KICT
KOREA INSTITUTE of CIVIL ENGINEERING and BUILDING TECHNOLOGY

2015 Annual Meeting of the Lunar Exploration Analysis Group

Vision and Plan for Korea Lunar Resource Prospecting

October 20, 2015 / Columbia, Maryland

Tai Sik Lee, Byung Chul Chang,
Hyu-Soung Shin, Janggeun Lee, Jaeho Lee

Korea Institute of Civil Engineering and Building Technology

KICT 한국건설기술연구원 | KIGAM 한국지질자원연구원 | KITECH 한국생산기술연구원 | KRISS 한국표준과학연구원 | KAERI 한국원자력연구원 Korea Atomic Energy Research Institute | KARI 항공우주연구원

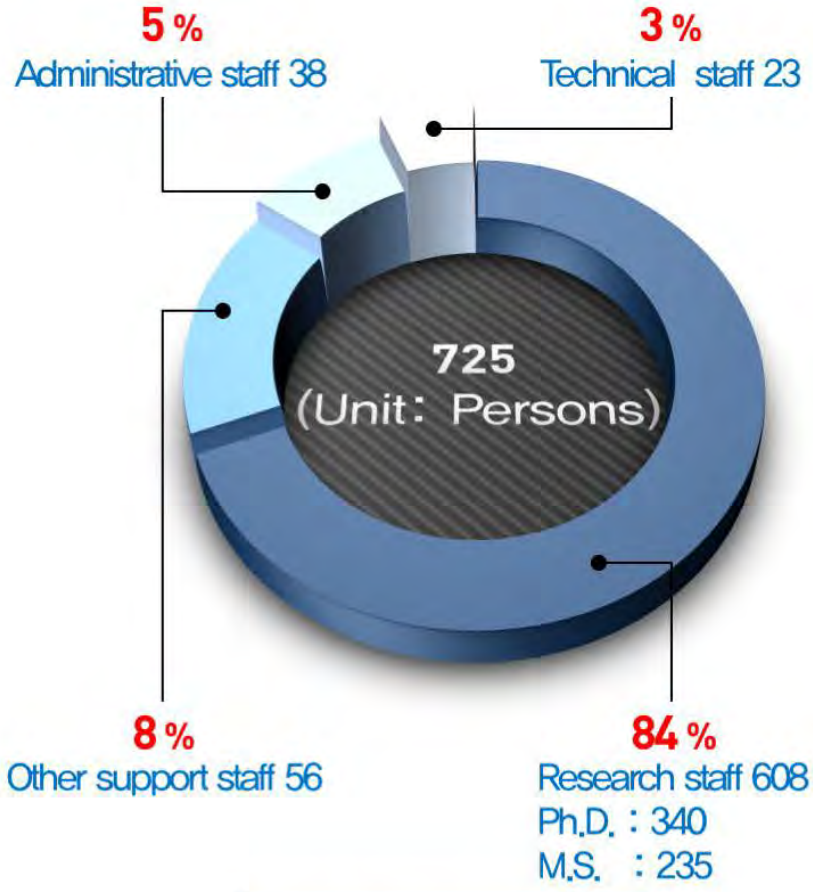
Contents

Vision and Plan for Korea Lunar Resource Prospecting

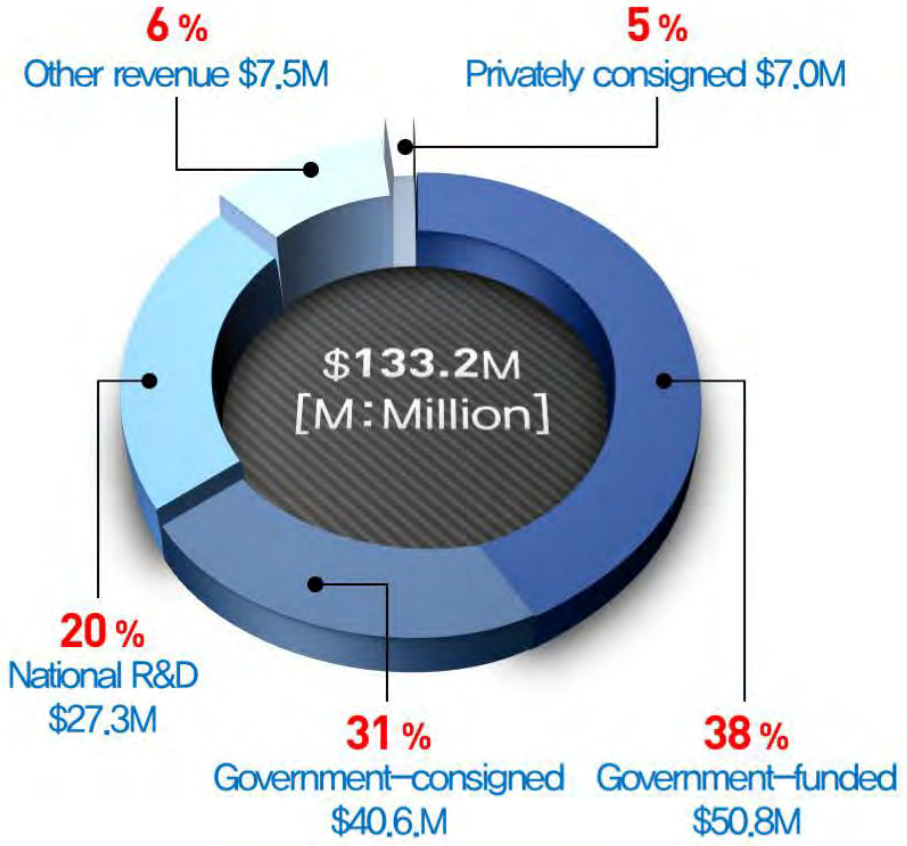
1. Introduction of KICT

Personnel & Budget

› Executives & Employees 725 / Budget for 2015 $133.2M (about KRW 150.4 billion)



Personnel (2015)



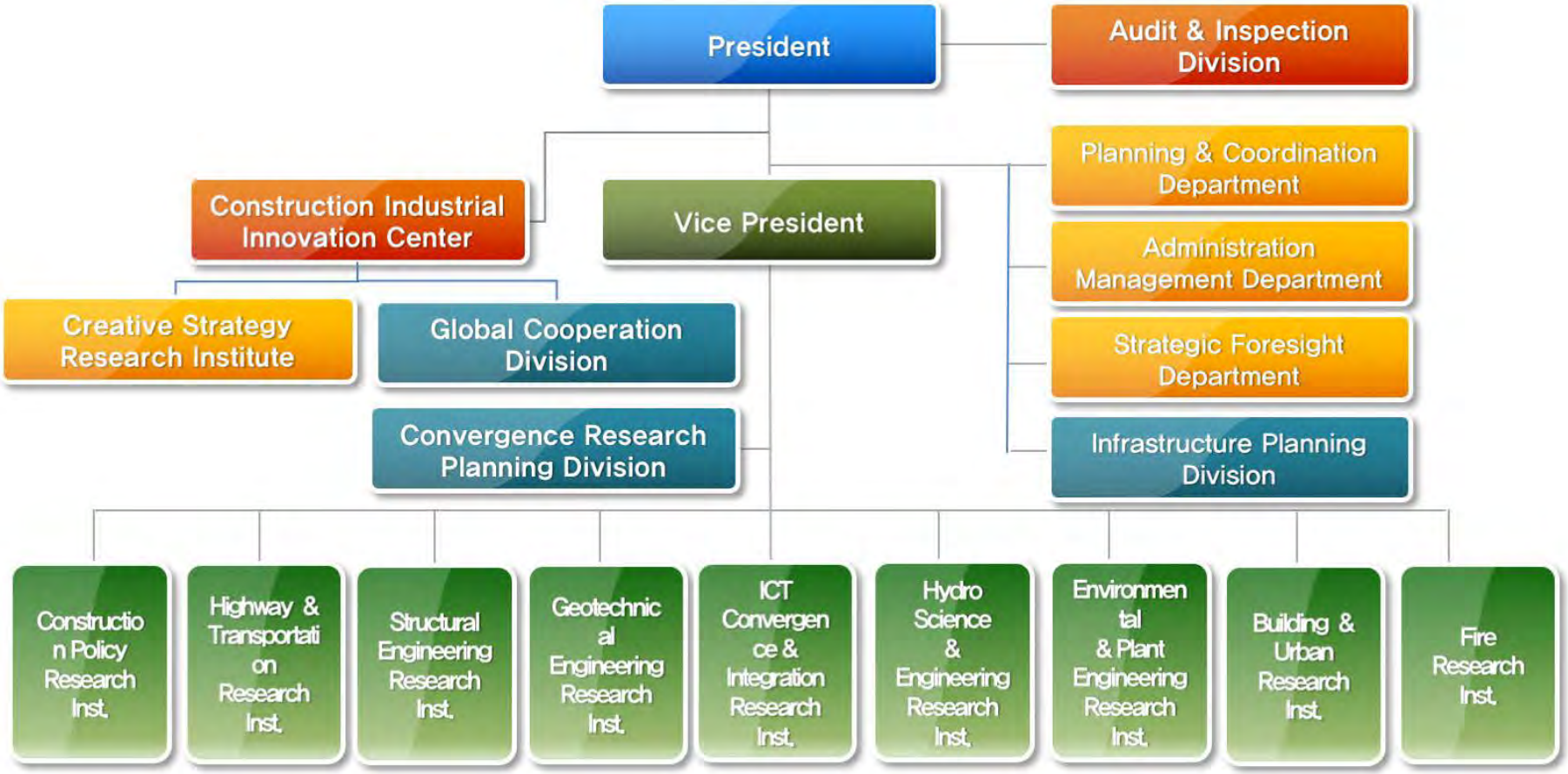
Budget (2015)

1. Introduction of KICT

Organization

› Ten Research Institutes , Three Departments, Three Divisions, One Center

◆ Reoriented to become a more task-oriented organization (July 2015)



I. Introduction of KICT

30 years Experience

Establishment of KICT

Completion of KICT Research Complex

Completion of Fire Research Center

Completion of River Experiment Center

Gov. sponsored Research Institute under the Jurisdiction of NST under the MSIP

Multidisciplinary R&D Areas

I. Introduction of KICT

Field Scale R&D

KICT Main Research Complex

- Goyang, Gyeonggi-Do
- Area : 141,552.6㎡
- Est. 1997

The SOC Evaluation Research Center

- Yeoncheon, Gyeonggi-Do
- Area : 692,119㎡
- Under construction(~2015)

The Fire Research Center

- Hwaseong, Gyeonggi-Do
- Area : 60,842㎡
- Est. 2006

The River Experiment Center

- Andong, Gyeongsangbuk-Do
- Area : 193,051㎡
- Est. 2009

1. Introduction of KICT

International Cooperation

/ *Strategic Relationships Based on MOU (48 Institutions as of June 30, 2015)*

- Delft University of Technology, Netherlands
- Fraunhofer Institute Bauphysik, Germany
- Colorado State University, USA
- Transport Research Laboratory, UK
- Department of Roads, Mongolia
- Asian Institute of Technology, Thailand
- BRE Global Limited, UK

/ *International Joint Seminars*

- Japan Institute of Construction Engineering, Japan
- Institute of Water Resources and Hydropower Research, China
- Public Works Research Institute, Japan
- Research Institute of Highway, China

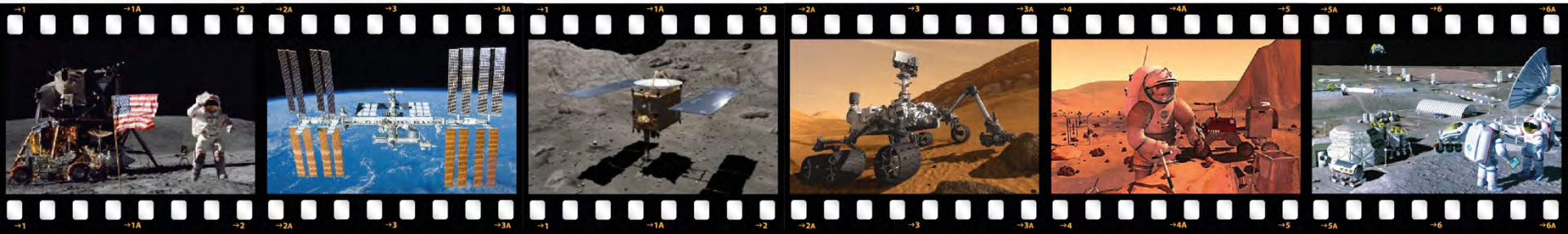
2. Background – Space Exploration

"The End of Earth
Will Not Be The End Of Us"

"Bring Him Home"

Engineering Manned mission ← **Science Remote/unmanned science mission** → **Engineering manned mission/ISRU**

Apollo | ISS | Hayabusa | Curiosity | Mars manned exploration | Moon/Mars base

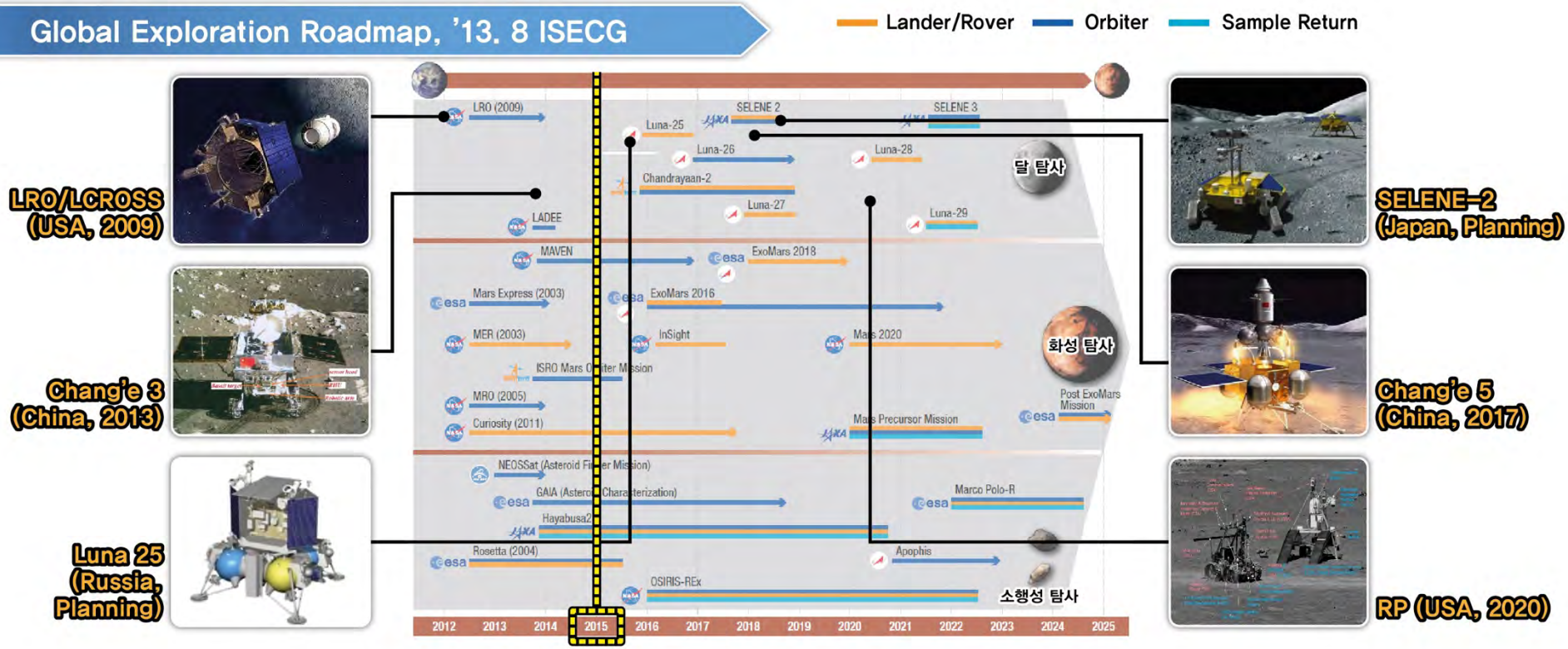


"Engineering enables science, and science enables engineering."

Dr. Michael Wargo(1951–2013), NASA HEOMD Chief Exploration Scientist

2. Background – Global Trend

Global Exploration Roadmap, '13. 8 ISECG

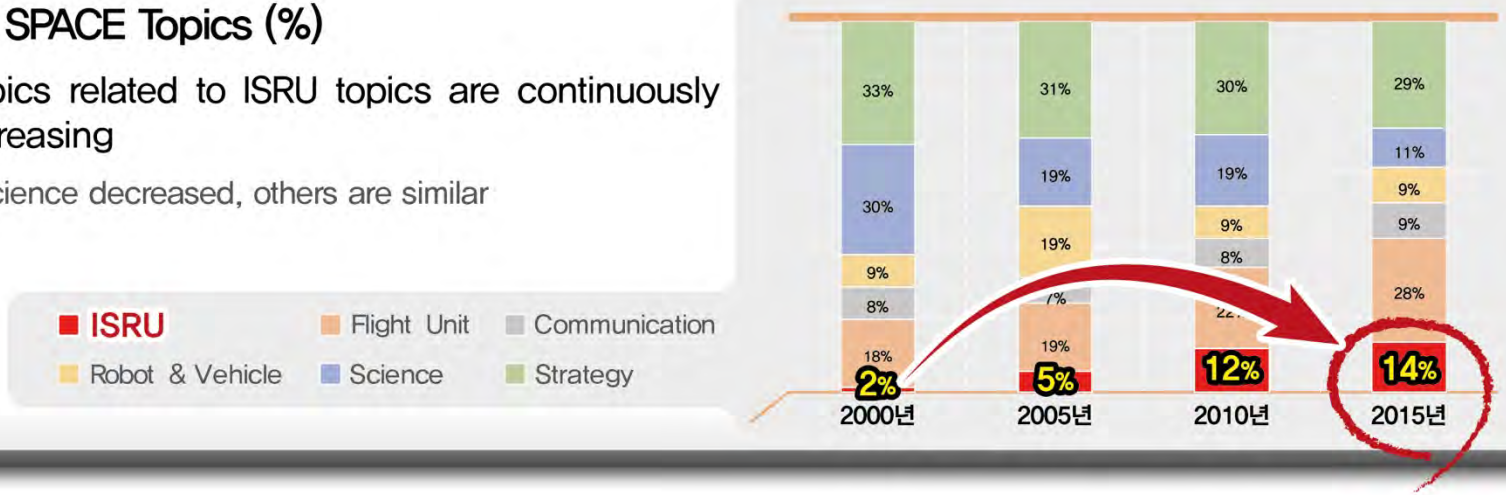


- **Global Trend of Space Exploration**
  - Golden time for **lunar exploration** and **international cooperation**
  - Rise of **Asian countries** to space exploration
  - Remote mission to **surface mission**

2. Background - ISRU

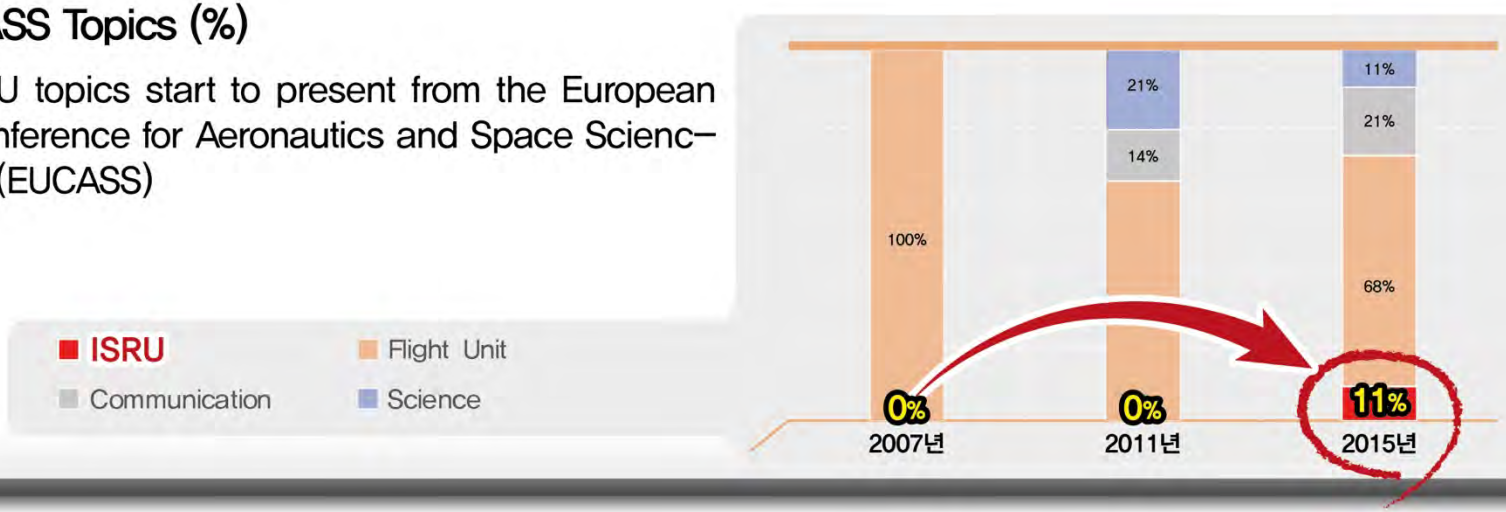
AIAA SPACE Topics (%)

- Topics related to ISRU topics are continuously increasing
  - Science decreased, others are similar



EUCASS Topics (%)

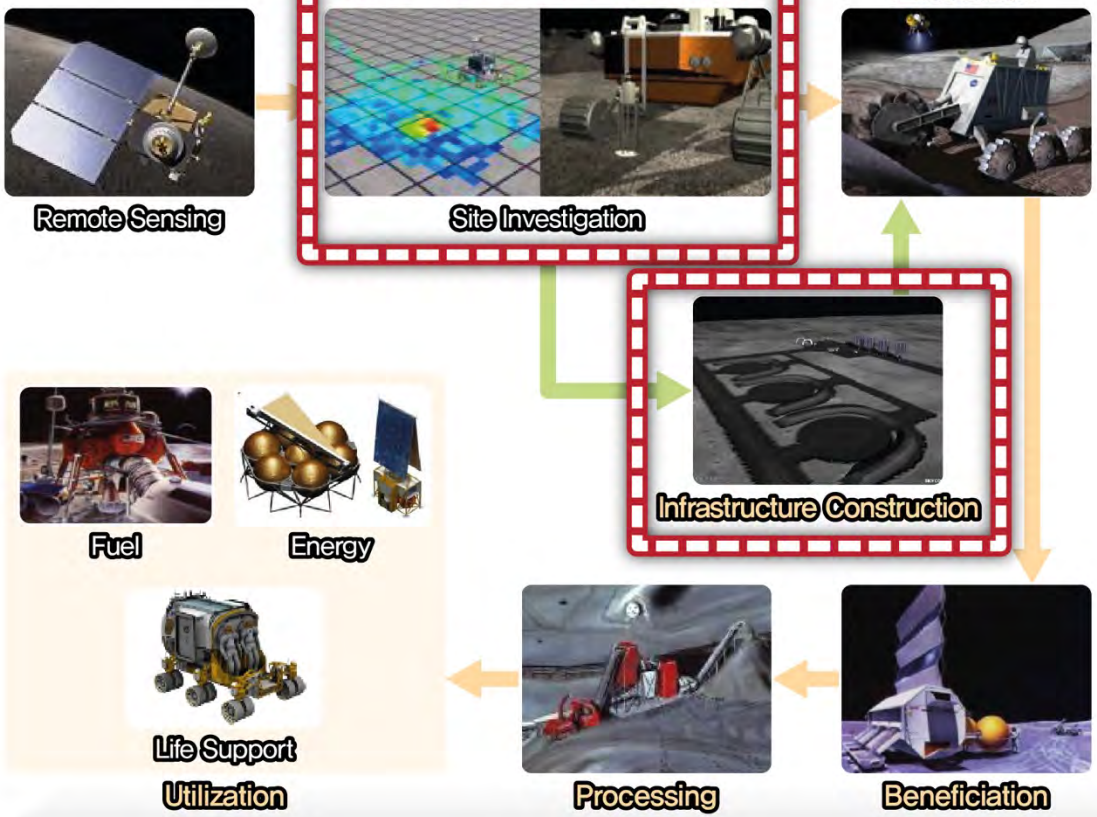
- ISRU topics start to present from the European Conference for Aeronautics and Space Sciences (EUCASS)



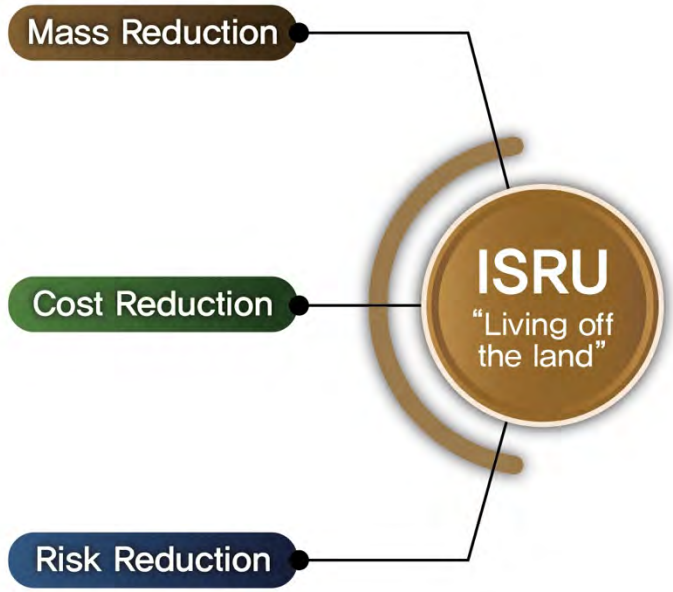
2. Background - ISRU

Lunar/Mars Manned Exploration → Limit of Payload & Resource from Earth → ISRU

ISRU(In-situ Resource Utilization)



ISRU

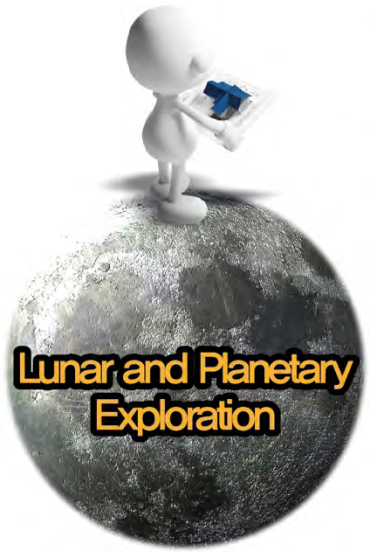


2. Background – National Trend

정부정책

- Government 13th policy task, “Space technology secure to be advanced space nation”
- Space technology development for launch vehicle, satellite, lunar exploration
- Diversify cooperating countries and technologies to improve Korea’s contribution

Mid and Long Term National Space Development Plan (November, 2013)



~ 2020

Lunar Exploration

~ 2030

Lunar Sample Return
Mars Landing

~ 2040

Asteroid, Deep Space Exploration

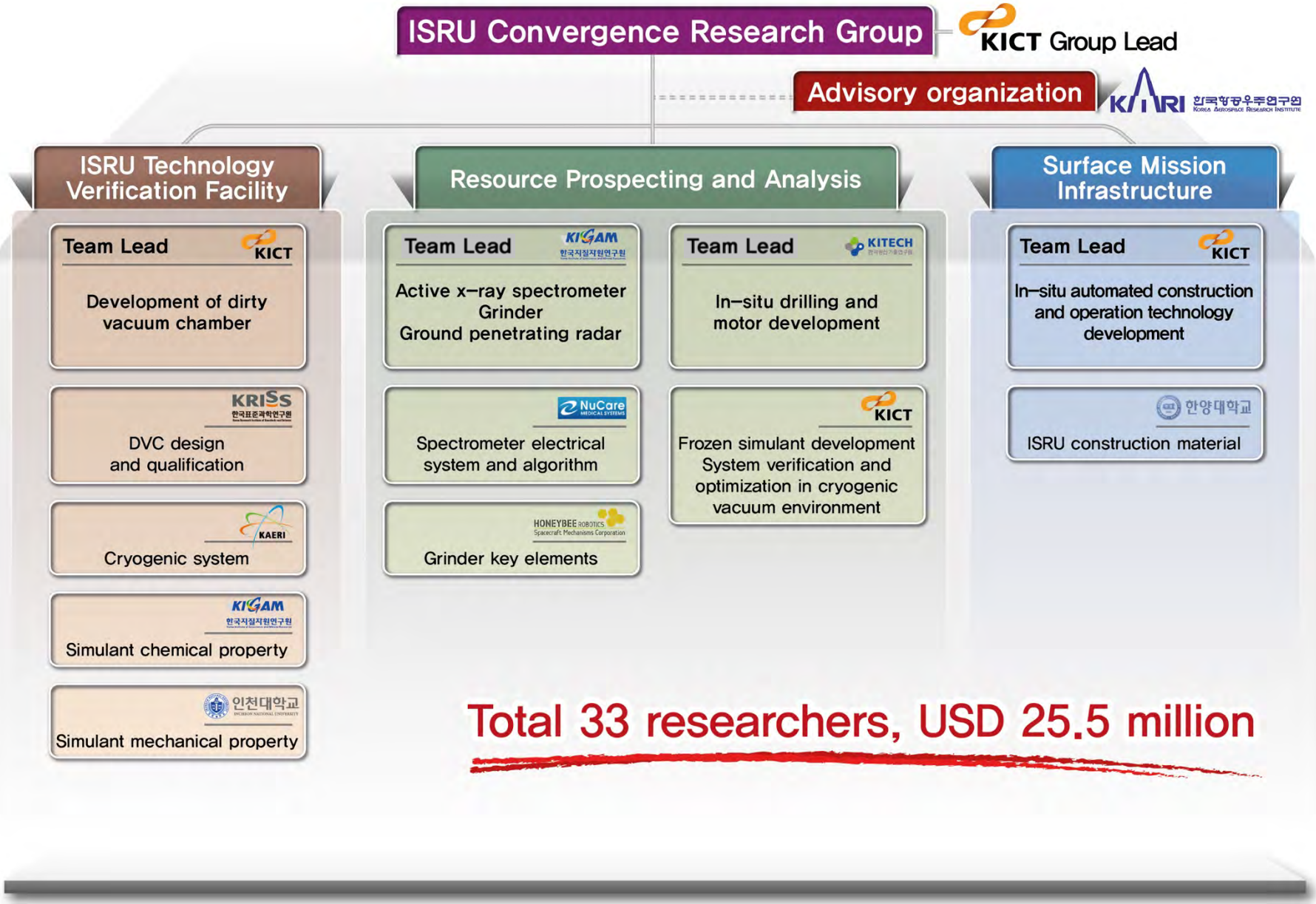
Asteroid, Deep Space Probe

3. Vision, Goal and Tasks

	Task 3	Task 2	Task 1	Task 4
Task	Space Resource In-situ Drilling	Space Resource In-situ Prospecting and Analysis	Dirty Vacuum Chamber for ISRU Technology Verification	Surface Mission Infrastructure Construction
Goal	• EQM level • 25kg • 150W • 1m depth • 25MPa (Frozen soil)	• EQM level • AXS : 20 element • GPR • 3kg	• 10^{-7} torr • −190℃ • Regolith simulant • 50m^3 volume	• BB level • 20MPa strength • In-situ additive construction • Measuring/Modelling/ Monitoring
Advance	Planetary surface investigation		System level verification	ISRU construction

Advance, Low Cost, High-efficient Space Resource In-situ Prospecting and Analysis Technology Development

3. Research Group



Total 33 researchers, USD 25.5 million

3. Research Plan – Task 1

Task 1 | Task 2 | Task 3 | Task 4

Final Goal

ISRU Technology Verification Facility
– Dirty vacuum chamber –

Key technology

- DVC design
- Key parts withstand extreme environment
- Solar simulator
- Technology verification process
- Regolith simulant(mech./chem.) considering different planetary condition

Output

- Dirty vacuum chamber and ISRU technology verification process

Application

- Surface mission device testing
- Science experiment
- Establish standards for planetary exploration device

10^{-7} torr
–190℃
System testable size (50m³)
Regolith simulant

3. Research Plan – Task 2

Task 1 | **Task 2** | Task 3 | Task 4

Final Goal

EQM level AXS, grinder, UWB full-Pol GPR development

Key technology

- AXS design, build
- UWB full-Pol GPR
- System integration and integrated platform operation
- Landing site decision process
- Geological resource investigation

Output

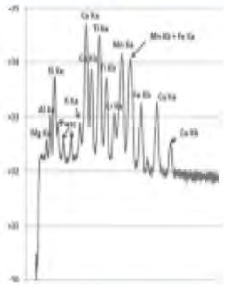
- In-situ resource prospecting AXS/grinder, GPR, landing site candidate report

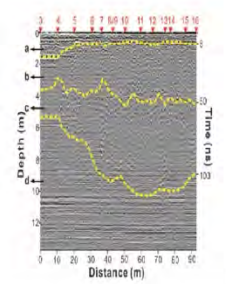
Application

- X-ray spectrometer for medical, industrial
- Extreme environment element investigation
- Cultural asset, underground detection
- Underground structural analysis

AXS
20 element
〈135eV resolution
〈0.1% error

GPR
〈3kg
10m underground investigation





3. Research Plan – Task 3

Task 1 | Task 2 | **Task 3** | Task 4

Final Goal

Low weight, high efficient 1m depth planetary drilling system for frozen soil and space environment (10^{-7} torr, −190℃)

Key technology

- Compact, light drilling design
- Monitoring and automated control system for safety and efficiency
- Thermal control system
- High efficient motor for space environment

Output

- EQM level drill/motor, auto control S/W, drilling system operation manual

Application

- Planetary stratigraphy investigation
- Science mission and sampling
- Regolith strength investigation
- Terrestrial polar region ground investigation and sampling

150W
〈25kg
30mm/min
Boring capacity (25MPa material)

〈NASA ARC Mars Drill Prototype〉

3. Research Plan – Task 4

Task 1 | Task 2 | Task 3 | **Task 4**

Final Goal

ISRU additive construction material (20MPa strength), automated construction technology and integrated testing environment

Key technology

- Infrastructure automated construction
- ISRU additive construction material
- Material forming/control
- Site topography, geological information analysis
- Site measuring, monitoring, modelling

Output

- Water–free construction material, automated construction system, monitoring system, 3D VR simulator

Application

- Planetary infrastructure (landing pad, apron, roads, blast wall, habitat)
- Construction for military, disaster, refugee region
- Eco– friendly construction
- Terrestrial construction automation and site monitoring system

BB level system
20MPa strength
25mm/s construction speed

〈USC Contour Crafting〉

3. Vision, Goal & Tasks

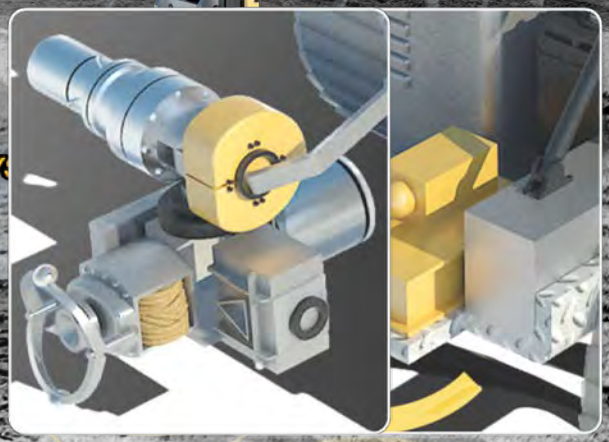
Space Resource In-situ Prospecting and Analysis Payload (EQM) Development until 2020

Task 1
Dirty Vacuum Chamber for ISRU Technology Verification
- System scale dirty thermal vacuum chamber
- Cryogenic shroud
- Regolith simulant characterization and development
- ISRU technology verification process

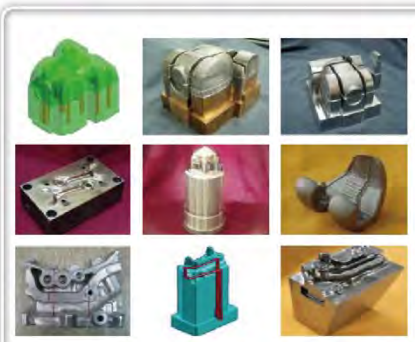
Task 4
Surface Mission Infrastructure Construction
- Construction site monitoring system
- ISRU additive construction material and method
- BB level automated construction device
- Site measuring and modelling

Task 2
Space Resource In-situ Prospecting and Analy
- EQM level active x-ray spectrometer/grinder
- EQM level ground penetration radar
- Primary resource prospecting site selection

Task 3
Space Resource In-situ Drilling
- EQM level drilling and motor
- Thermal control system
- Automated operation



4. Research Group



Mission
Manufacturing technology development and commercialize

Role
Drill design, build, and system integration

Key Technology
- Boring drill
- Horizontal direction drill
- Construction and maintenance robotic system

KITECH
한국생산기술연구원

Mission
Land/undersea geological survey, underground resource investigation/development/utilization

Role
In-situ resource prospecting and analysis technology development

Key Technology
- Planetary exploration science device
- Lunar geological/resource investigation
- Planetary resource geochemistry investigation

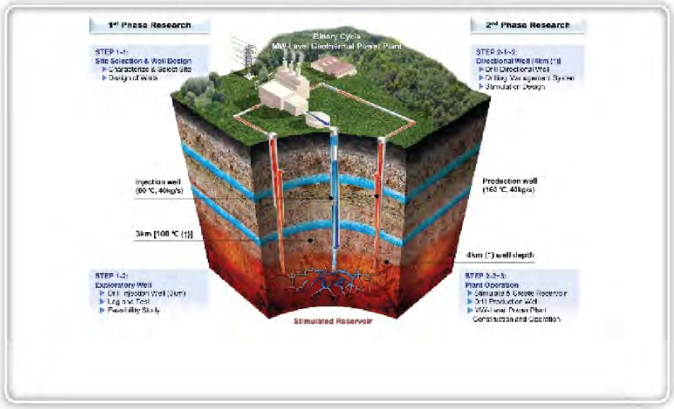
KIGAM
한국지질자원연구원

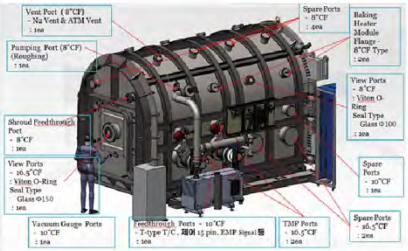
KICT
한국건설기술연구원

Mission
Construction and land management technology development

Role
Extreme environment construction technology development, drilling operation optimization

Key Technology
- Frozen land pipeline design and construction
- South pole base management
- Deep underground drilling





Mission
National measurement standards, measurement technology R&D

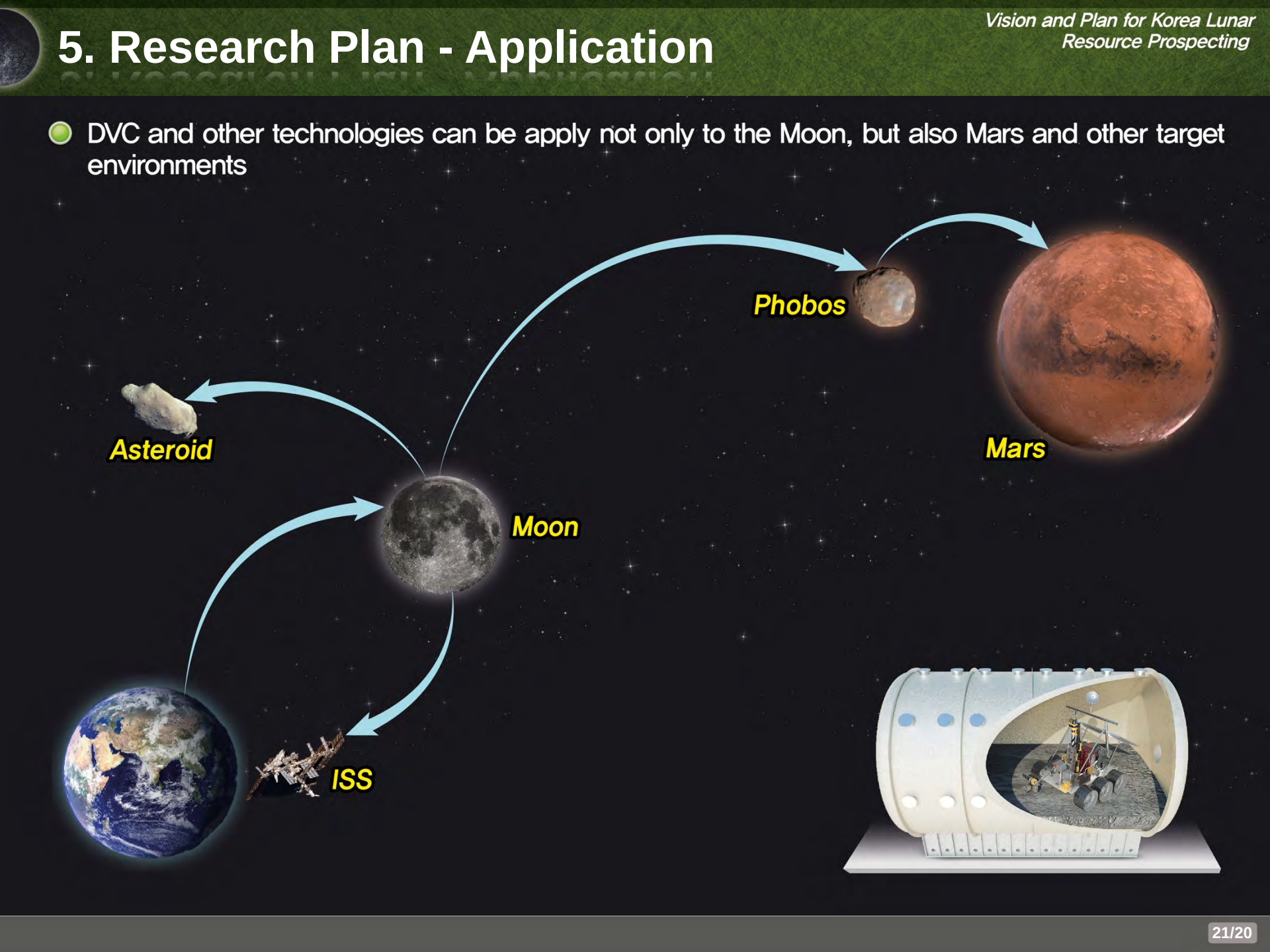
Role
Development of dirty vacuum chamber and testing facility

Key Technology
- Vacuum technique
- Ultra thin film measuring technology
- Vacuum environment measuring technology

KRISS
한국표준과학연구원

5. Research Plan - Application

- DVC and other technologies can be apply not only to the Moon, but also Mars and other target environments



KICT
KOREA INSTITUTE OF CONSTRUCTION TECHNOLOGY

KICT 한국건설기술연구원 | KIGAM 한국지질자원연구원 | KITECH 한국생산기술연구원 | KRISS 한국표준과학연구원 | KAERI 한국원자력연구원 | KARI 한국항공우주연구원

사람과 미래를 생각하는
한국건설기술연구원 KICT 미래기술 강국 대한민국의 내일을 밝혀갑니다.

Thank you

극한지 신공간 건설 사업 지원

- 극한지 신공간 건설 사업 지원
- 미래 건설시장 마케팅
- 에너지 자원 확보

범 례

→ 극지 : 극권(極圈)에서 극에 이르는 사이의 지역

→ 심해저 : 대륙사면에 연속되는 비교적 평탄하고 광대한 해저 지형

→ 흑서지