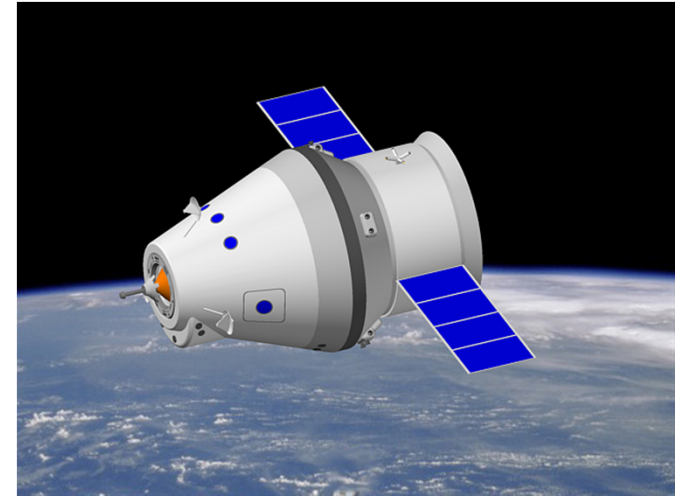


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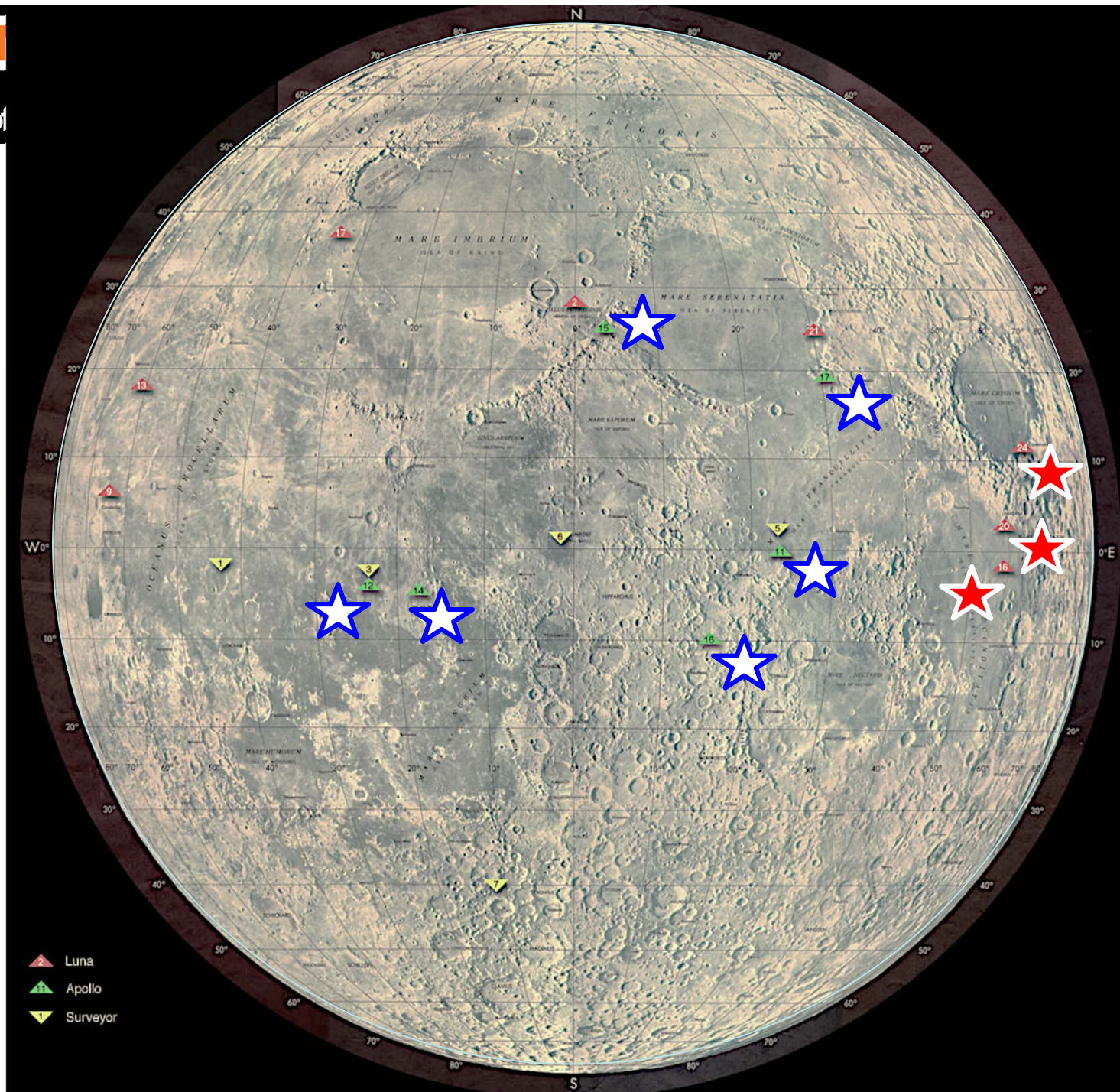


# **The Concept of Human-Robotic Integrated Mission (HRIM) For Moon Exploration**

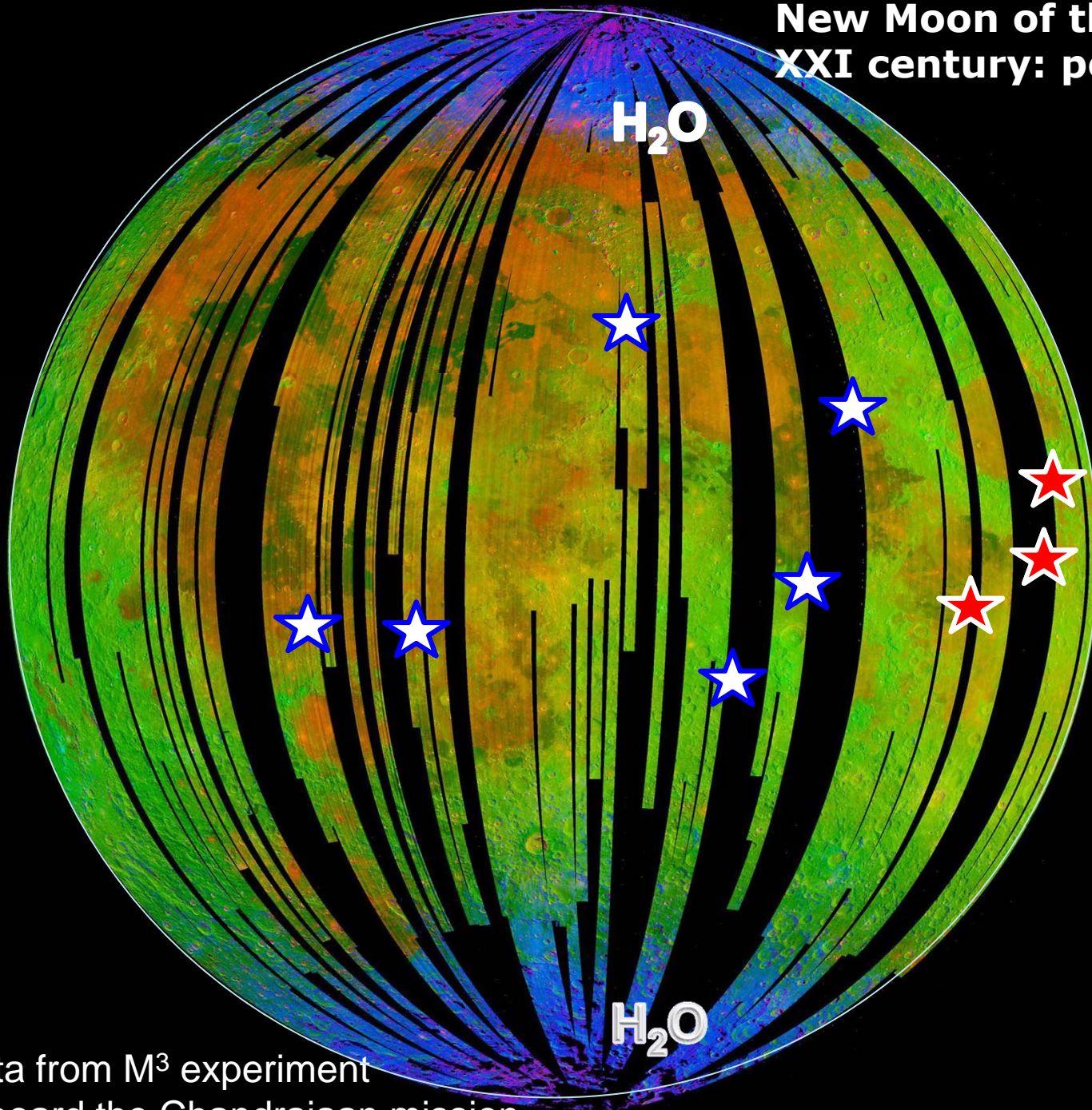
*Igor Mitrofanov and Lev Zelenyi*

Institute for Space Research  
of Russian Academy of Science  
with  
contribution from colleagues  
of Lavochkin science and industry  
association





# New Moon of the XXI century: poles

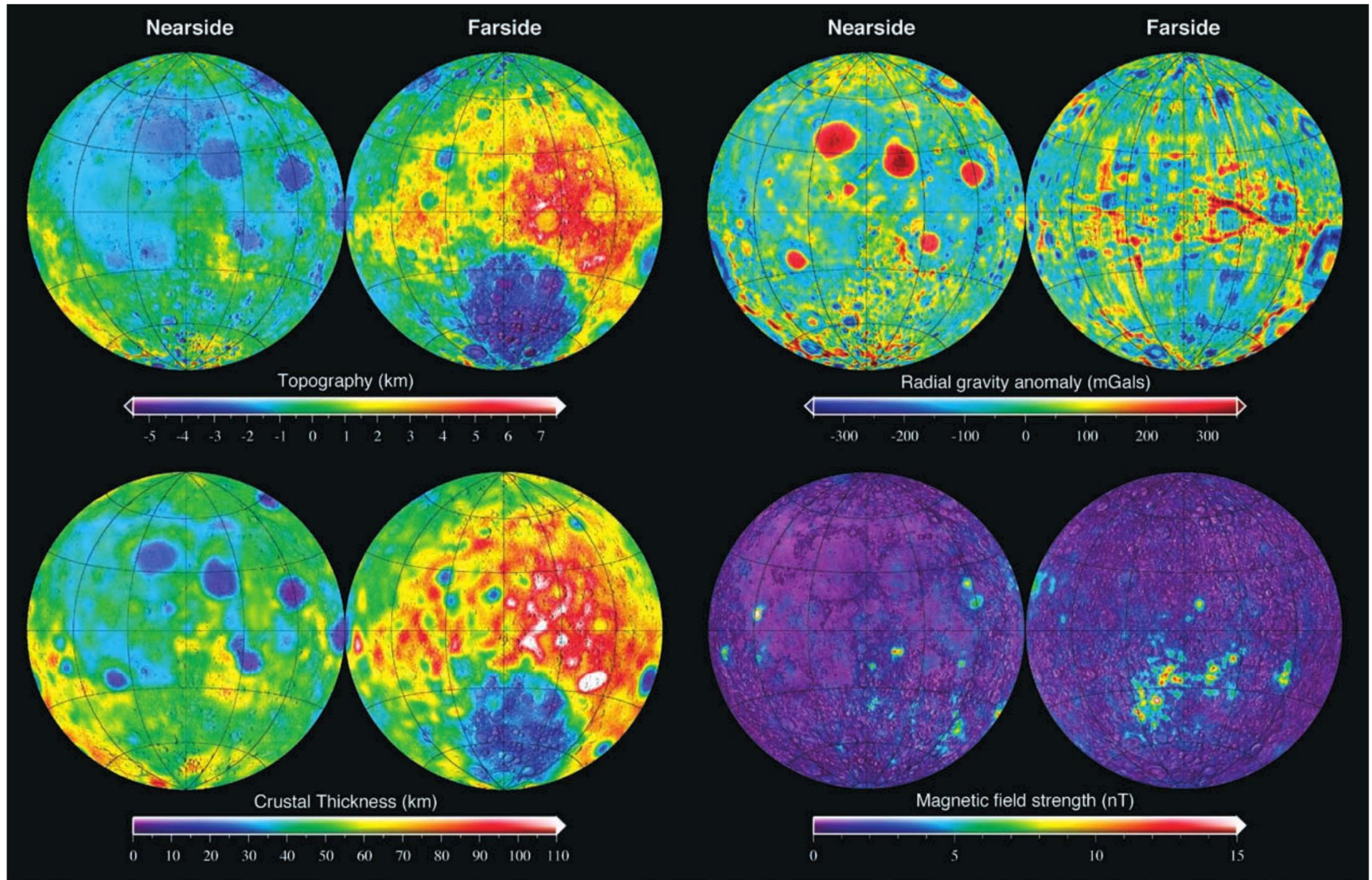


Data from M<sup>3</sup> experiment  
onboard the Chandrayaan mission

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New Moon of the  
XXI century: far side



## Goals of the 1<sup>st</sup> stage of Russian Lunar Program:

### *Robotic missions*

**Goal 1:** Study of mineralogical, chemical, elemental and isotopic content of regolith and search for a volatiles in regolith of polar area of Moon.

**Goal 2:** Study of plasma, neutral and dust exosphere of Moon and interaction of space environment with Moon' surface at poles.

**Goal 3:** Study dynamic of daily processes at lunar poles, including thermal property variations of subsurface layers of regolith and evolution of hydration and volatiles.

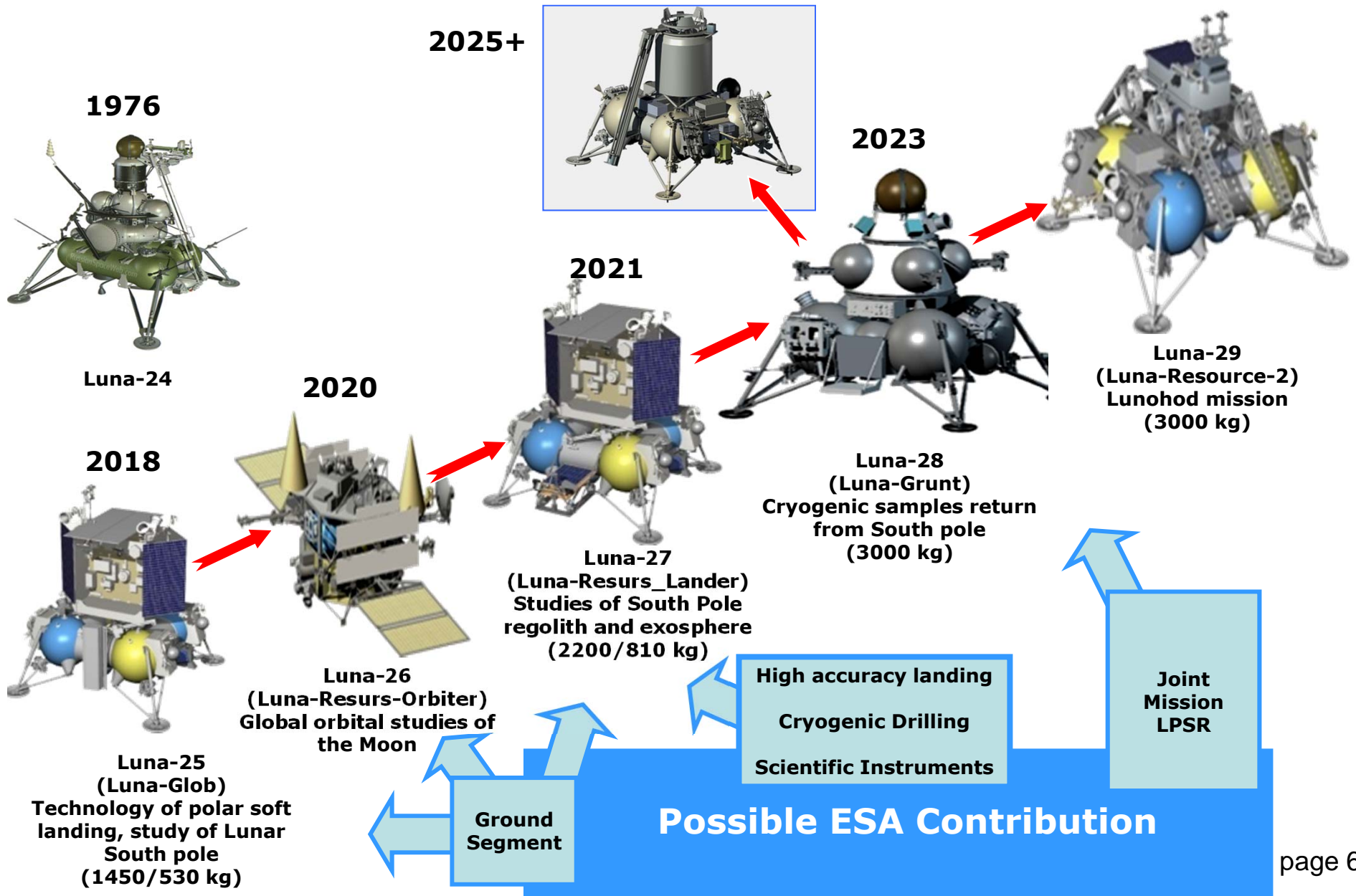
**Goal 4:** Study of inner structure of Moon by means of seismic, radio and laser ranging experiments.

**Goal 5:** Preparation for future exploration of Moon and utilization of lunar resources

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## The sequence of Russian lunar robotic missions



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**MAX Aeroshow 2015:**  
**Manned s/c together with robotic s/c**

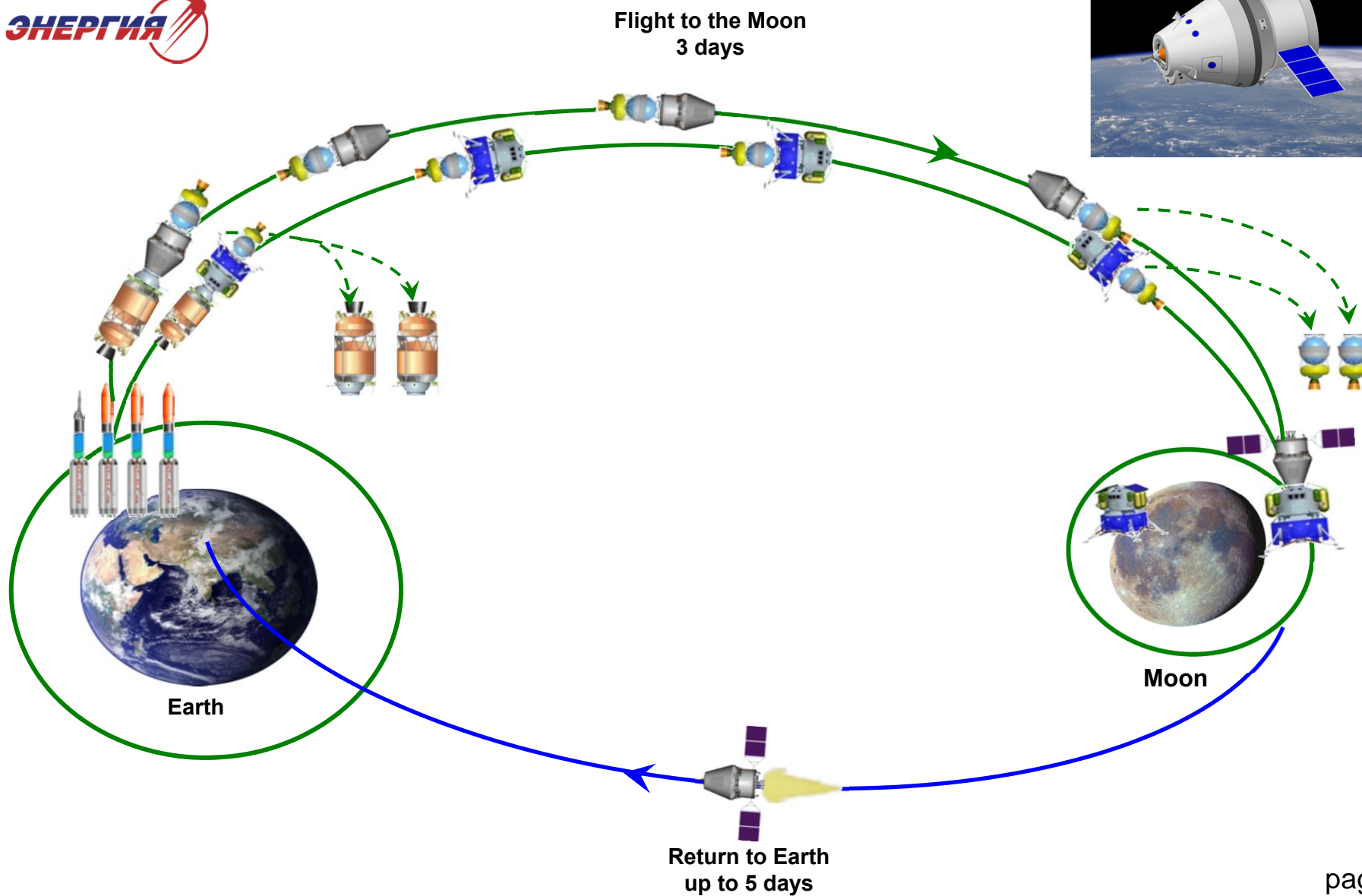


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## Current concept of the manned landing Lunar mission



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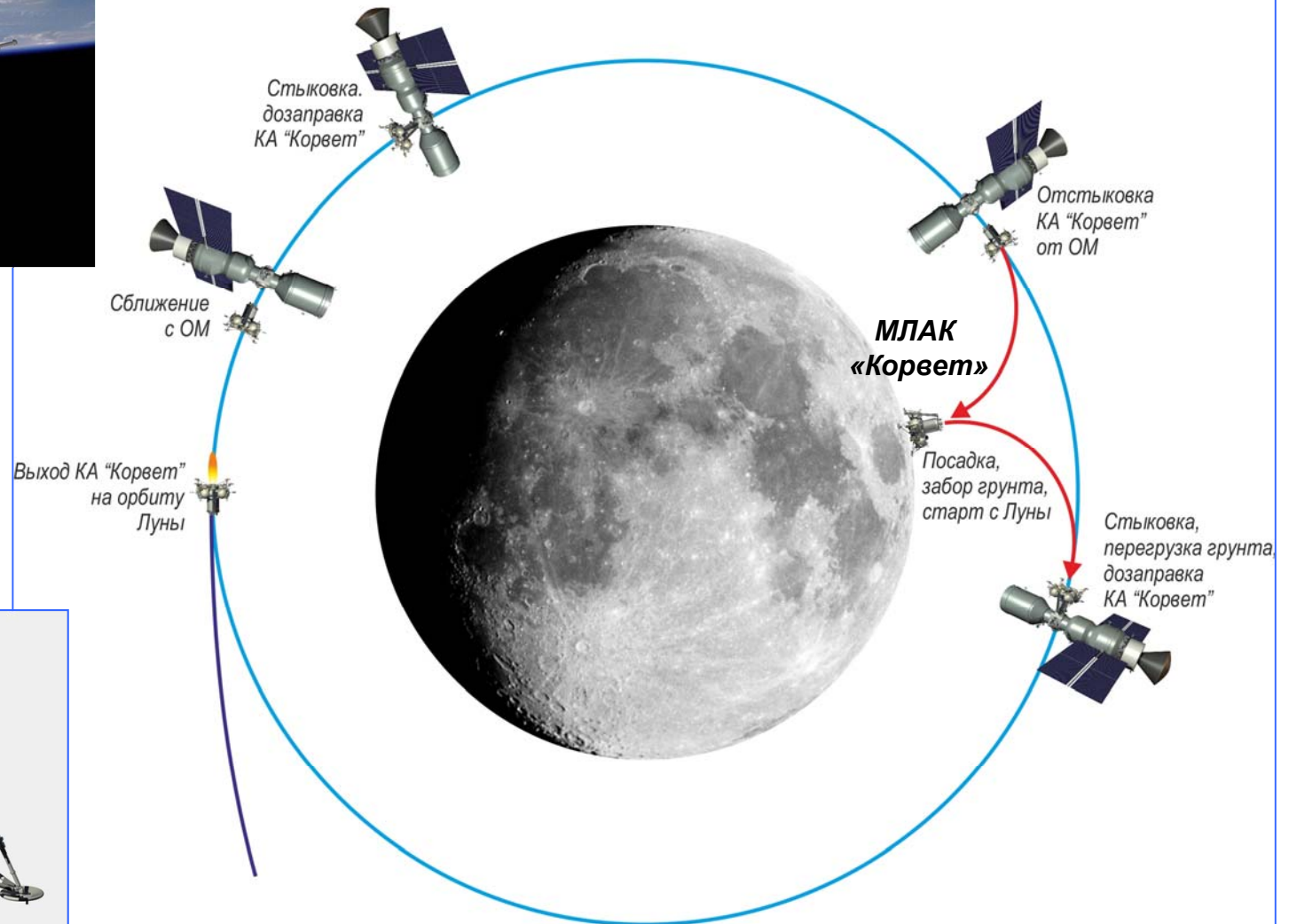
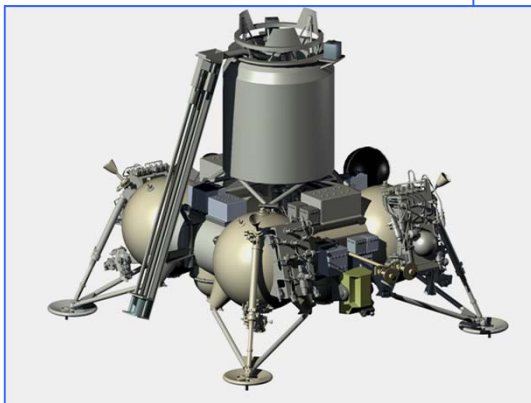
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## Human Robotic Integrated Mission (HRIM): Basic concept



Manned flight S/C

Robotic  
"Corvette" S/C



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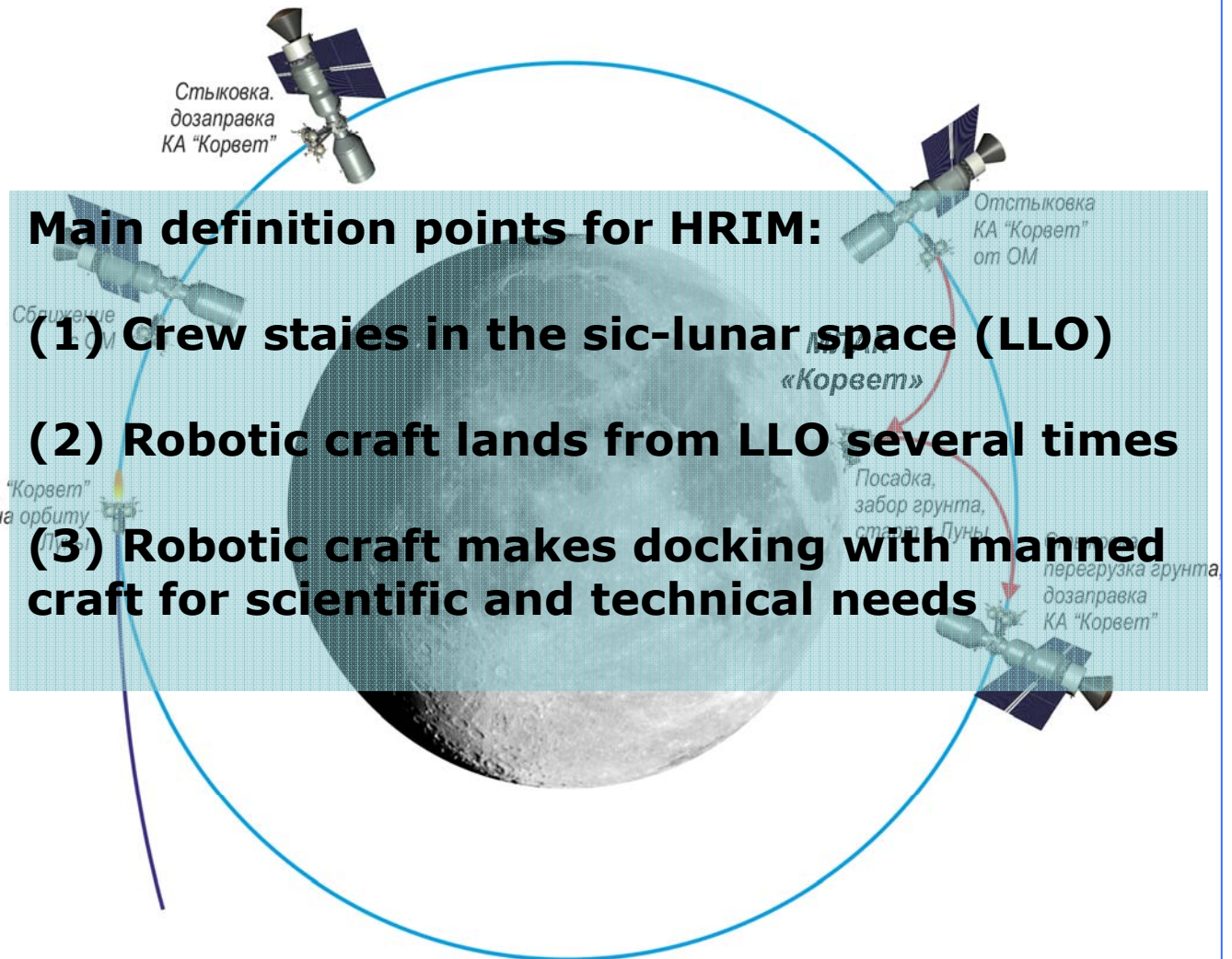
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## Human Robotic Integrated Mission (HRIM): Basic concept



Manned flight S/C

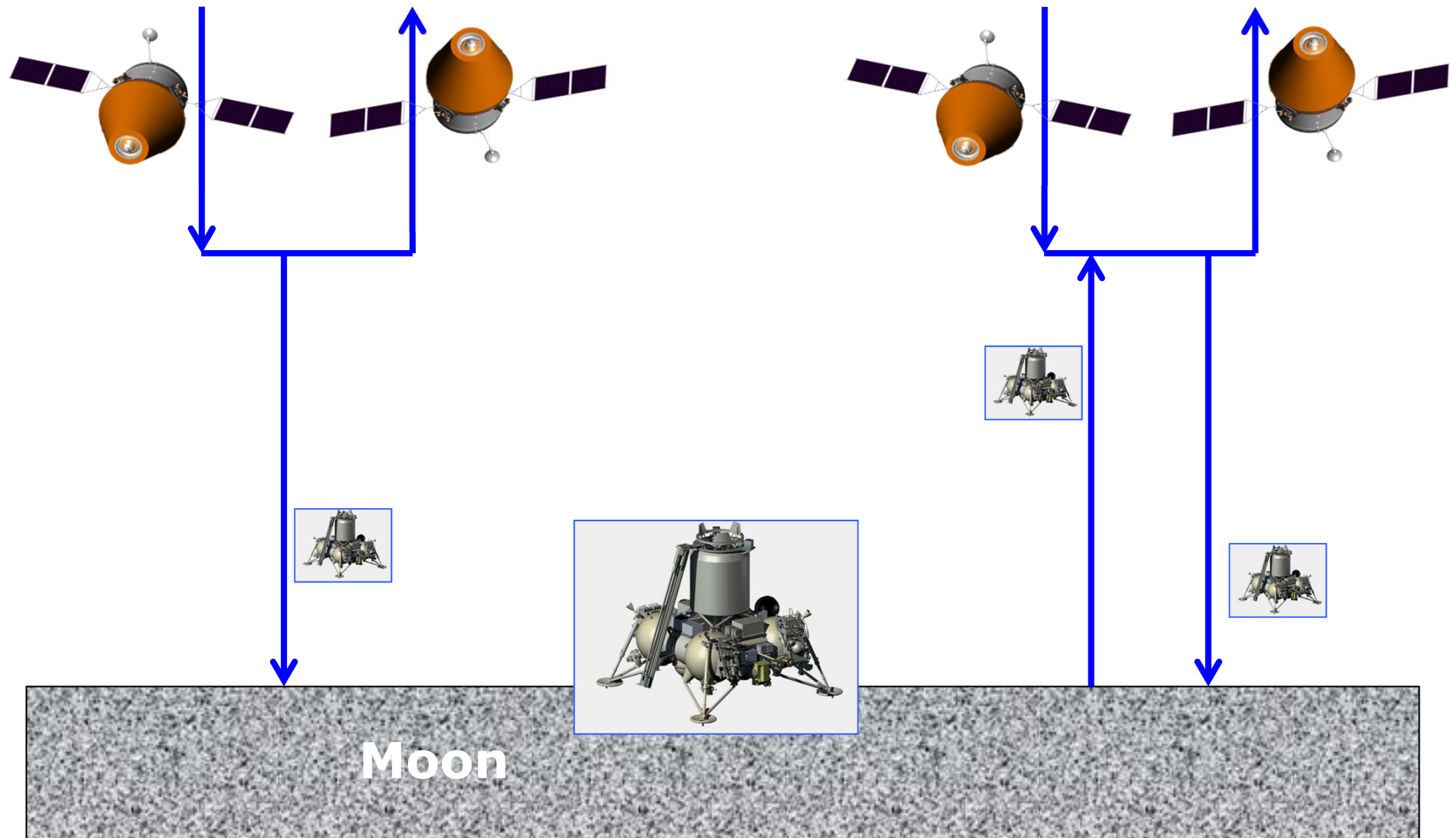
Robotic  
"Corvette" S/C



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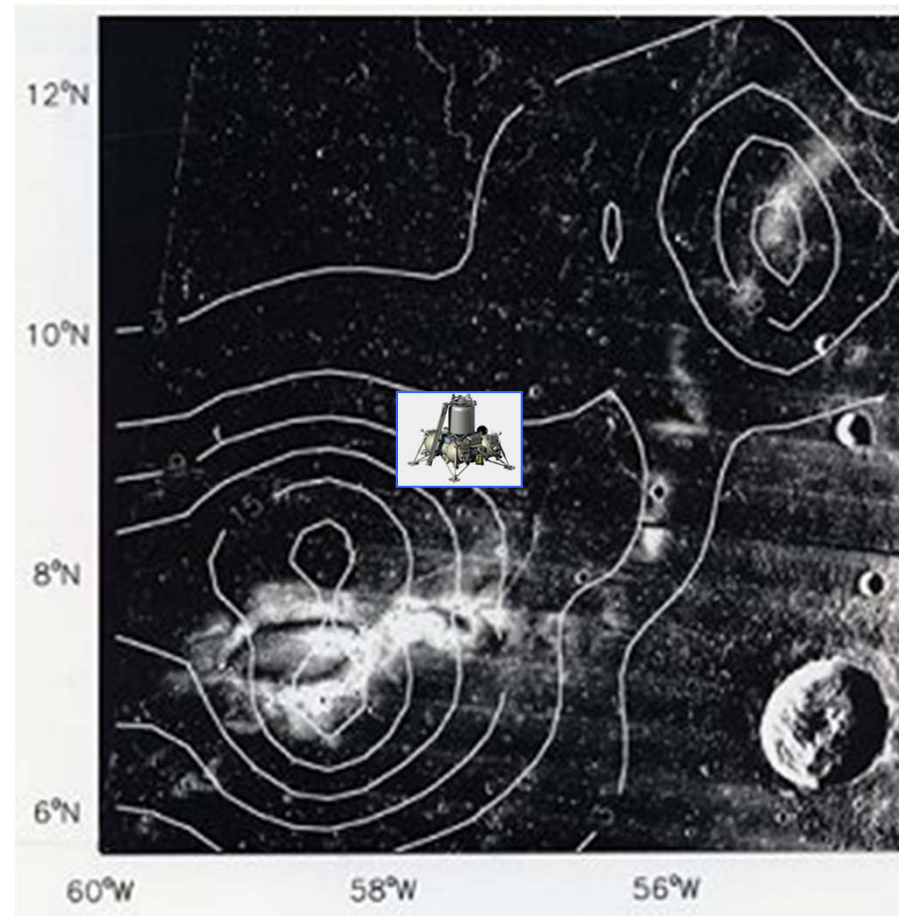
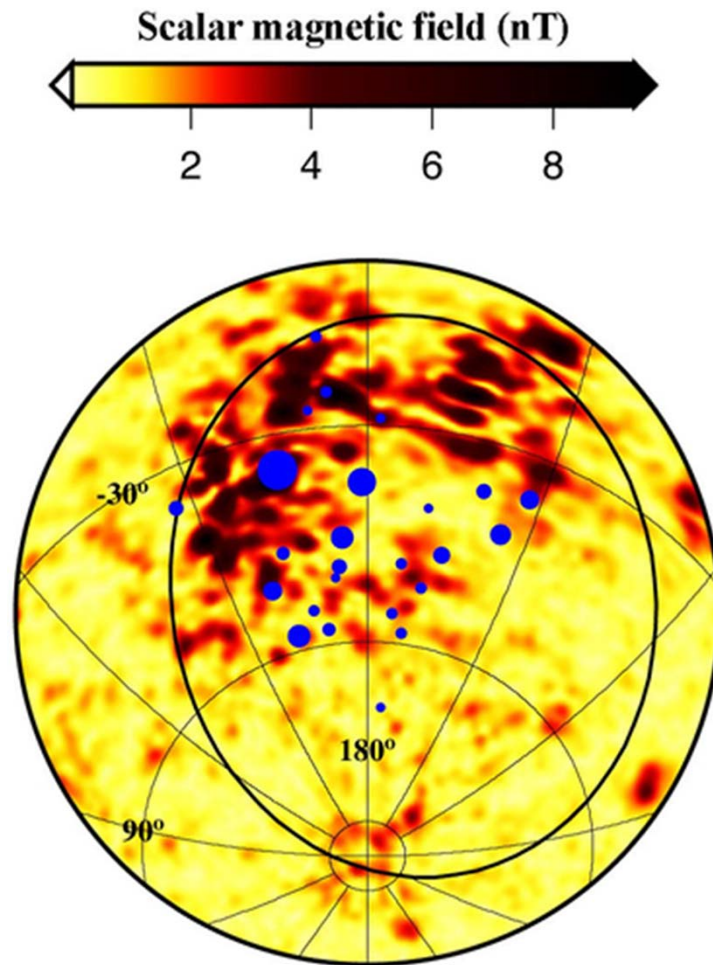
## HRIM Project: Scenario I



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## HRIM Project science: Studies of magnetic anomalies



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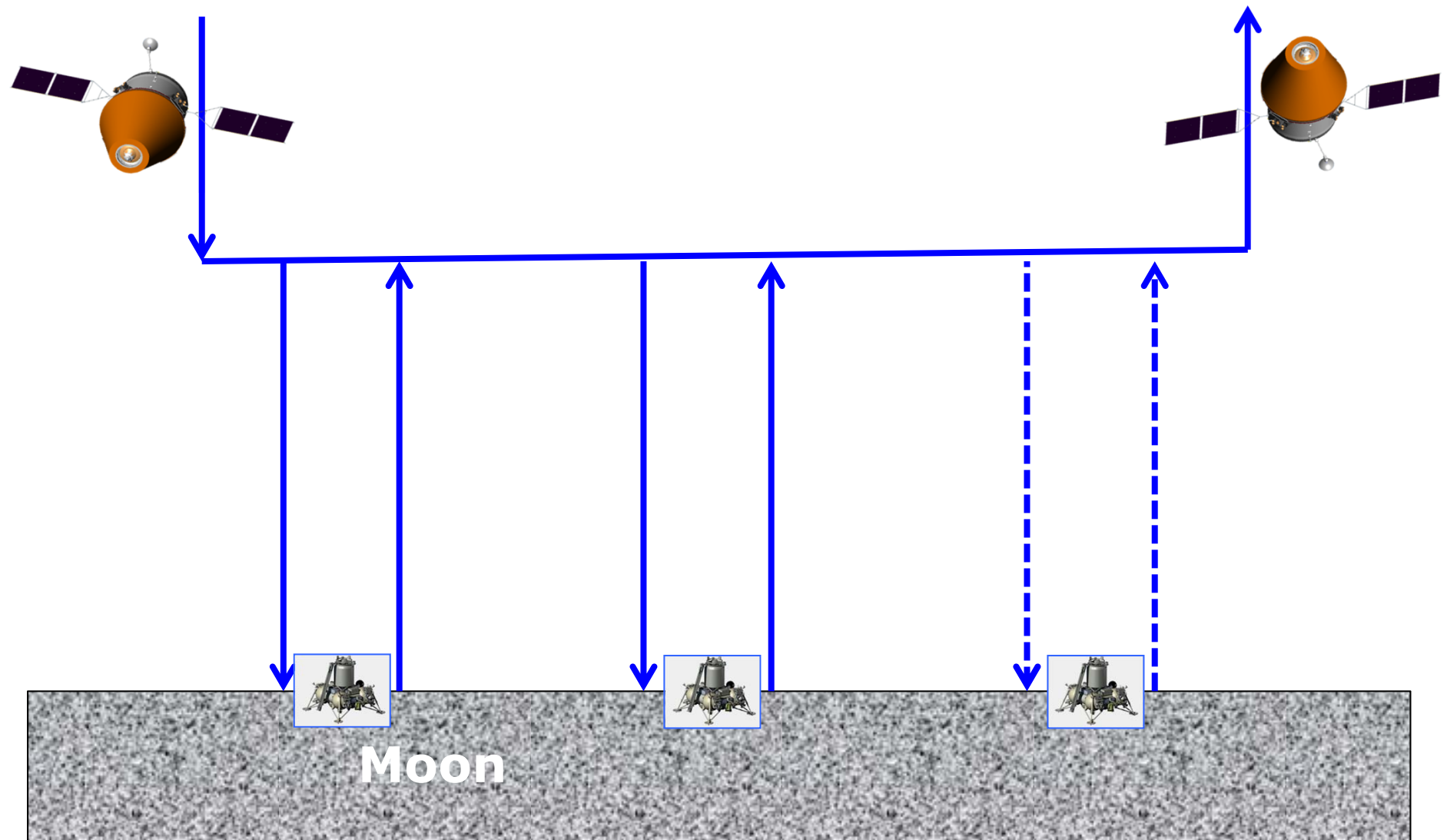
## HRIM Project science: Lunar botanic (and zoology!)



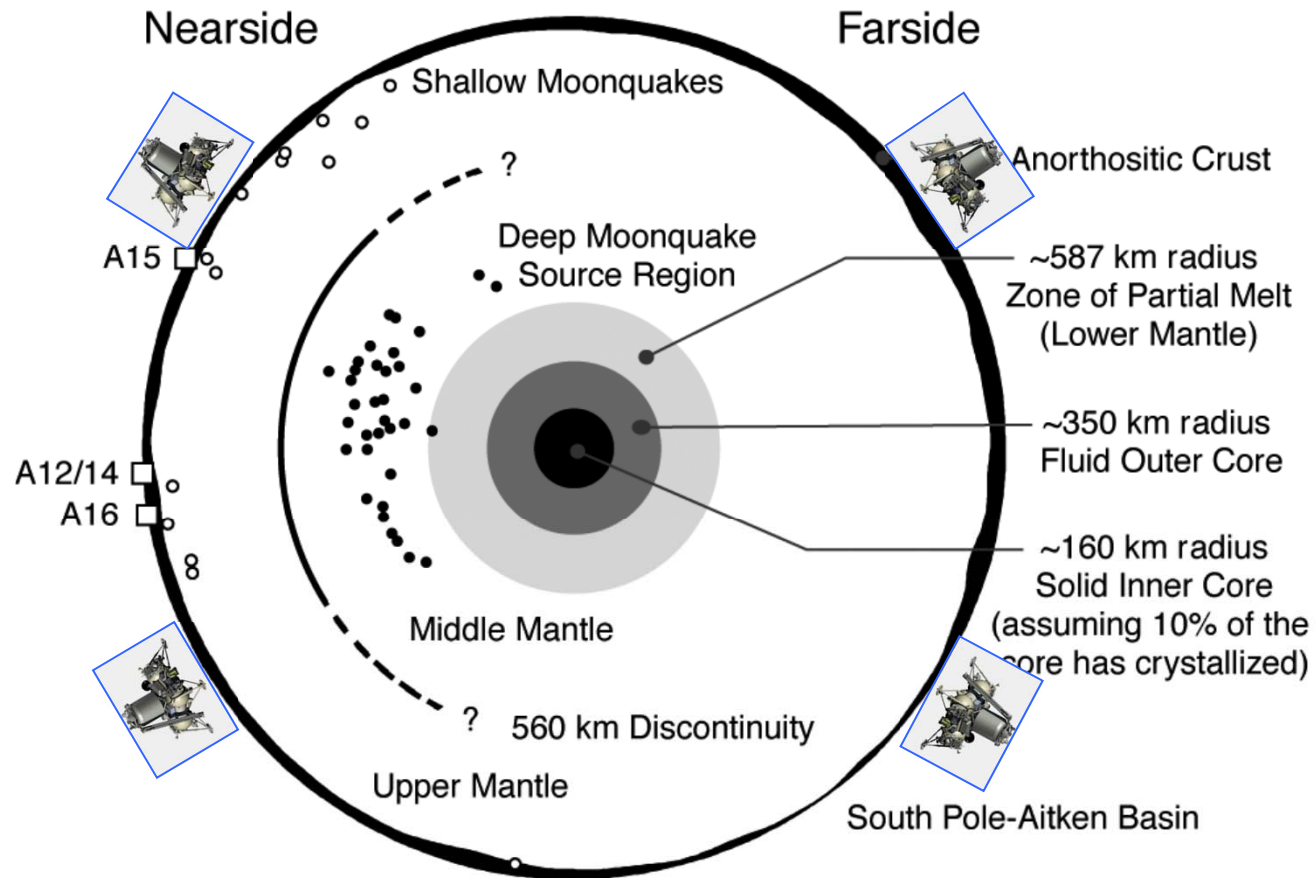
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## HRIM Project: Scenario II



## HRIM Project science: Lunar seismology and interior

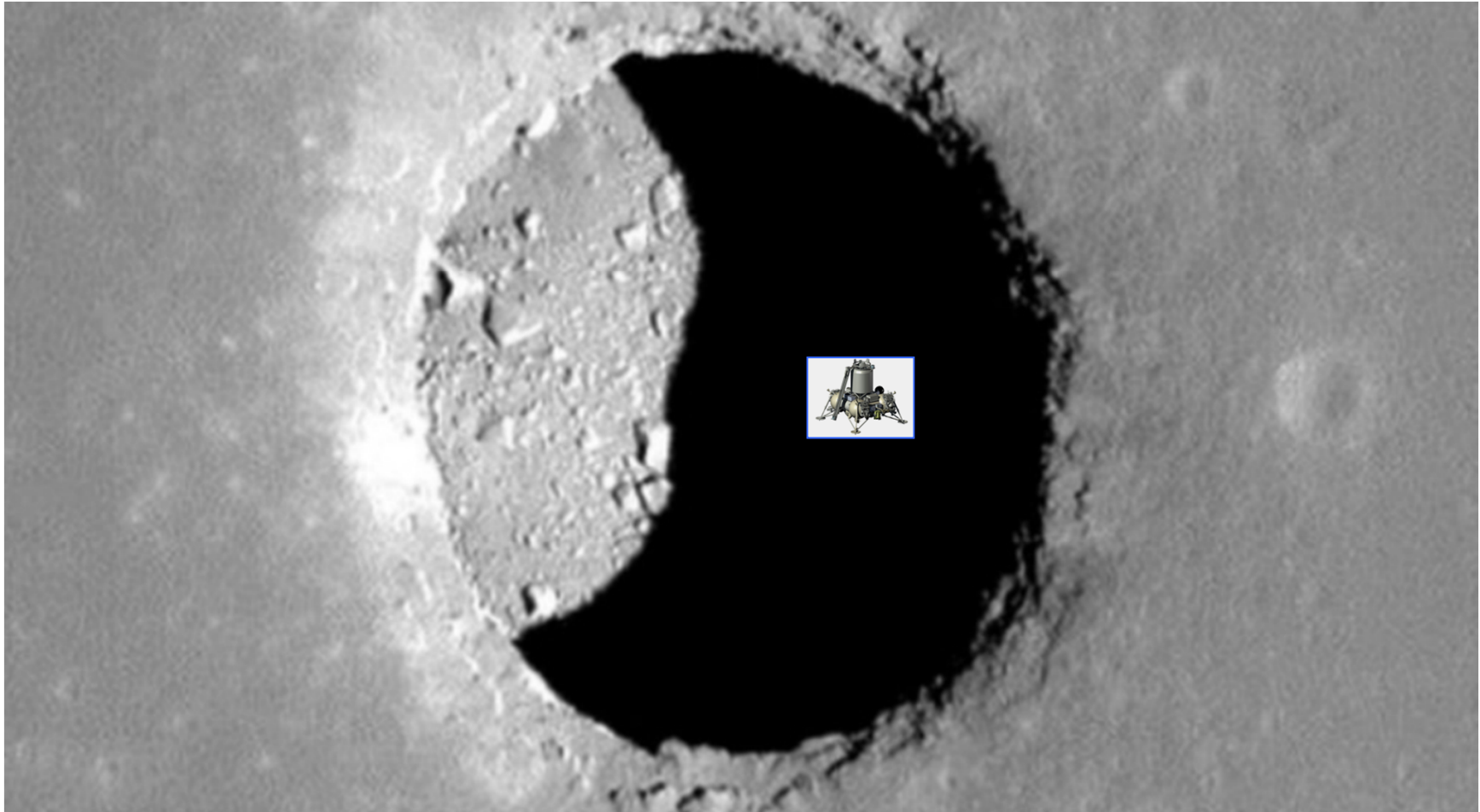


**FIGURE 4** Schematic diagram of the Moon's interior structure as determined by geophysical means. Apollo landing sites are indicated by squares. FROM WIECZOREK ET AL. 2006

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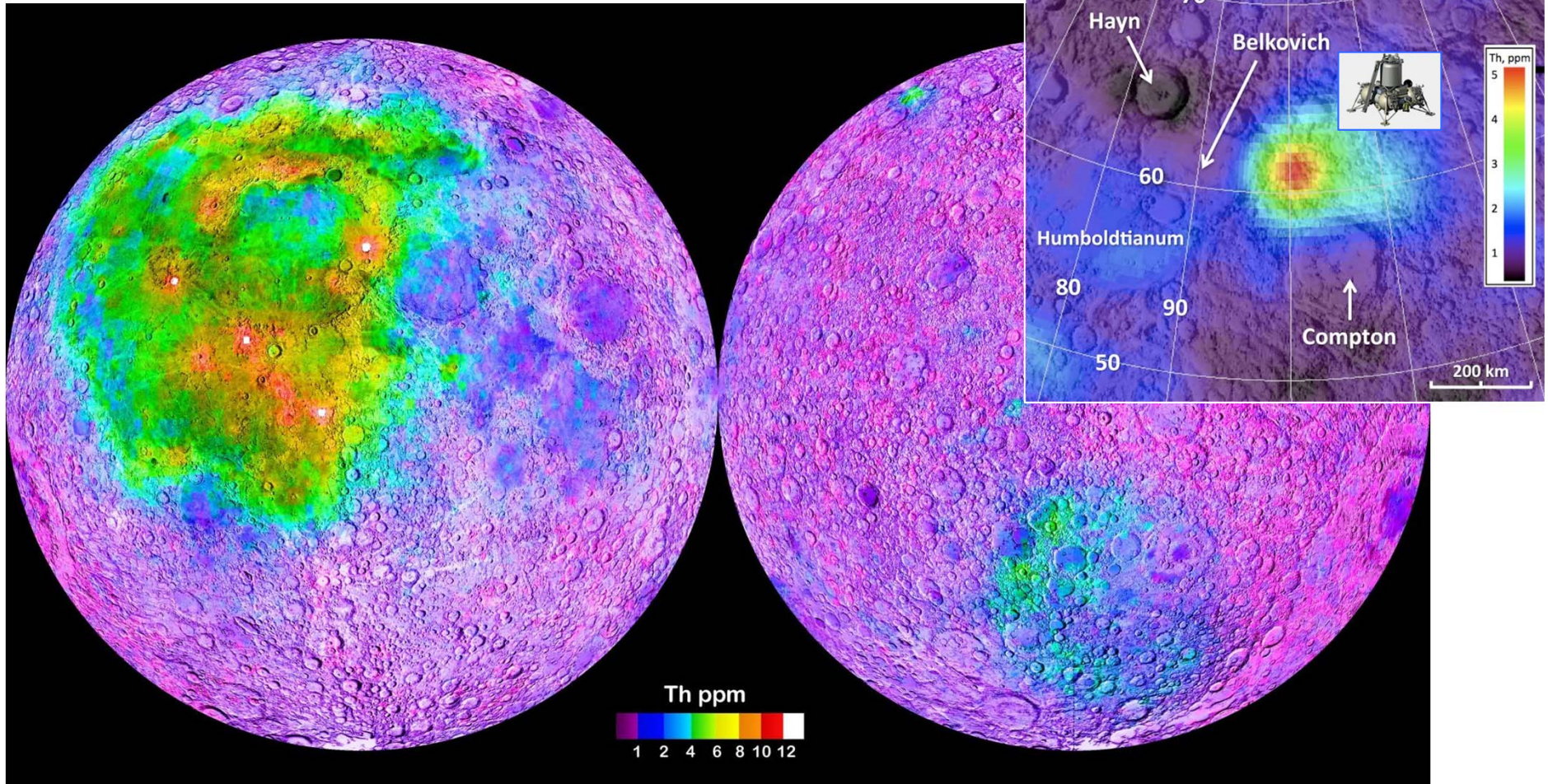
## HRIM Project science: Lunar caves and lava tubes



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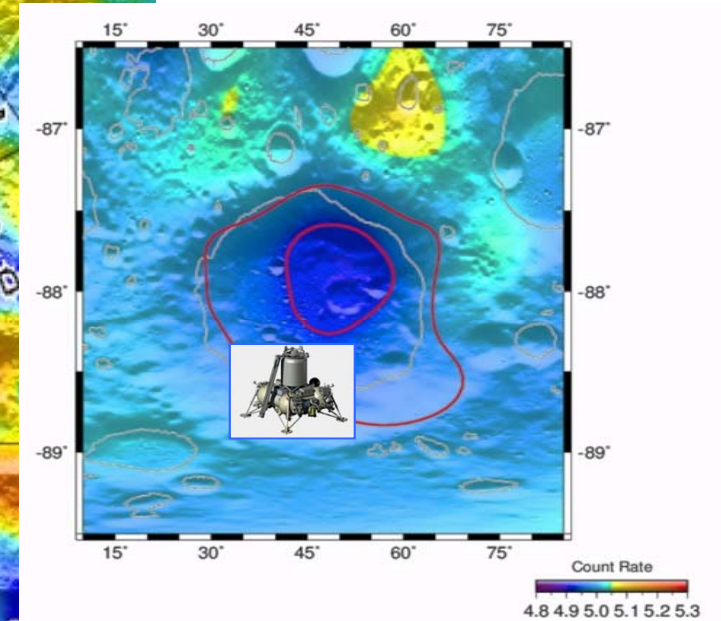
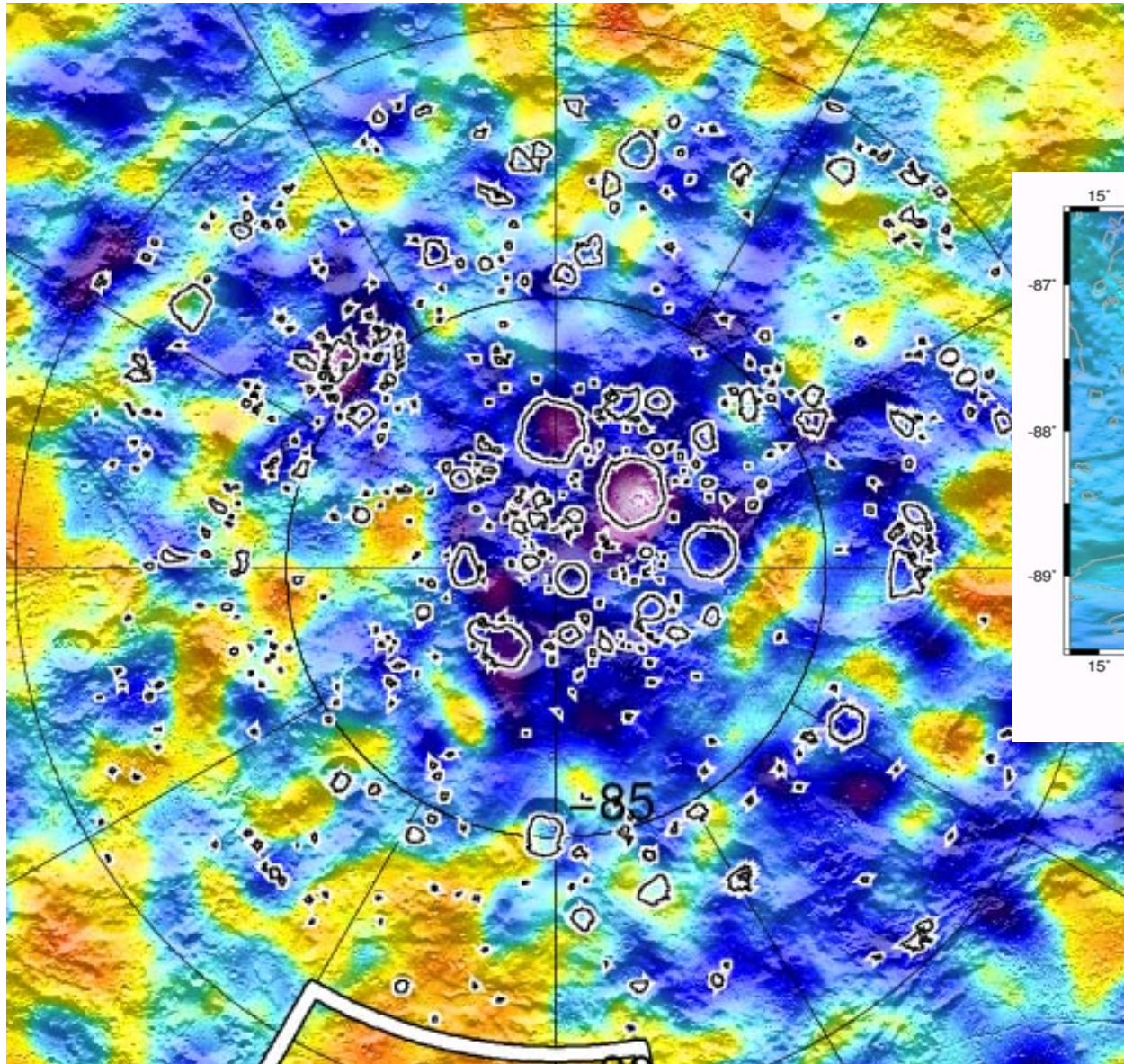
## HRIM Project science: Lunar minerals and resources



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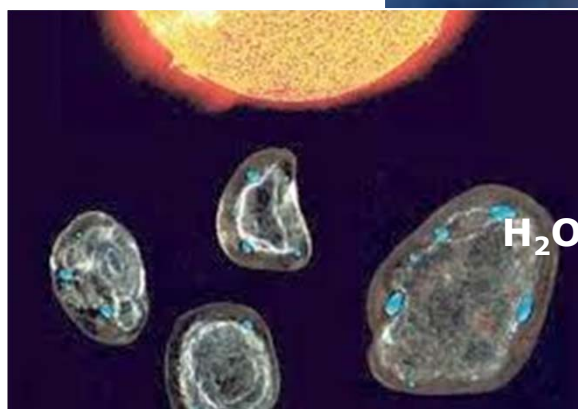
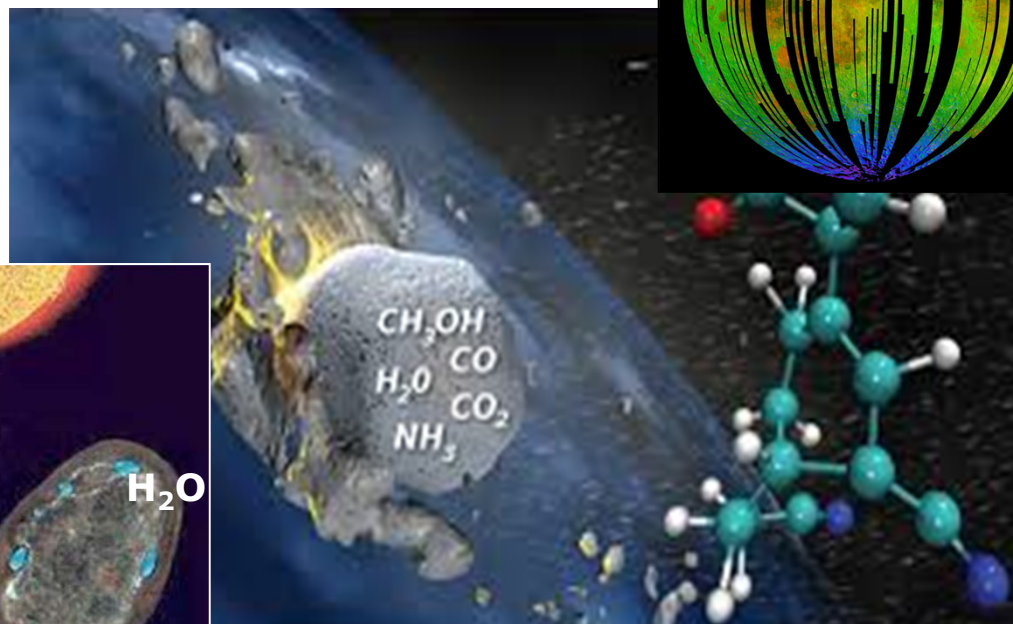
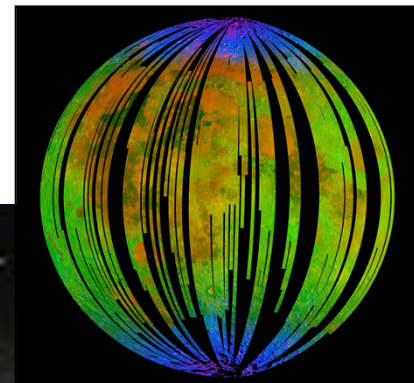
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## HRIM Project science: Lunar polar volatiles



## Molecules in the interstellar medium and comets,

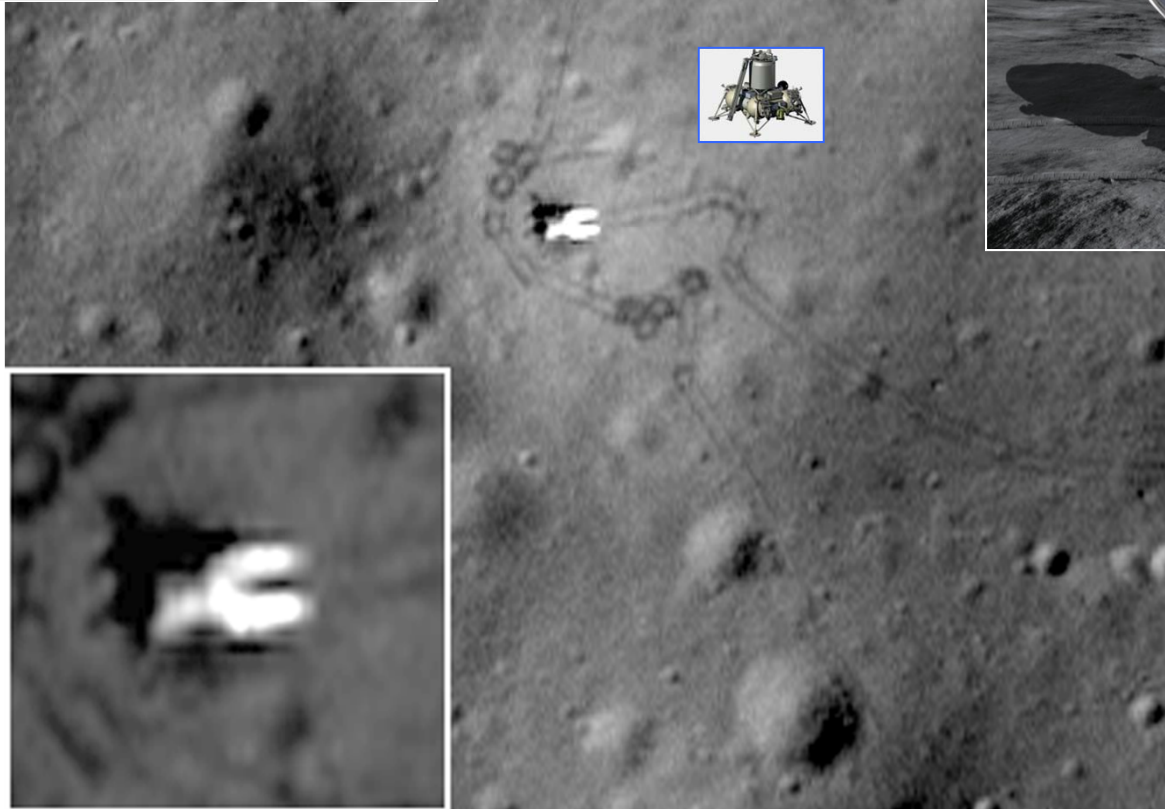
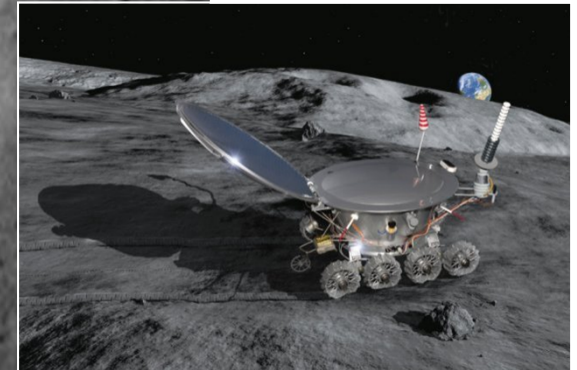
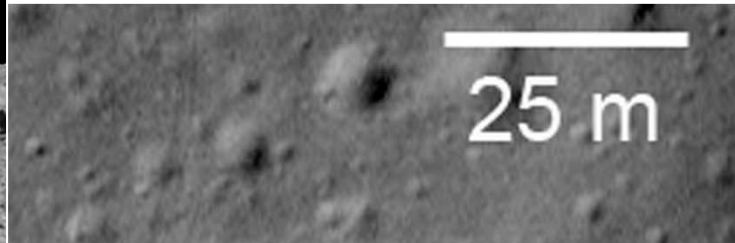
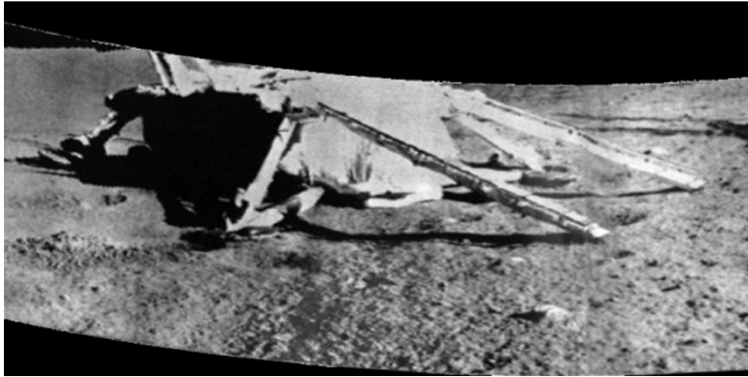
Number of Atoms								
2	3	4	5	6	7	8	9	≥ 10
H <sub>2</sub>	C <sub>3</sub>	c-C <sub>3</sub> H	C <sub>5</sub>	C <sub>5</sub> H	C <sub>6</sub> H	CH <sub>3</sub> C <sub>3</sub> N	CH <sub>3</sub> C <sub>4</sub> H	CH <sub>3</sub> C <sub>5</sub> N
AlF	C <sub>3</sub> H	l-C <sub>3</sub> H	C <sub>4</sub> H	H <sub>2</sub> C <sub>4</sub>	CH <sub>2</sub> CHCN	HCOOCH <sub>3</sub>	CH <sub>3</sub> CH <sub>2</sub> CN	(CH <sub>3</sub> ) <sub>2</sub> CO
AlCl	C <sub>2</sub> O	C <sub>3</sub> N	C <sub>4</sub> Si	HC <sub>4</sub> H	CH <sub>3</sub> C <sub>2</sub> H	CH <sub>3</sub> COOH	(CH <sub>3</sub> ) <sub>2</sub> O	HOCH <sub>2</sub> CH <sub>2</sub> OH
C <sub>2</sub>	C <sub>2</sub> S	C <sub>3</sub> O	l-C <sub>3</sub> H <sub>2</sub>	C <sub>2</sub> H <sub>4</sub>	HC <sub>5</sub> N	C <sub>7</sub> H	CH <sub>3</sub> CH <sub>2</sub> OH	NH <sub>2</sub> CH <sub>2</sub> COOH
CH	CH <sub>2</sub>	C <sub>3</sub> S	c-C <sub>3</sub> H <sub>2</sub>	CH <sub>3</sub> CN	CH <sub>3</sub> CHO	H <sub>2</sub> C <sub>6</sub>	HC <sub>7</sub> N	C <sub>2</sub> H <sub>5</sub> CHO
CH <sup>+</sup>	HCN	C <sub>2</sub> H <sub>2</sub>	CH <sub>2</sub> CN	CH <sub>3</sub> NC	CH <sub>3</sub> NH <sub>2</sub>	HOCH <sub>2</sub> CHO	C <sub>8</sub> H	HC <sub>9</sub> N
CN	HCO	HCCN	CH <sub>4</sub>	CH <sub>3</sub> OH	c-C <sub>2</sub> H <sub>4</sub> O	C <sub>2</sub> H <sub>3</sub> CHO	CH <sub>3</sub> CONH <sub>2</sub>	CH <sub>3</sub> C <sub>6</sub> H
CO	HCO <sup>+</sup>	HCNH <sup>+</sup>	HC <sub>3</sub> N	CH <sub>3</sub> SH	CH <sub>2</sub> CHOH	C <sub>6</sub> H <sub>2</sub>	CH <sub>2</sub> CHCH <sub>3</sub>	CH <sub>3</sub> OC <sub>2</sub> H <sub>5</sub>
CO <sup>+</sup>	HCS <sup>+</sup>	HNCO	HC <sub>2</sub> NC	HC <sub>3</sub> NH <sup>+</sup>		CH <sub>2</sub> C <sub>2</sub> H <sub>3</sub> CN	C <sub>8</sub> H <sup>-</sup>	C <sub>6</sub> H <sub>6</sub>
CP	HOC <sup>+</sup>	HNCS	HCOOH	HC <sub>4</sub> CHO		*C <sub>2</sub> H <sub>6</sub>		HC <sub>11</sub> N
SiC	H <sub>2</sub> O	HOCO <sup>+</sup>	CH <sub>2</sub> NH	NH <sub>2</sub> CHO				
HCl	H <sub>2</sub> S	H <sub>2</sub> CO	H <sub>2</sub> C <sub>2</sub> O	C <sub>5</sub> N				
KCl	HNC	H <sub>2</sub> CN	H <sub>2</sub> NCN	HC <sub>4</sub> N				
NH	HNO	H <sub>2</sub> CS	HNC <sub>3</sub>	c-H <sub>2</sub> C <sub>3</sub> O				
NO	MgCN	H <sub>3</sub> O <sup>+</sup>	SiH <sub>4</sub>	CH <sub>2</sub> CNH				
NS	MgNC	NH <sub>3</sub>	H <sub>2</sub> COH <sup>+</sup>					
NaCl	N <sub>2</sub> H <sup>+</sup>	SiC <sub>3</sub>	C <sub>4</sub> H <sup>-</sup>					
OH	N <sub>2</sub> O	C <sub>4</sub>						
PN	NaCN	CH <sub>3</sub>						
SO	OCS							
SO <sup>+</sup>	SO <sub>2</sub>							
SiN	c-SiC <sub>2</sub>							
SiO	CO <sub>2</sub>							
SiS	NH <sub>2</sub>							
CS	H <sub>3</sub> <sup>+</sup>							
HF	SiCN							
SH	SiNC							
FeO	AlNC							
PO	HCP							
O <sub>2</sub>	*CO <sub>2</sub> <sup>+</sup>							
CF <sup>+</sup>	*H <sub>2</sub> O <sup>+</sup>							
N <sub>2</sub>	*CS <sub>2</sub>							
SH	*H <sub>2</sub> S <sup>+</sup>							
*OH <sup>+</sup>								
*S <sub>2</sub>								



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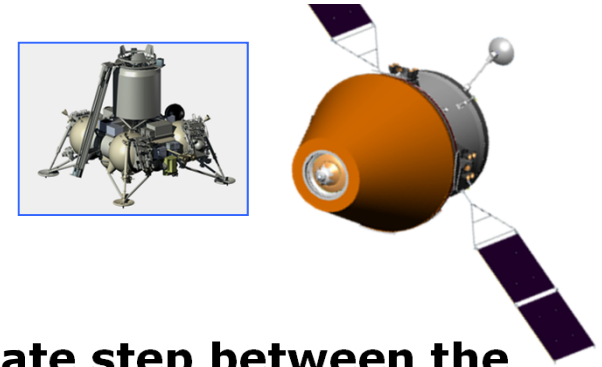
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## HRIM Project technology: Lunar landers visiting and studying



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### CONCLUSIONS

- (1) HRIM projects could be the necessary intermediate step between the stage of *Robotic Precursors* and the stage of *Visiting Human Outpost* on the Moon.**
- (2) HRIM projects allows to perform the unique lunar science with multi-sites sampling, comparable studying of the surface and network monitoring of the interior**
- (3) HRIM projects allows to perform long-duration biological experiments with plants and animals samples return, or onboard investigations**
- (4) HIRM projects allows to perform technological experiments and tele-operated surface activity with up/down transportation activity**
- (5) HIRM allows to get the valuable experience for lunar surface-LLO transportation**
- (6) HIRM is perfect stage for the Renaissance of international partnership in the sic-lunar space.**