022/12/31



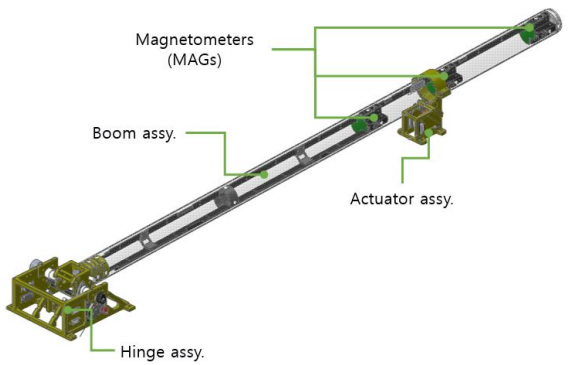
Earth Phase Change for a month (2023/1/6 ~ 2/4)



- **Earth is 4 times bigger than the Moon(Moon was 4 times farther than the Earth from Danuri)**

KMAG (KPLO Magnetometer)

KMAG Configuration



MAG unit

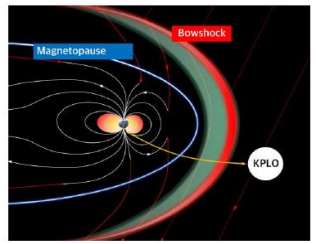
- **Supplier: Kyung Hee Univ.**
- **To measure the magnetic strength of the lunar environment.**

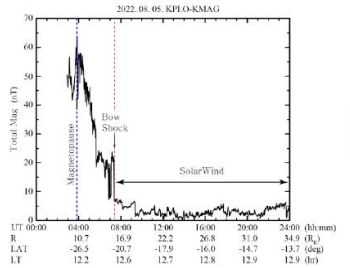
Specification

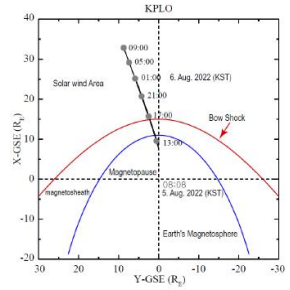
Item	Contents	
Science	Measure DC and low frequency perturbations of the magnetic field in space and Moon	
Performance	Measuring range	± 1000 nT
	Resolution	< 0.2 nT at 10 Hz sampling rate
System	Mass	Total 3.5 kg
	Power	Input: +28 V (unregulated +24 ~ 32.8 V) Consumption: 4.6 Watt
	Interface	RS-422, 115,200 bps
	Operating temperature	MAG Unit : -55°C ~ +70°C FCE Unit : -20°C ~ 50°C
Magnetic cleanness	< 700 nT at the inner magnetometer (MAG3) in the boom	
Operation	Duty: 100% Data generation: 295.31 Mbit/day	

Observation on the Earth Magnetopause & Bow shock boundary(where the earth magnetic field rapidly declines) on 05, Aug. 2022

– During the journey to the moon



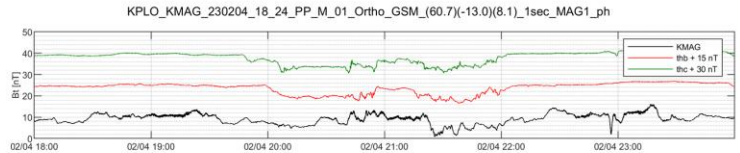


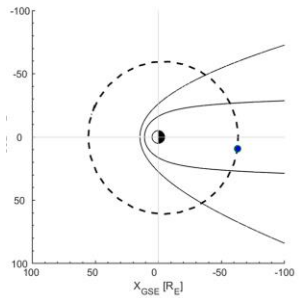


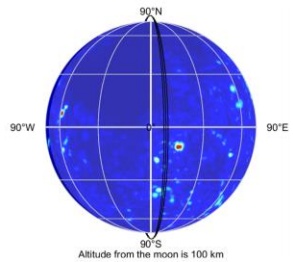
Observation on the Lunar Orbit 04. Feb. 2023

– KMAG is operating normal and measuring the magnetic field around the lunar orbit

– Comparison to Themis B & C

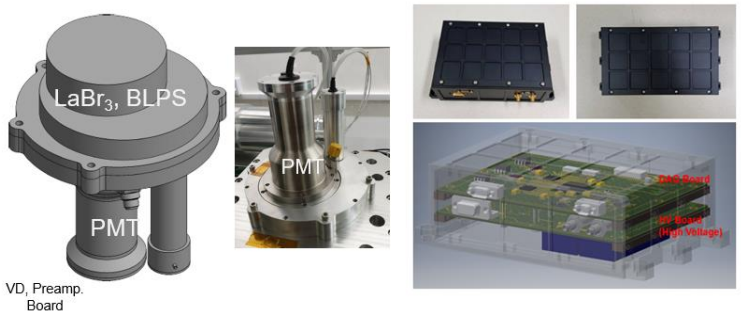






KGRS(Gamma Ray Spectrometer)

KGRS Configuration



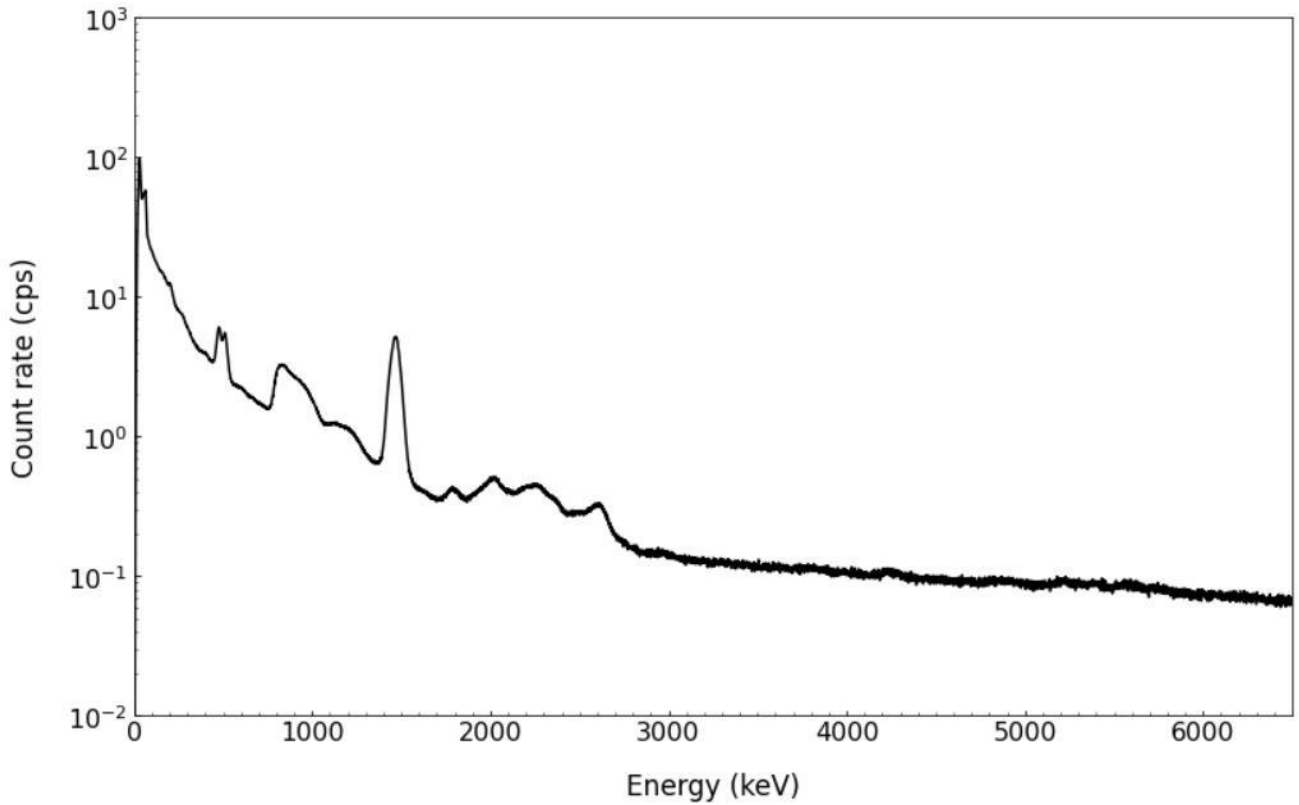
- Supplier: Korea Institute of Geoscience and Mineral Resources(KIGAM)
- To investigate the chemical composition of the lunar surface materials by mapping the spatial distribution of gamma-ray energy(30 keV ~ 12 MeV).

Specification

Item		Contents
Science	Measure Gamma-rays from the Lunar surface for elemental mapping	
Performance	Energy range	~30 keV to 12 MeV (H.G.: 3 MeV, L.G.: 12 MeV)
	Energy resolution	< 5 % @ 662 keV
System	Mass	Total 7 kg (SU, EU)
	Detectors	$LaBr_3$ (primary), BLPS (shielding)
	No. Energy channels	$LaBr_3$ (8192,4096), BLPS (1024)
	Power	Input: +28 V Consumption: 8.5 W
	Interface	RS-422, 115,200 bps
	Operating temperature	SU: Operation: -20 °C ~ +50 °, Survival: -35 °C ~ +65 °C EU: Operation: -20 °C ~ +55 °C, Survival: -30 °C ~ +70 °C
Operation	Life time	~ 1 year
	Data collection / generation	10 sec / Max. 1.85Gbits / day (Duty 100%)
	Pointing	Nadir direction

Observation during 9 days on lunar orbit

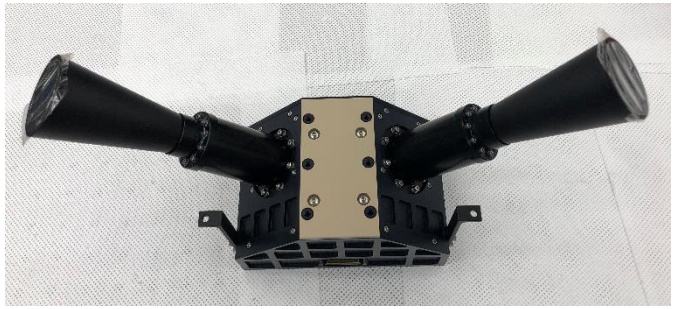
– Provided by KiGam



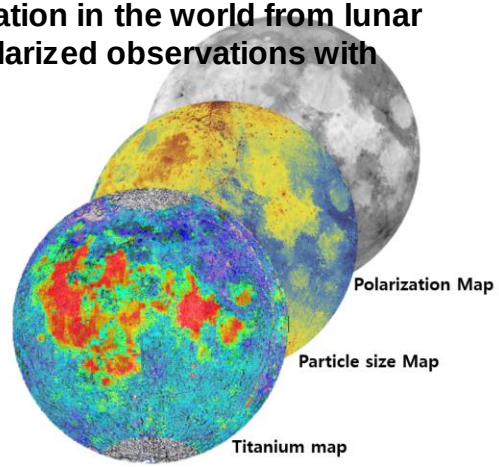
- 9 consecutive days of gamma ray observation accumulated data(sampling interval: 10 seconds)
- KGRS works well with low energy level

PolCam (Wide-Angle Polarimetric Camera)

▪ Optical Module

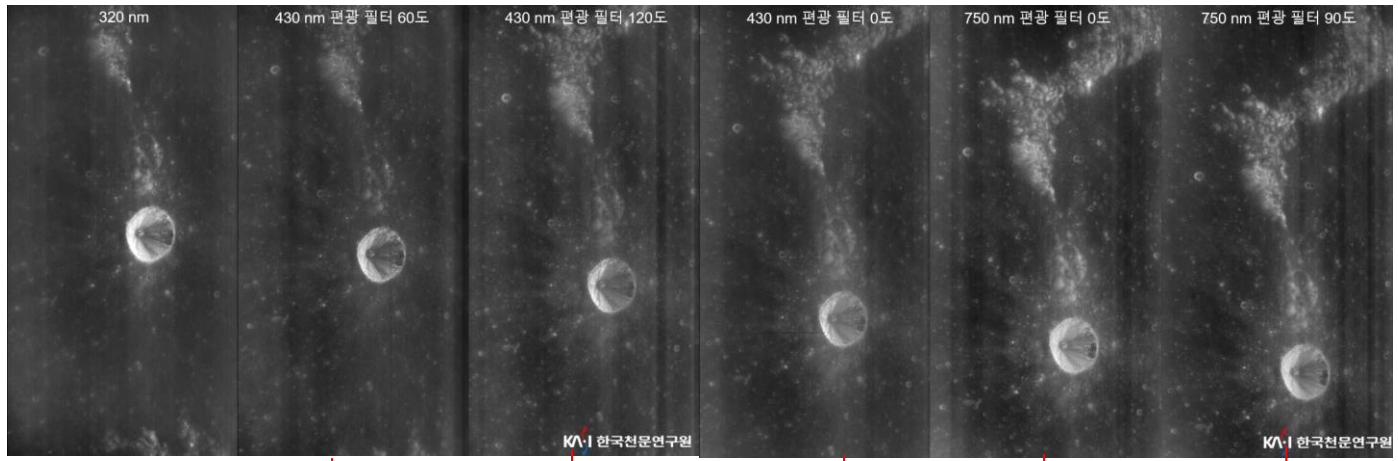


- **Supplier: Korea Astronomy & Space Science Institute(KASI)**
- **To acquire the polarimetric images of the lunar surface except the polar regions to investigate the characteristics of lunar regolith.**
- **Can acquire the polarimetric images on the far side of the moon(Not directly visible from the Earth)**
- **The First polarization observation in the world from lunar orbit(many cases exist for polarized observations with ground based telescope)**



▪ Observation Wichmann Crater 11, Jan. 2023

– 6-channel polarization imaging



30nm

430nm –Polarization filter 60 degree

430nm –Polarization filter 120 degree

430nm –Polarization filter 0 degree

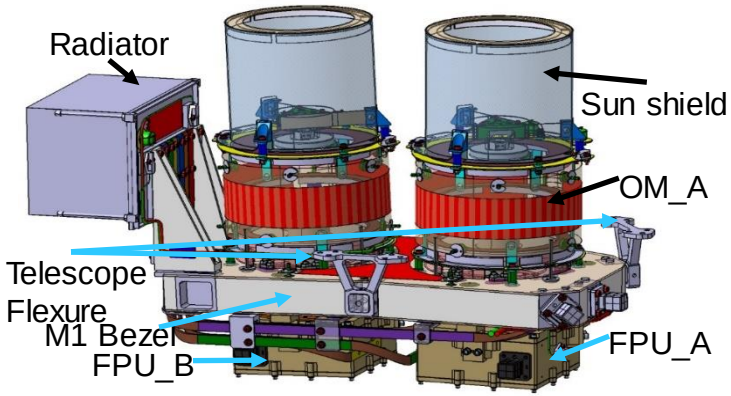
750nm –Polarization filter 0 degree

750nm –Polarization filter 90 degree

- Mapping and Resolution : 35.2 km at 100 km orbit
- Multi-Band : 320, 430 and 750 nm
- Phase Coverage: 45° of tilting angle

LUTI (Lunar Terrain Imager)

LUTI Configuration

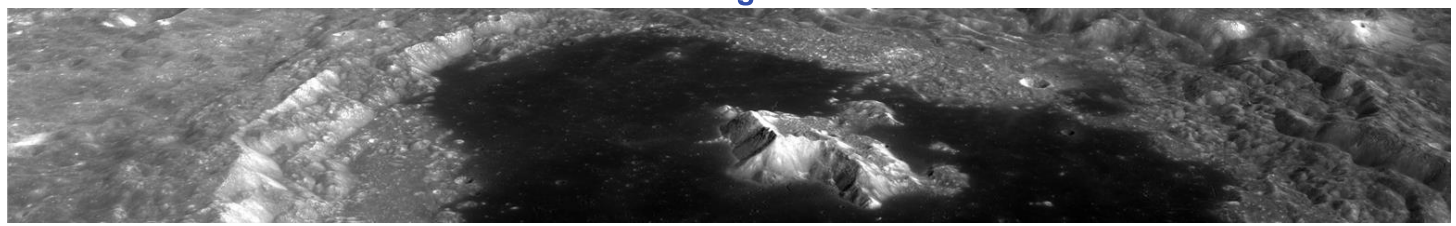


- **Supplier: Korea Aerospace Research Institute(KARI)**
- **To take less than 5m high resolution images(>8km swath width @ 100km) for possible landing sites of the 2nd stage lunar exploration mission**

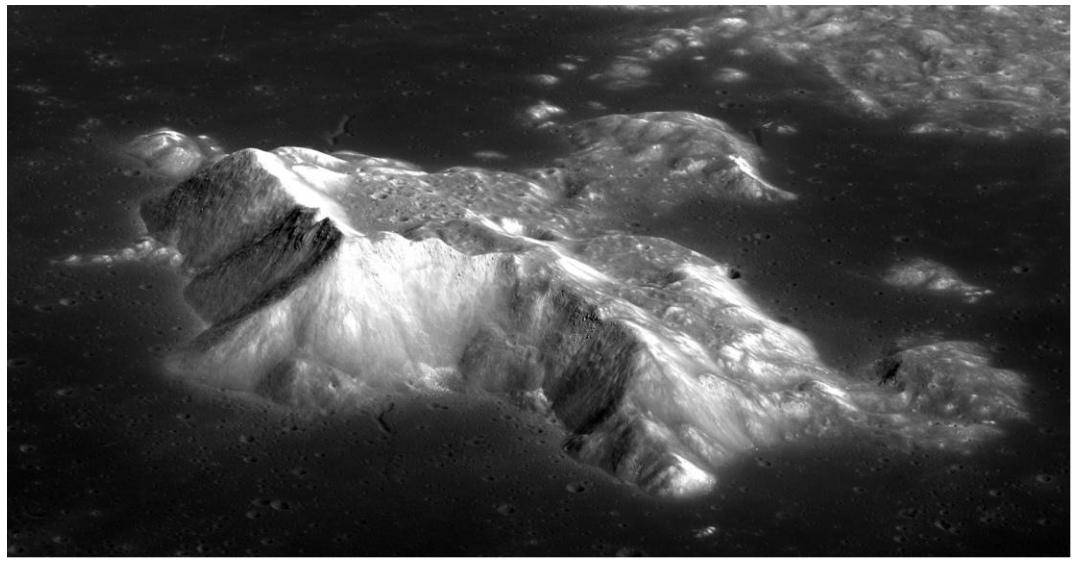
Requirement
Mass: 3.5 kg
1st natural frequency > 120Hz
Design load: 30g
Critical Interface Stability M1 distance to M2 : ±3 μm Decenter : ±10 μm , Tilt : ±50 μrad
Op Temp.: -5°C ~ +40°C Nop Temp.: -15°C ~ +55°C
Sine Qual. Level : 20g Random Qual. Level : 14.1grms (X, Y), 18.4grms(Z)
Shock response spectrum 2,000 – 10,000 Hz : 700g (X, Y) 3,000 – 10,000 Hz : 700g (Z)

Observation Tsiolkovsky Crater(a large lunar impact crater located on the far side on the moon) and Peaks on Lunar Surface 21, March 2023

Total image width : ~220Km



Enlargement

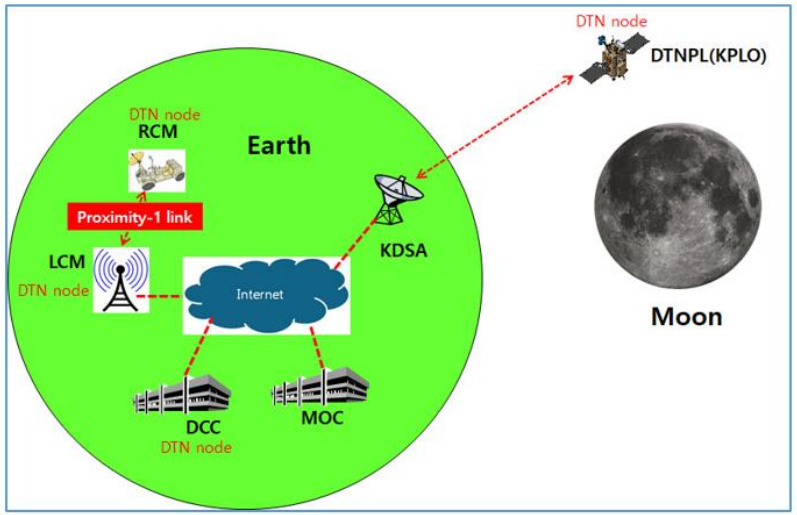


Photographed by the crew of Apollo 13, 04/14/1970

DTNPL (Delay Tolerant Network Experimental Payload)

- **DTN (Supplier: Electronics and Telecommunications Research Institute)**
  - The purpose of DTNPL is to test DTN communication between DTNPL onboard the KPLO and ground station to verify DTN is useful for the space communication
  - For the DTN test, Lander & Rover DTN communication models will be located on Earth to emulate Lander & Rover communication on Lunar surface (Left figure)
  - Contents of DTN tests
    - DTN message, DTN file transfer using CFDP, DTN video streaming

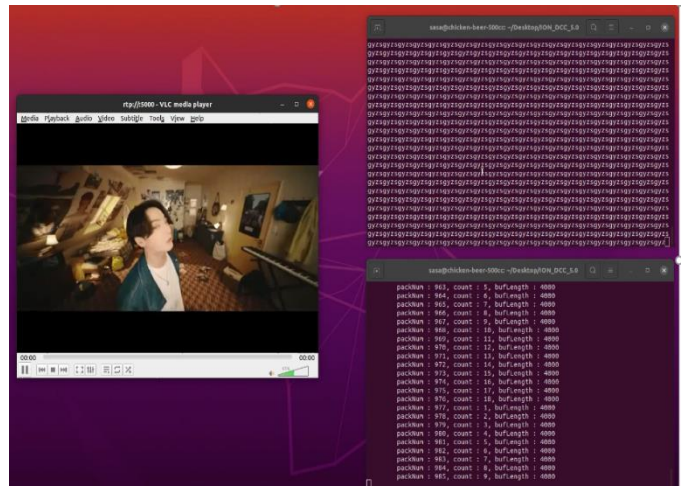
DTN Network Configuration



Communication test at about 1.2million km after travelling to SUN

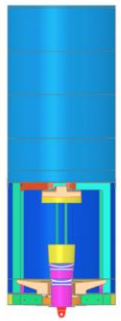
High resolution image transmission

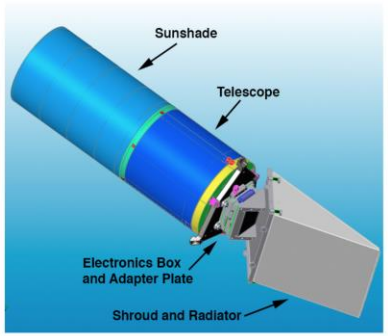
Real-time live video streaming



SHC (ShadowCam)

▪ SHC Configuration



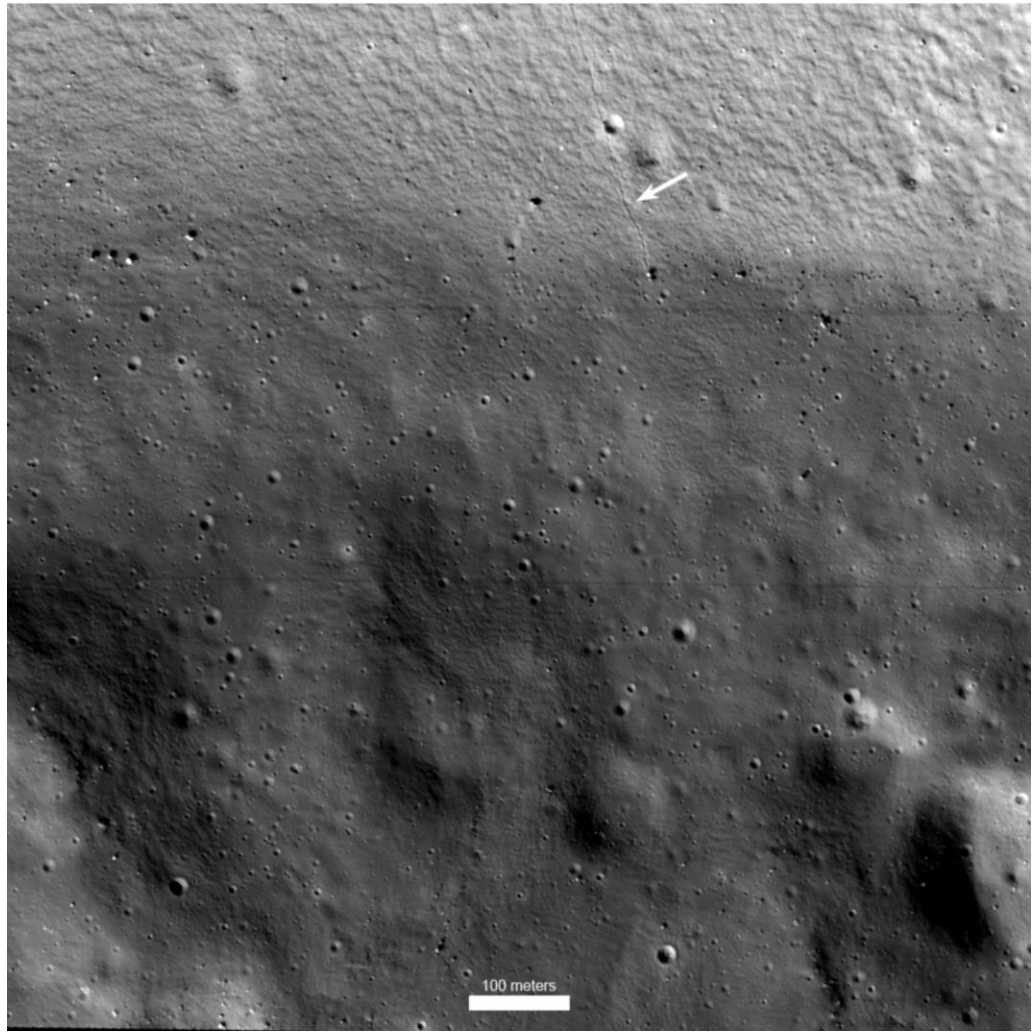


- **Supplier: NASA(& Arizona State Univ.)**
- **To map the reflectance within the permanently shadowed regions to search for evidence of frost or ice deposits.**
- **To observe the PSRs to detect seasonal changes and measure the terrain inside the craters, including the distribution of boulders.**
- **Based on LRO Narrow Angle Camera, but 800 times sensitive**

- **SHC Description**
  - Rebuild of an LROC NAC, but with a Time Delay Integration (TDI) detector
    - >500x sensitivity (TDI, integration time, pixel size)
  - Saturate in illuminated regions
  - PSR imaging with SNR >100, pixel scales of 1.7 m from 100 km altitude

▪ Shackleton Crater in Unprecedented Detail

Credit: NASA (https://www.nasa.gov/feature/nasa-s-shadowcam-images-lunar-south-pole-region)

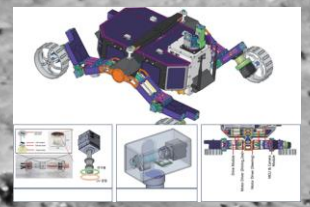


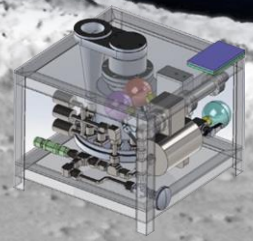
Phase 2 – Plan for KSLV-III & Korea Robotic Lunar Lander

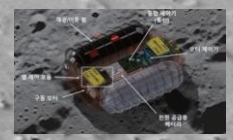
Phase 2 - Korea Robotic Lunar Lander

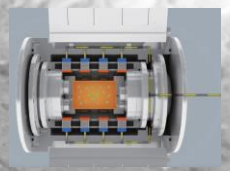
Korea Robotic Lunar Lander Overview

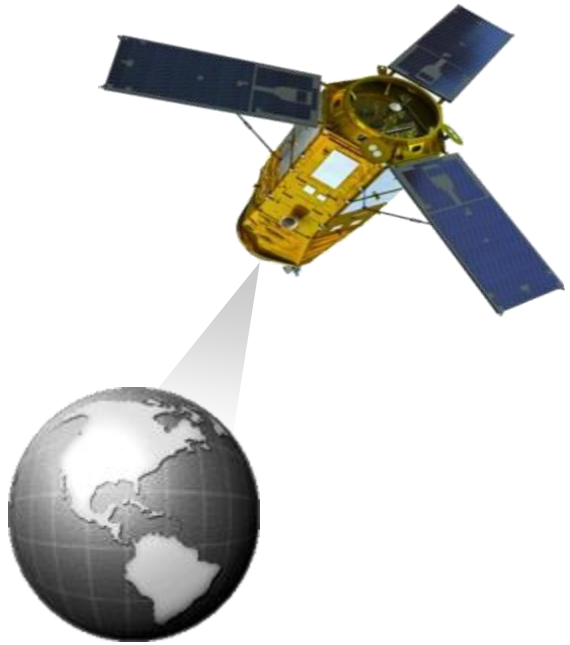
- **Launch Vehicle: Next-generation KSLV (KSLV-III)**
  - Launch date: Late 2032
  - Launch mass: 1800 kg
  - Payload mass: 43 kg (TBD) (2.4% of Wet Mass)
- **Lunar Transfer Trajectory**
  - Direct Trans-Lunar or Phasing Loop Transfer
- **Lunar Surface Landing**
  - Precise Soft Landing with Hazard Avoidance
- **Mission**
  - Rover, RTG, Lunar Sci. & ISRU Tech. Demonstration











Thank you

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Korea Aerospace Research Institute