

룩셈부르크는 우주에서 자원을 캔다

한국천문연구원  
문홍규

theworldin.com.

공기와 물과 흙



H-K Moon

금속

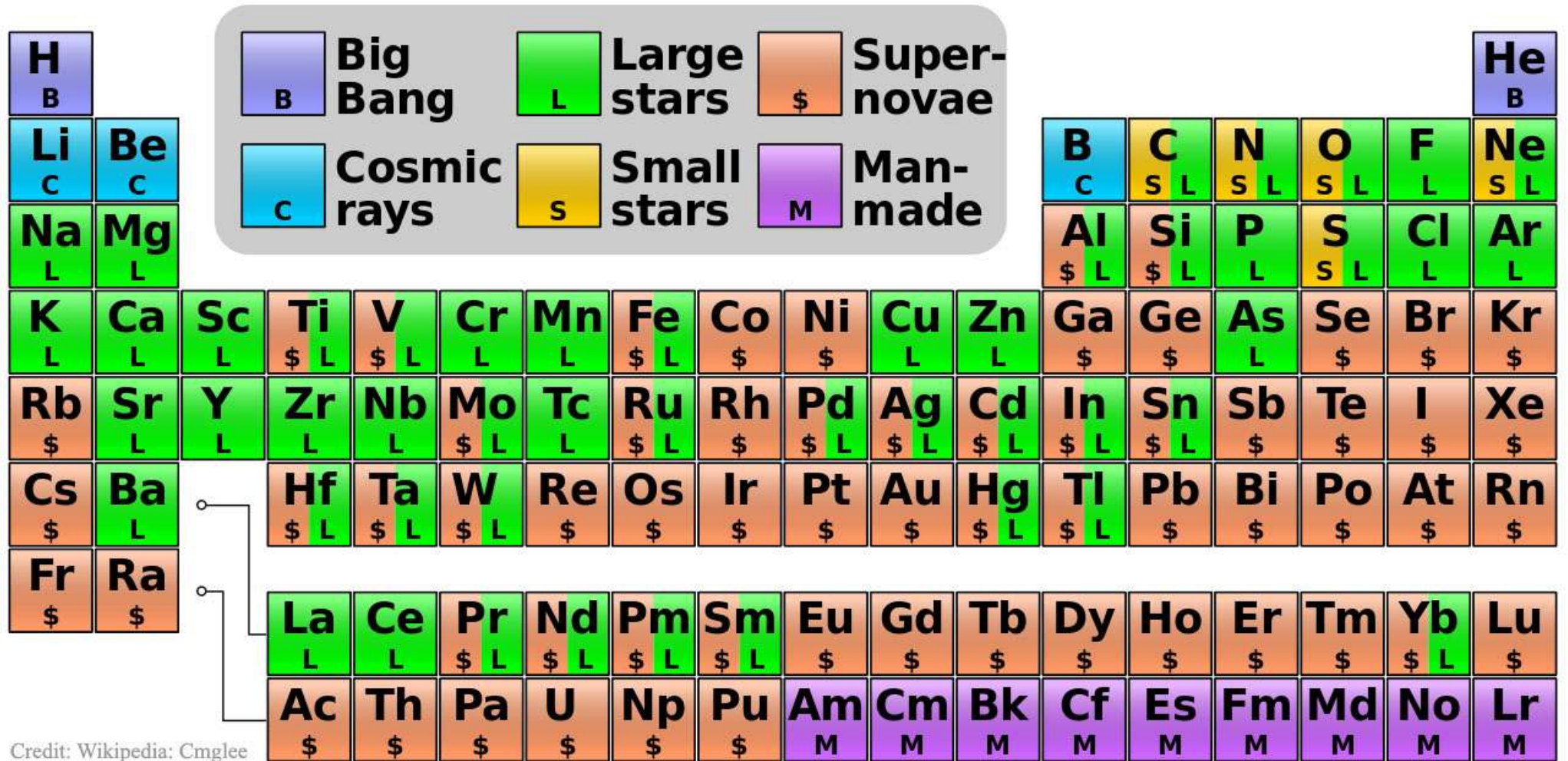


H-K Moon

# 빅뱅 Big Bang

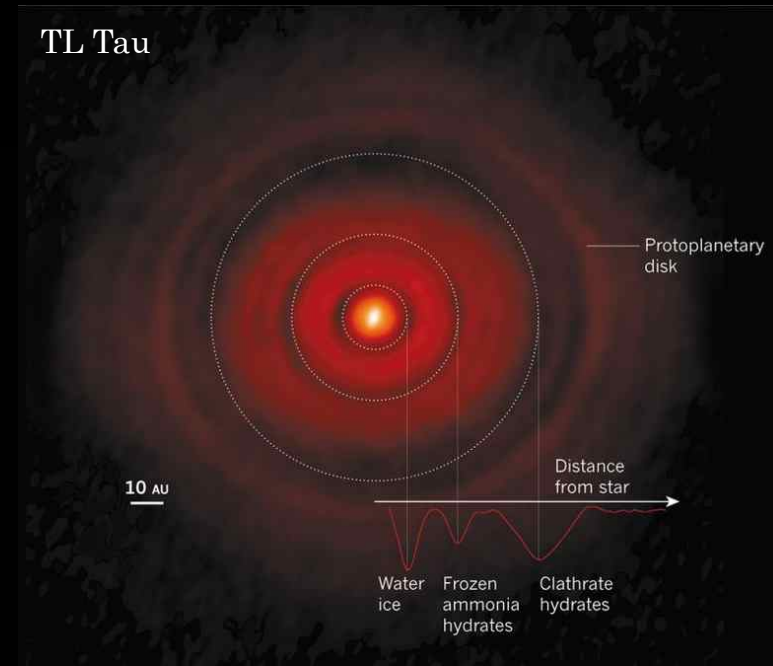
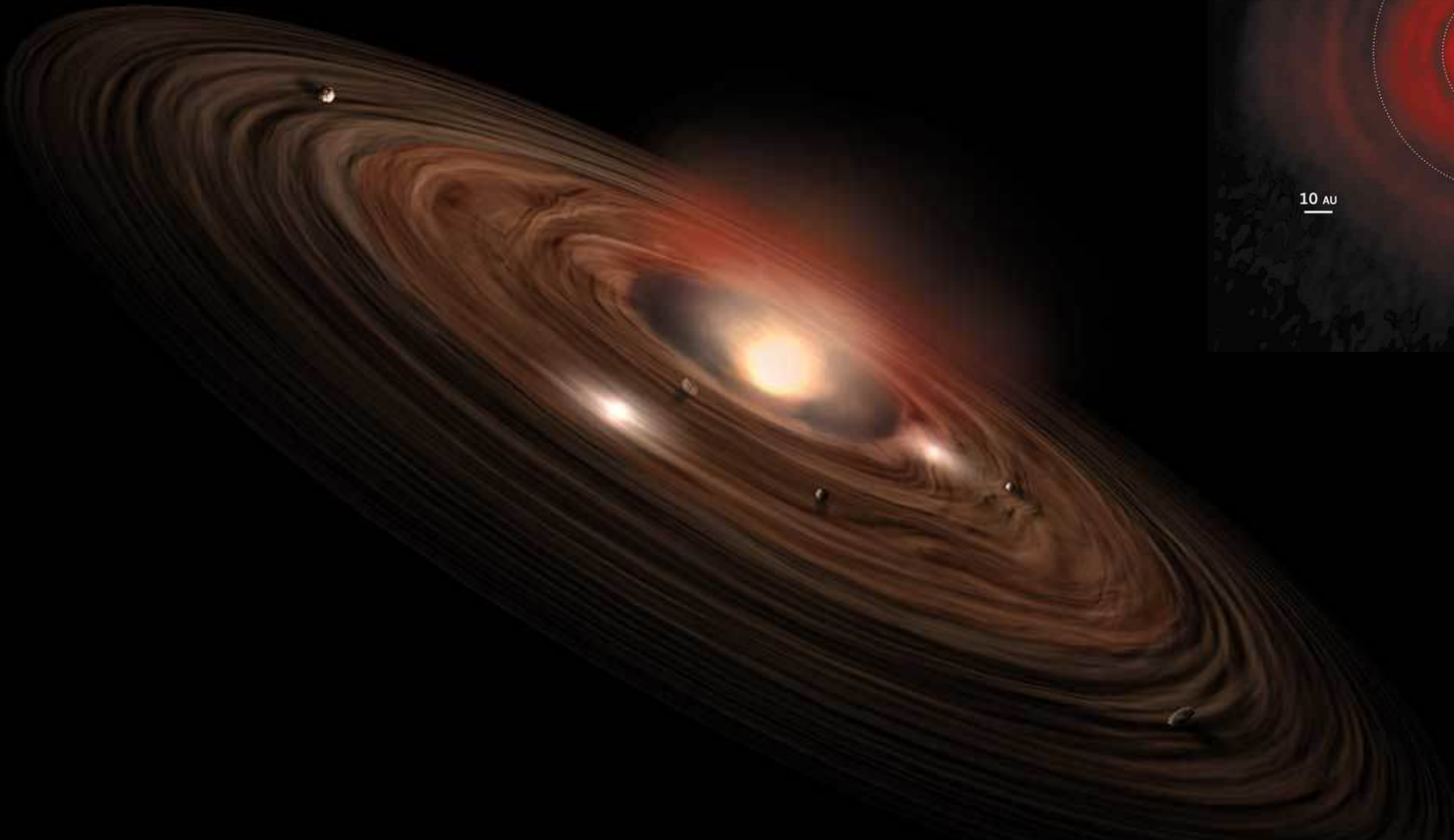


# 모두, 어디에서 왔나?



Credit: Wikipedia: Cmglee

# 태양계의 탄생 Formation of the Solar System



BBC, K. Zhang, ALMA

# 지구 The Earth



탐사



시료 The sample

2010년 6월 13일  
호주 우메라 Woomera 사막

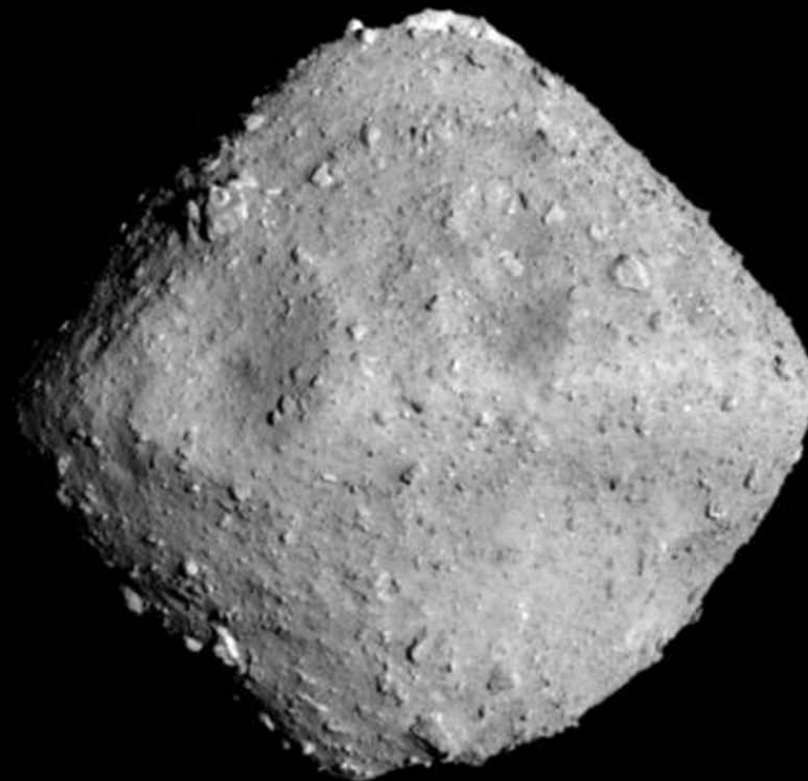


National Geographic

# イトカワ・龍宮



25143 Itokawa  
0.5 × 0.3 × 0.2 km  
Hayabusa, 2005



162173 Ryugu  
1.0 km  
Hayabusa2, 2018

Hayabusa  
はやぶさ



**HAYABUSA**  
はやぶさ

竹内結子 西田敏行  
高嶋政宏 佐野史郎 山本耕史 鶴見辰吾  
英 利夫 市川実和子 甲本雅裕 マギー 正名僕哉 六角慎司 高橋長実 生瀬勝久

『20世紀少年』シリーズ 『明日の記憶』  
監督:堤 幸彦

あきらめない勇気を与えてくれたのは、君——。

協力: JAXA 宇宙航空研究開発機構  
主題歌: (umika)「たいせつな光」(Ariola Japan)  
ノベライズ: 『はやぶさ/HAYABUSA』(角川文庫、角川つばさ文庫) 参考書籍: 『はやぶさの冒険日誌』(毎日新聞社)

10.1 7年間、60億キロ—(はやぶさ)の帰還を信じて困難と闘い続けた人々の真実のドラマ。

hayabusa-movie.com

LEGO CUUSOO 21101

LEGO

Ages/edades/対象年齢  
**12+**  
21101

CUUSOO

はやぶさ  
**HAYABUSA**  
Chosen by more than 1,000 CUUSOO users in Japan

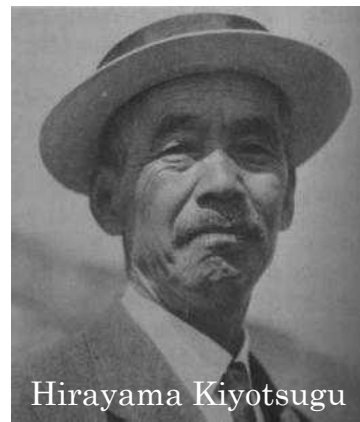
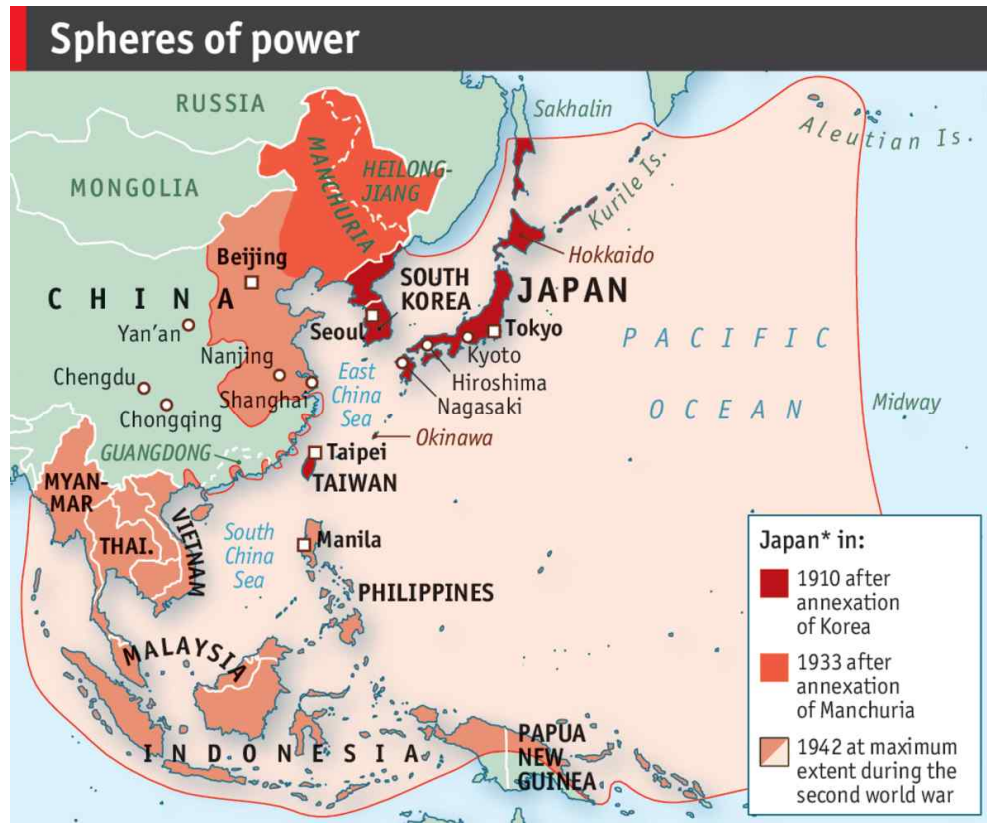
369 pcs/Stck/pzs/db/ピース

Building Toy  
Konstruktionsspielzeug  
Jouet de Construction  
Juguete para Construir  
Brinquedo para Construir  
Epijáték  
組み立てのおもちゃ

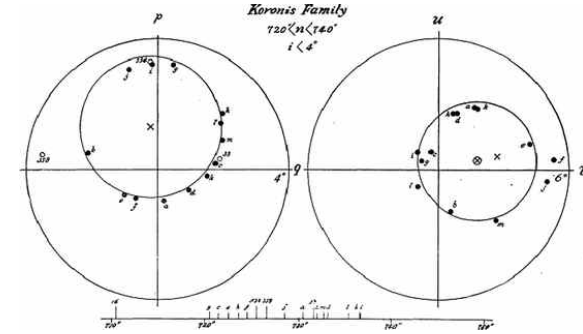
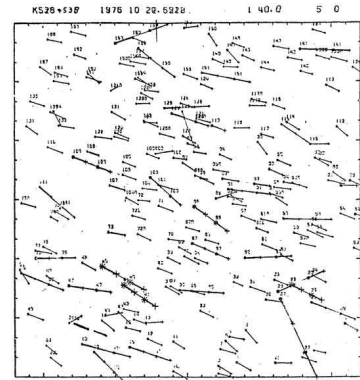
LEGO, hayabusa-movie.com



Yurimoto Keiko, 1939



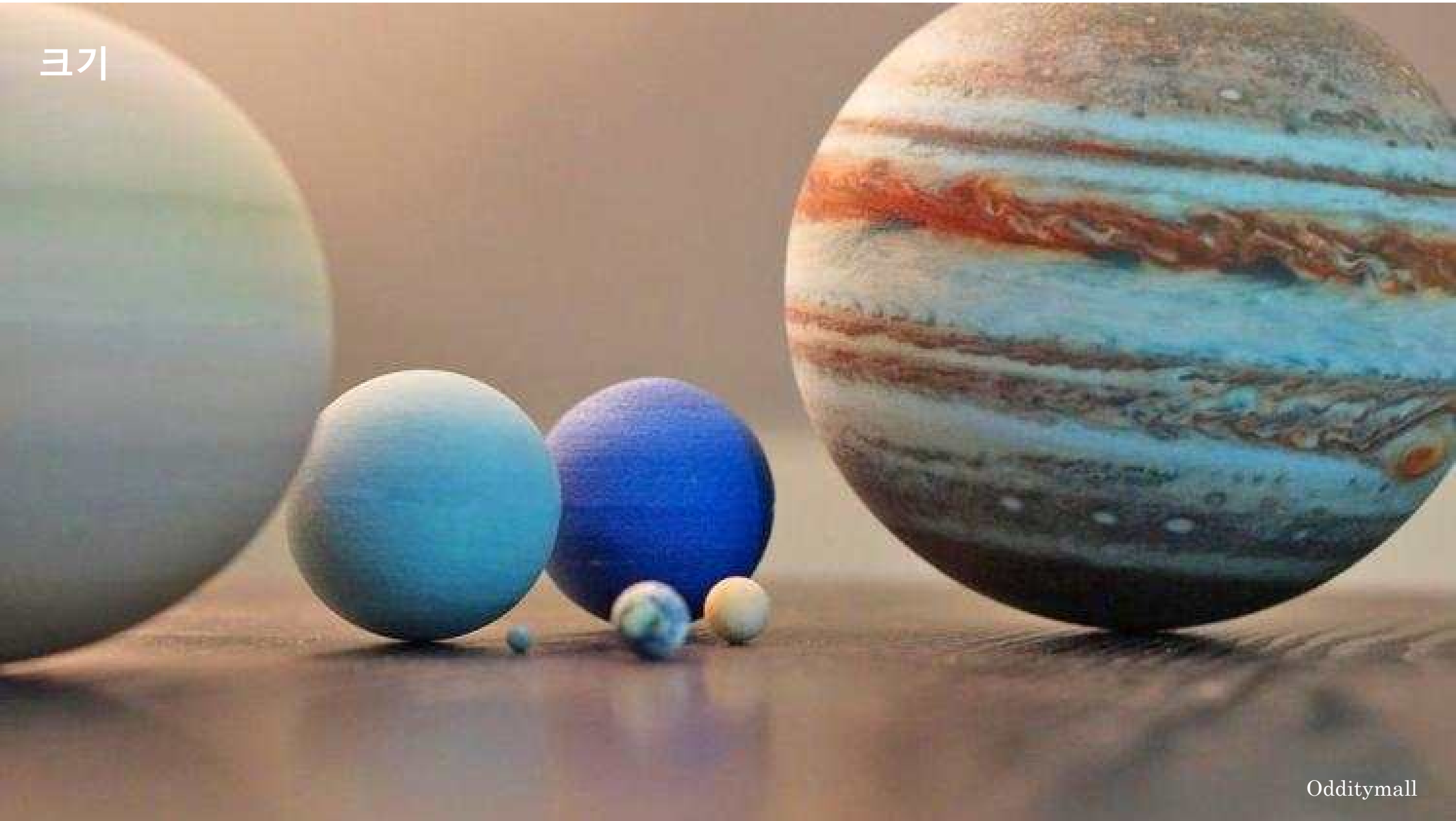
Hirayama Kiyotsugu



Economist, Springer Link, Kyoto Municipal Art Museum

ABC

크기



## 거리

수성	1.9
금성	3.6
지구	5.0
화성	7.6

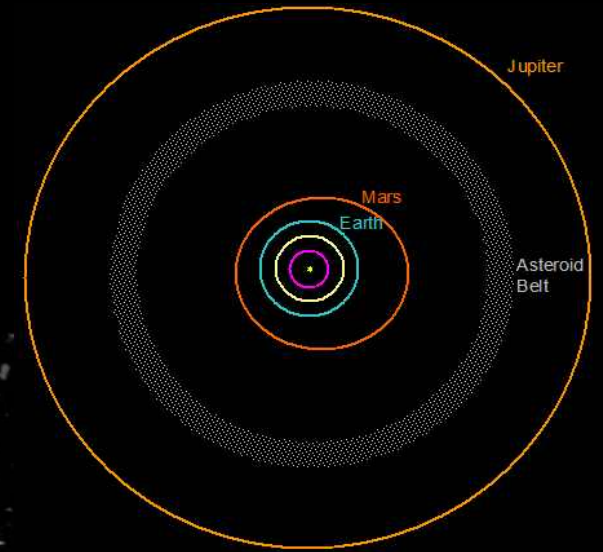
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목성	25.9
토성	47.5
천왕성	95.4
해왕성	150.0

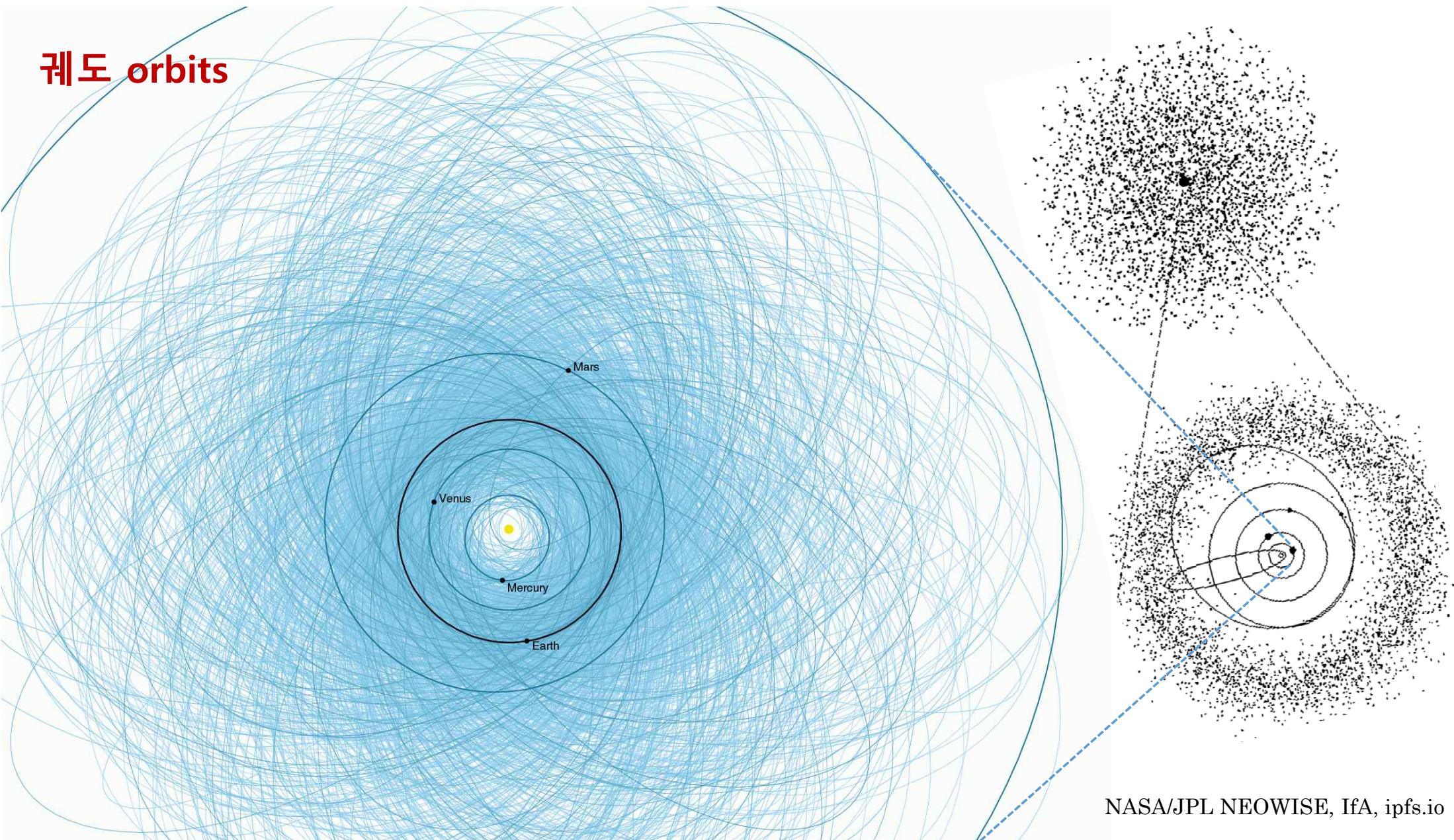




소행성대 the main belt = MB



# 궤도 orbits



NASA/JPL NEOWISE, IfA, ipfs.io

한국의?

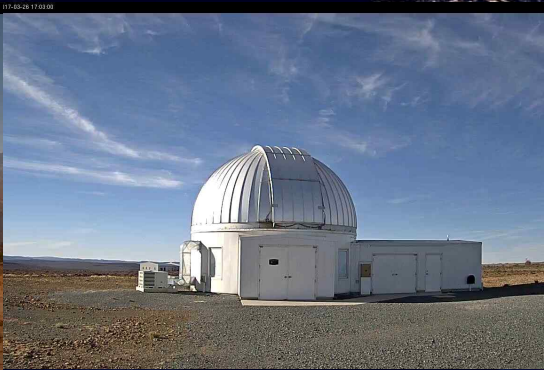
# KMTNet DEEP-South



**Cerro Tololo Inter-American  
Observatory**

**Chile**

**Telescope:  
05 - 2014  
CCD:  
09 - 2014**



**South African Astronomical  
Observatory**

**South Africa**

**Telescope:  
08 - 2014  
CCD:  
12 - 2014**



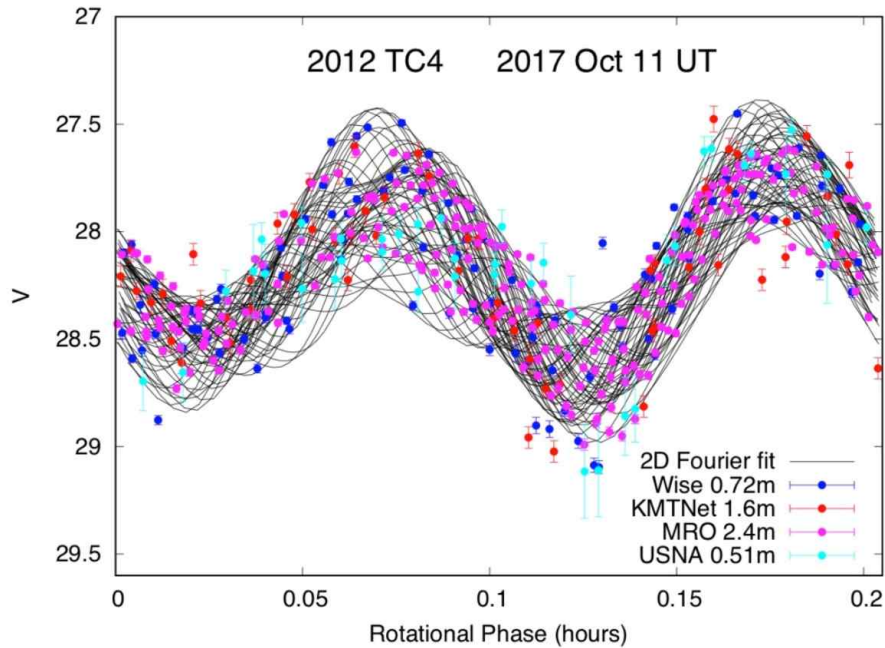
**Siding Spring Observatory**

**Australia**

**Telescope:  
11 - 2014  
CCD:  
05 - 2015**

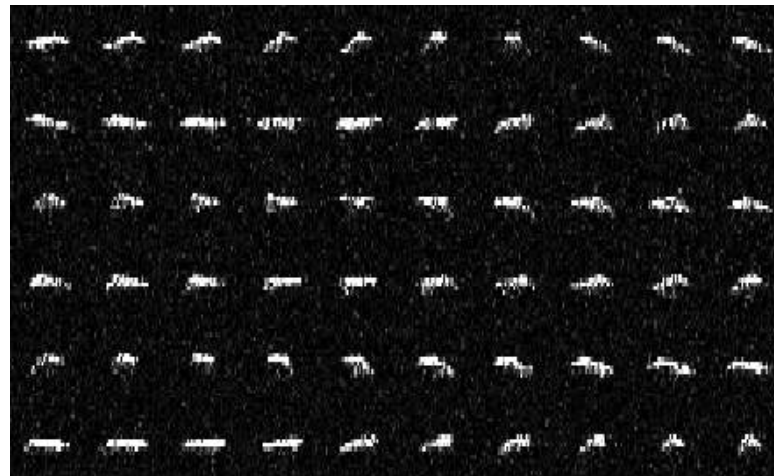
# 국제공동관측 캠페인

## Potentially Hazardous Asteroid 2012 TC4



Observatory/Telescope	Date (UTC)	B-V	V-R	V-I
Magdalena Ridge 2.4-m	2017 10 11.14-16	0.64±0.06	0.44±0.04	0.85±0.06
KMTNet-SAAO 1.6-m	2017 10 10.908		0.351±0.063	0.855±0.064
	2017 10 10.894		0.480±0.073	0.760±0.069

Observatory/Telescope	Date (UTC)	g-r	r-i	g-i
Palomar Hale 5-m	2017 09 20.38-41	0.55±0.07	0.46±0.07	1.01±0.08



소행성, 혹은 혜성?  
소행성인줄 알았던 2008 XO8, 혜성으로 밝혀지다!

One of the twin separated ~300-500 yr ago?



- **Activity from presumed asteroid 2008 XO8** confirmed using KMTNet
- Reported to CBET 4460
- $a = 4.25$  AU,  $e = 0.65$ ,  $q = 1.48$  AU,  $i = 12$  deg,  $T_J = 2.6$
- Observed for 14 days until Nov 29, 2017



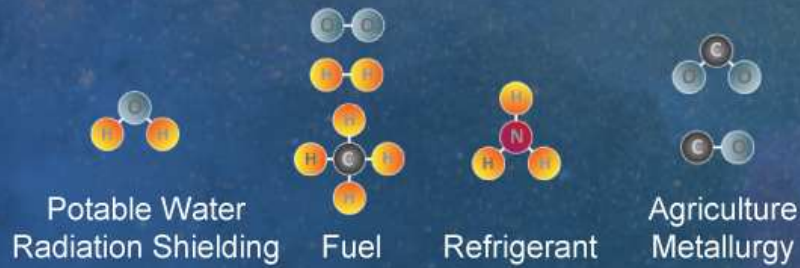
	2008 XO8	265P
a (AU)	4.25	4.25
e	0.65	0.65
i (°)	12	14
q (AU)	1.48	1.49
LNP (°)	21	16

# Comet DEEP-SOUTH in “The man from a star”



자원





**VOLATILES AND H<sub>2</sub>O**  
to fuel the growth of  
humanity into new frontiers



**INDUSTRIAL METALS**  
to construct and  
sustainably service space  
platforms

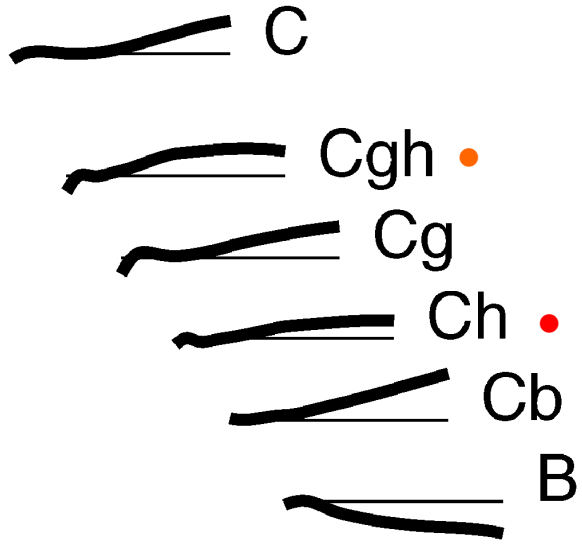


**PLATINUM GROUP METALS**  
to support demand growth on  
Earth

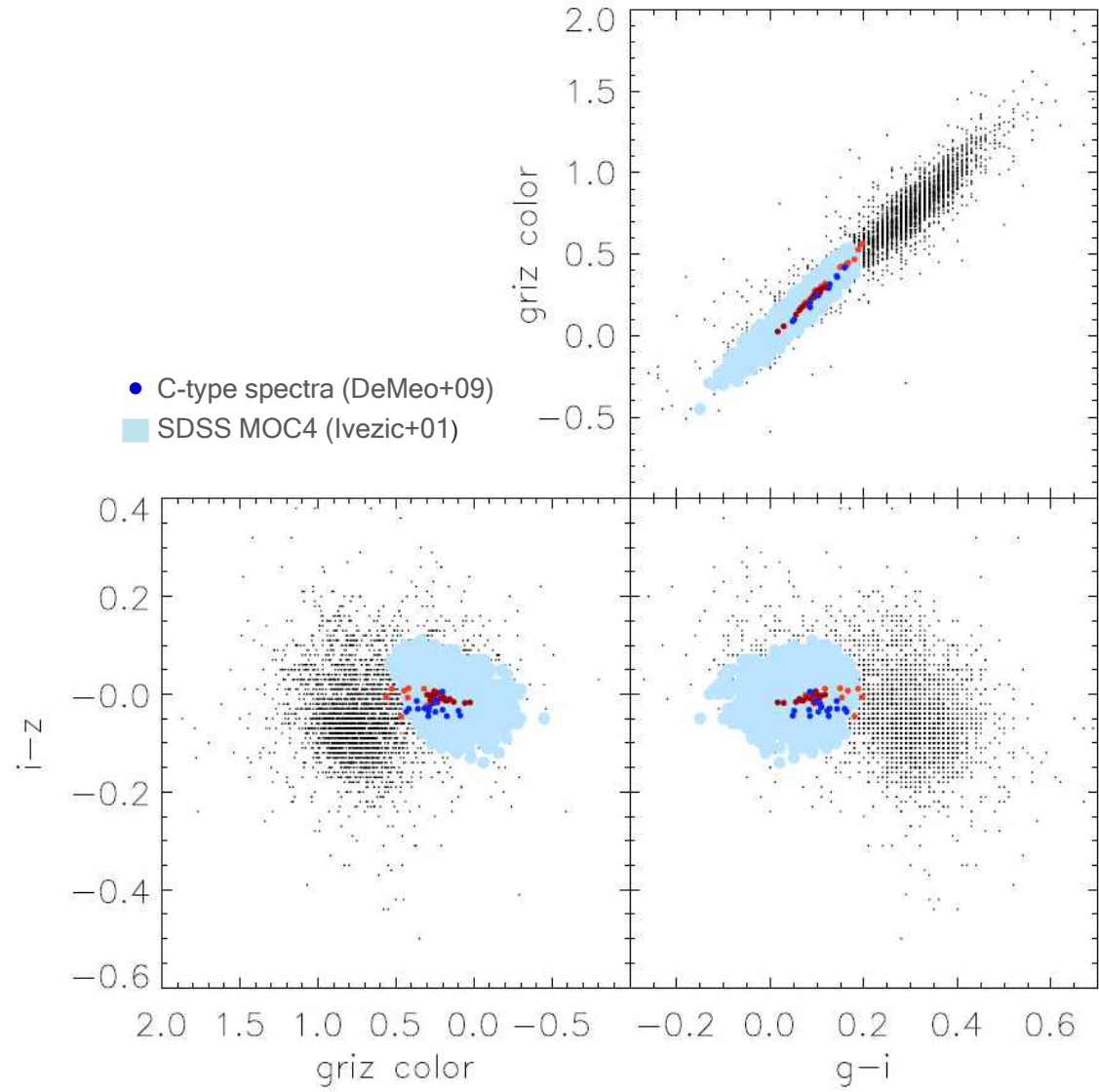


Despite desire to reduce dependency,  
one-in-four manufactured goods require PGMs.

☾  
H<sub>2</sub>O



D-G Roh, in preparation; DeMeo+09



Units: kilometers/second

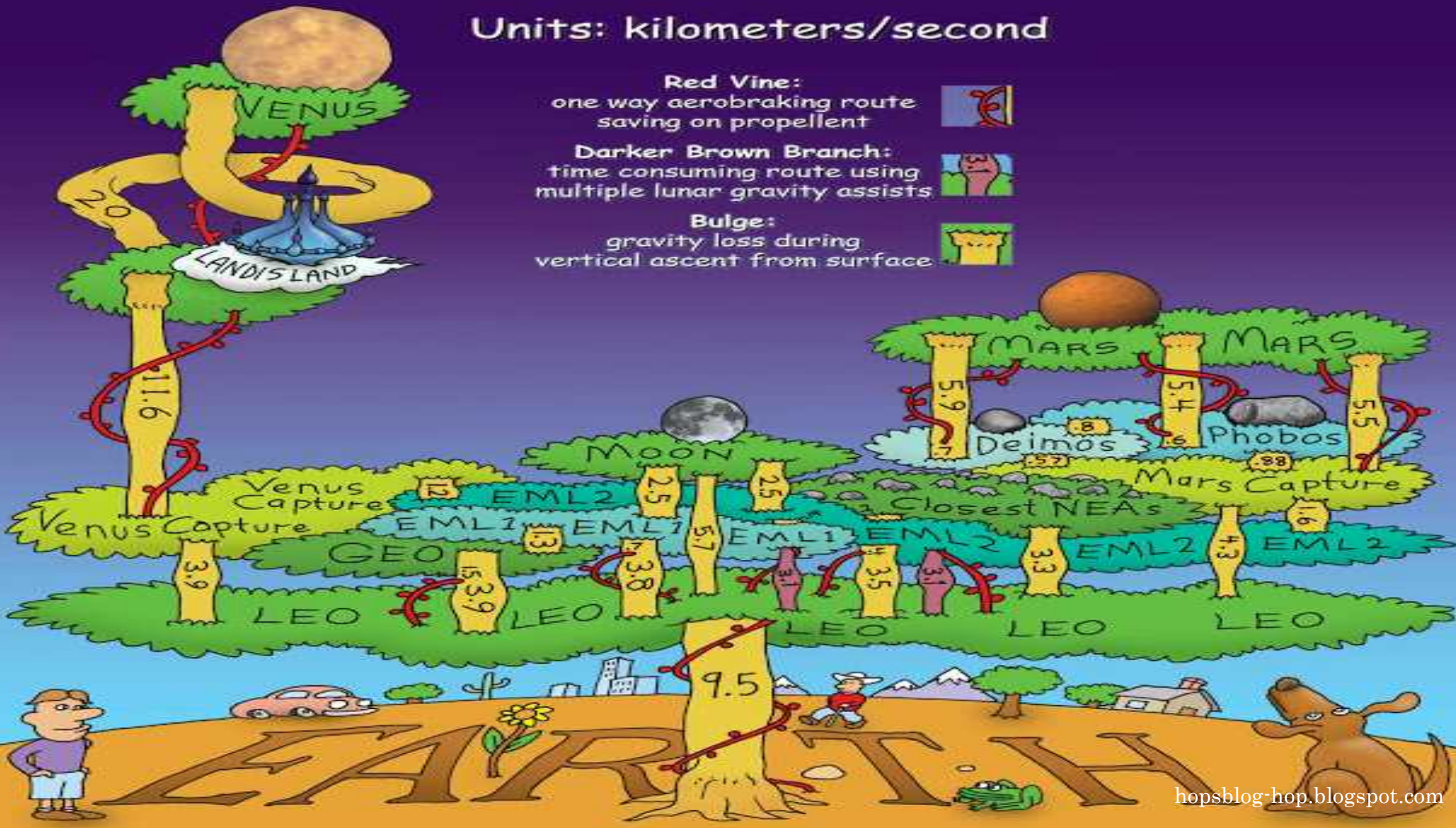
**Red Vine:**  
one way aerobraking route  
saving on propellant



**Darker Brown Branch:**  
time consuming route using  
multiple lunar gravity assists



**Bulge:**  
gravity loss during  
vertical ascent from surface



룩셈부르크

**ASIME-2018**  
April 16 and 17, 2018

# INVITATION

## Asteroid Science Intersections with In-Space Mine Engineering

Join us for an intensive two day workshop to discuss  
our present day understanding of the composition of asteroids

April 16 and 17, 2018 – University of Luxembourg, Belval Campus

Registration and further information on [asime.uni.lu](http://asime.uni.lu)

# ASIME 2018

Image Credit: NASA/JPL-Caltech/UCLA/MPS/DLR/IDA





H-K Moon

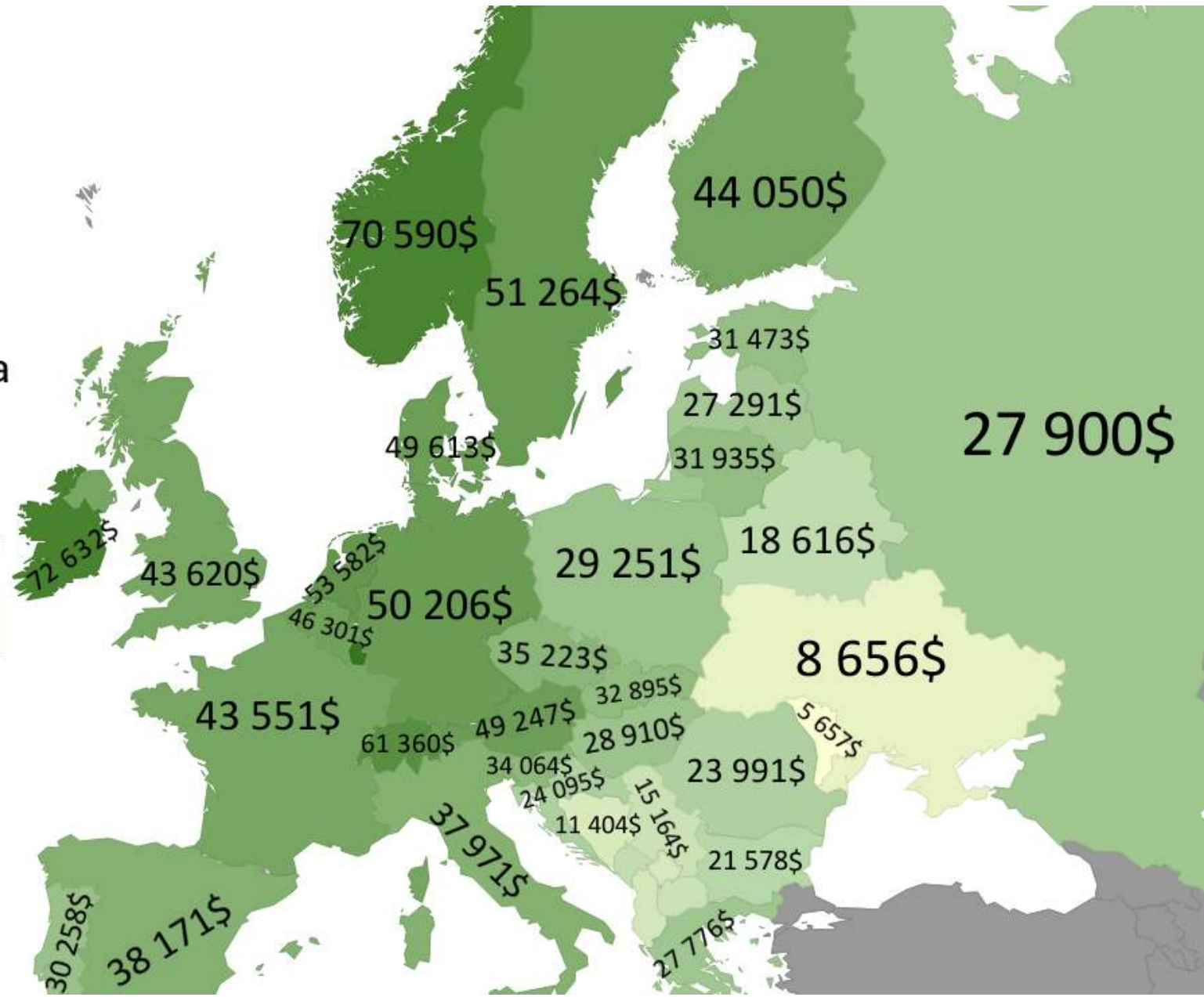


# Map of Europe for 2017 showing Gross Domestic Product estimates per capita in Purchasing Power Parity (international dollars) - current prices

Source: IMF World Economic Outlook Database October 2017  
Tools: Google sheets and GIMP



- List of countries which are too small to have their GDP shown on map:
- Luxembourg - 109 192\$
  - San Marino - 60 359\$
  - Malta - 42 532\$
  - Montenegro - 17 439\$
  - Macedonia - 15 203\$
  - Albania - 12 472\$
  - Kosovo - 10 383\$



철강산업  
Steel industry





라디오 방송  
Radio-Luxembourg

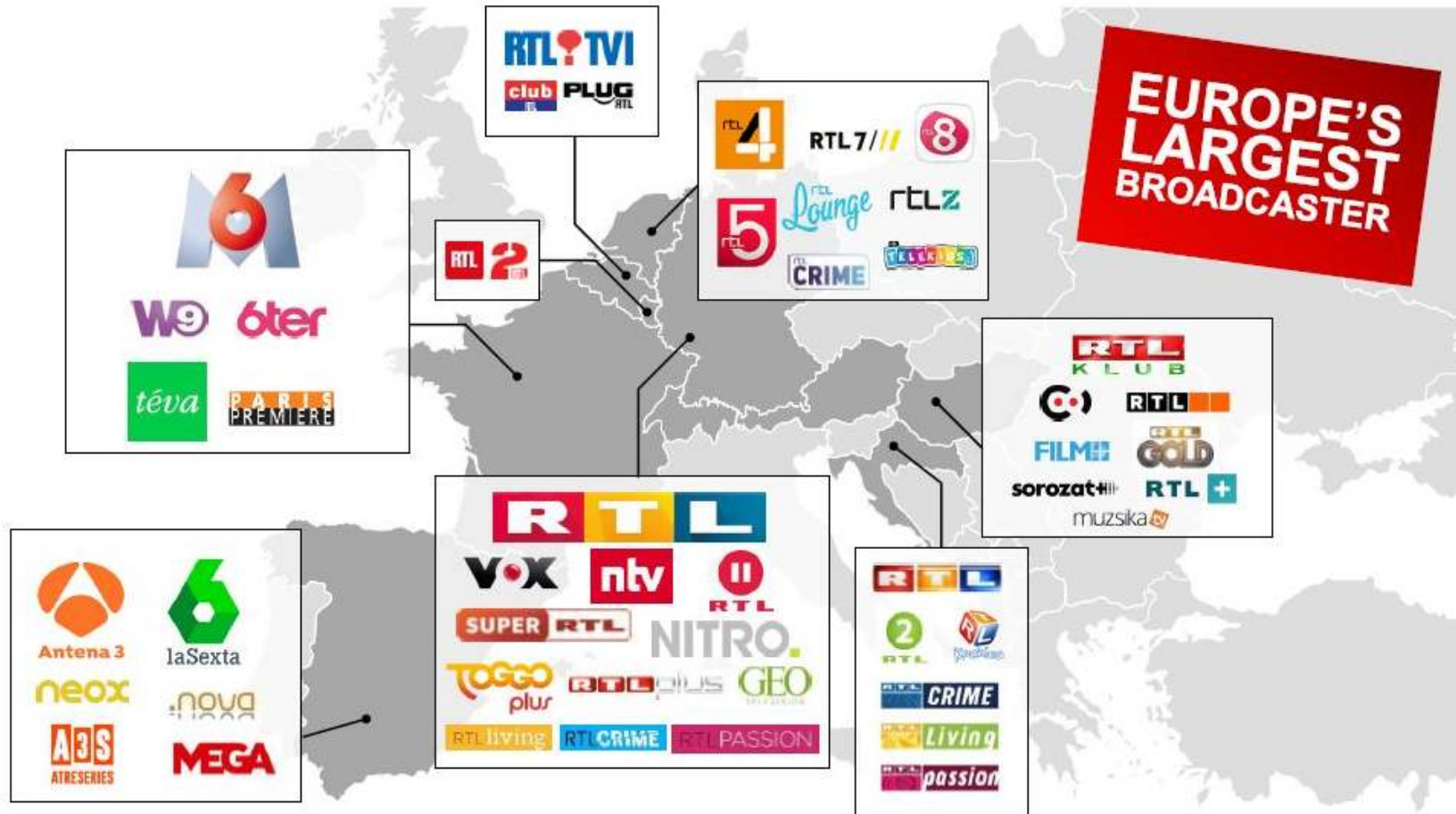


Radio-Luxembourg

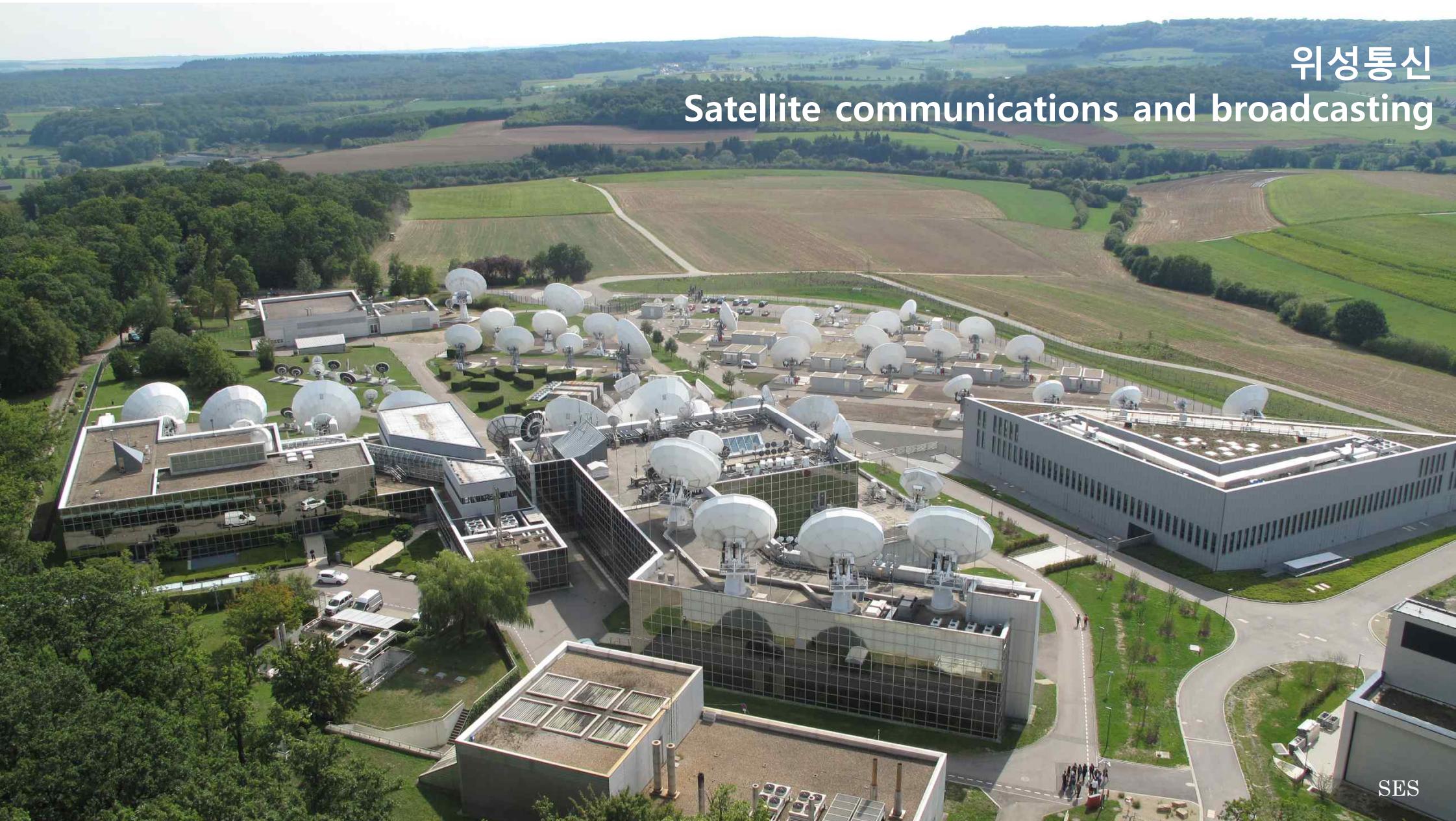
Poste d'émission de Junglinster

Vue extérieure

# 57 TV channels



위성통신  
Satellite communications and broadcasting



금융

Financial business

European  
Investment  
Bank



경제부총리

Deputy Prime Minister for Economy



H-K Moon



EXPLORING  
NEW FRONTIERS



LUXEMBOURG  
SPACE  
CLUSTER

**DRAFT LAW**  
ON THE EXPLORATION AND  
USE OF SPACE RESOURCES



# LUXEMBOURG LAUNCHES SPACE MINING PLAN



S&P ASX ▲ 103.60

THE BUSINESS  
VIEW



# LUXEMBOURG SPACE AGENCY

X SPACE  
EXPERTISE

SPACE  
INNOVATION

X SPACE  
SKILLS





- **Chamber of Commerce**, a professional organisation and public institution encompassing all sectors of the economy apart from agriculture and skilled trades
- **Employment Development Agency (ADEM)**, the country's public employment agency
- **Groupeement luxembourgeois de l'aéronautique et de l'espace (GLAE)**, an industry group for the aerospace sector
- **Institute of Intellectual Property Luxembourg (IPIL)**, an organisation bringing together national and international intellectual property expertise
- **Luxembourg Science Center (LSC)**, a private non-profit organisation whose goal is to generate enthusiasm for science, technology, engineering and mathematics among young people and promote interest in science and technology among the general public
- **Luxembourg Space Tech Angels (LSTA)**, a business angels network helping space start-ups to establish themselves in Luxembourg, providing early-stage funding, mentoring and advice
- **Luxinnovation**, a key partner for companies conducting innovative activities in Luxembourg
- **Luxembourg National Research Fund (FNR)**, the country's main provider of research funding
- **SES**, a global leader in commercial satellite operation, launched in Luxembourg in 1985 as a public-private partnership
- **Société Nationale de Crédit et d'Investissement (SNCI)**, a public-sector financial institution specialising in medium- and long-term financing of investment projects
- **Technoport**, a technology-oriented business incubator that supports innovative young companies in validating their ideas and turning them into commercial reality
- **University of Luxembourg**, the country's public university



GRAND DUCHY OF LUXEMBOURG  
Trade and Investment Office Seoul

 LUXEMBOURG  
TRADE & INVEST

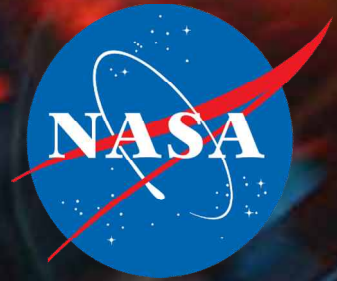
29-10-2018

## 룩셈부르크와 폴란드, 우주활동을 위한 협력 체결

**우주자원**의 평화적인 탐사 및 사용을 촉진하기 위해 룩셈부르크 정부가 2016년에 발족한 **우주자원** 계획(Space resources initiative)은 룩셈부르크를 “**새로운 우주**” 경제의 국제적 핫 스팟이자 매력적인 사업 파트너 국가로 만들었다. 룩셈부르크와 폴란드는 2018년 10월 **우주자원**에 대한 상호협력을 시작하기 위한 양해각서(Memorandum of Understanding)를 체결했다. 룩셈부르크는 이미 포르투갈, 일본, 중국, 체코, 아랍 에미리트와 유사한 협정을 체결한 바가 있다.

비전

**Armstrong's Vision:  
To fly what others only imagine.**



Universal Pictures

# JAXA/ISAS: Missions



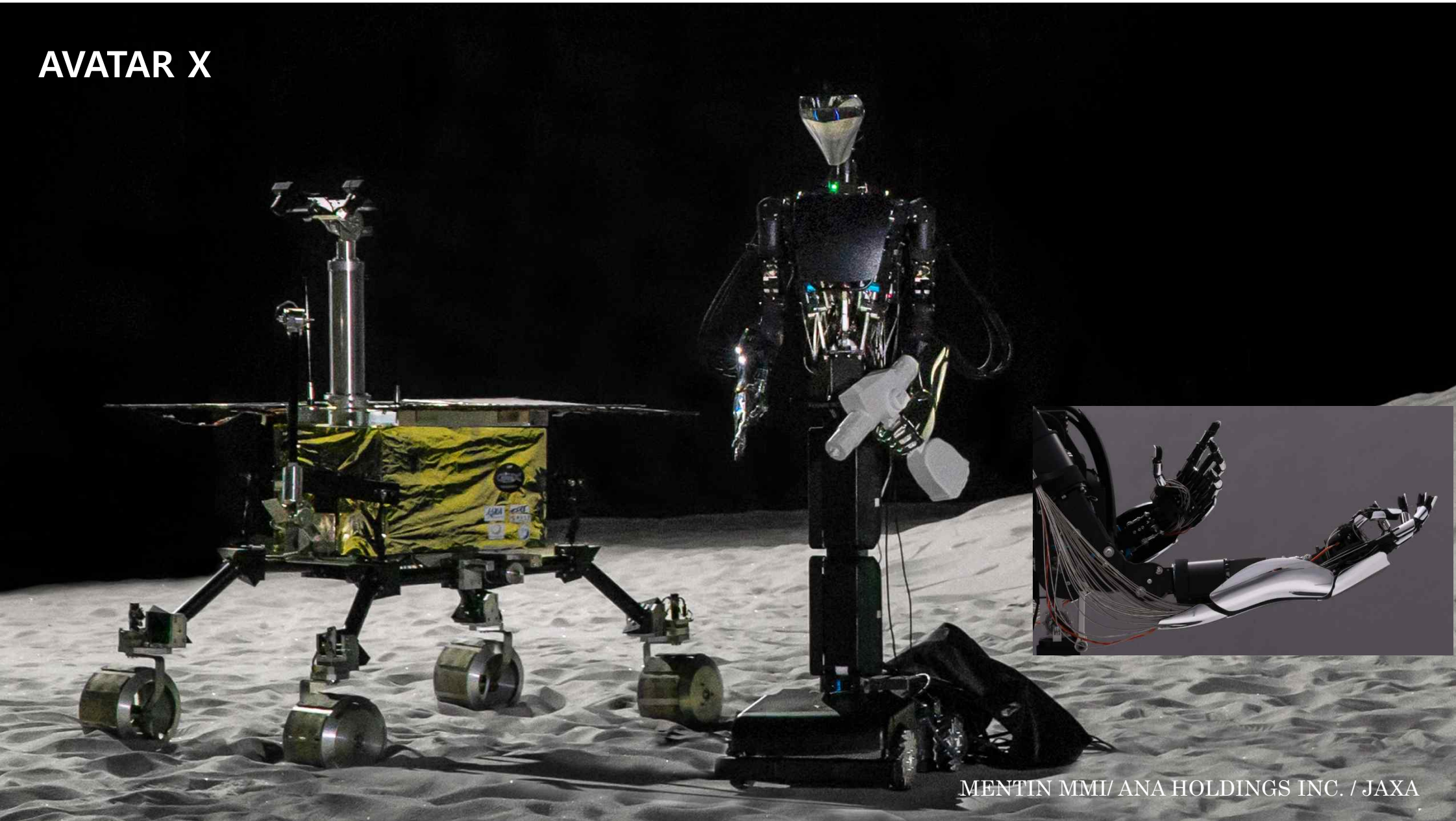
- **To answer fundamental problems of the modern space science** and make them common intellectual properties of the society
- To create and execute **new exploration programs** such as **landing on celestial bodies** like the moon, the Mars and its satellites and **collecting extraterrestrial materials and going back to the earth** through the *close cooperation between science and engineering*
- To continuously develop the space transportation system to execute missions with lower cost and higher frequency
- To sustainably realize space science missions with the **cooperative structure** that universities and research institutes both inside and outside the country work together according to the Inter-University Institute System
- **To cultivate students** to get involved in space development and researches on space science
- To contribute to the space development of Japan including **space utilization**



**Wall Street Journal:** JAXA signed a MoU with ispace to work on building up mining and resource-extraction technologies on the moon that would allow for more extensive space exploration.

**CNBC:** The Japanese government is offering \$940 million to fund space start-ups in a new push to grow the industry, the government announced Tuesday at an event in Tokyo. The funds will be made available through investments and loans over the next five years.

# AVATAR X



MENTIN MMI/ ANA HOLDINGS INC. / JAXA

Bloomberg

**Tom Risen**

■ AEROSPACE AMERICA  
REPORTER

Bloomberg

**JAPAN EXPLORING ASTEROID MINING**



# The Space Probe

Hayya Bn Sa



다시, 한국

## 2. 과학기술정보통신부



~'17      '18~'22      '23~'30      '31~'40

**발사체**

**한국형 발사체**

한국형발사체 개발(~'21)      발사서비스 생태계 육성(~'25)      양산체계 확립(~'30)      해외 발사서비스 시장 진출('31~)

시합발사체      한국형발사체

1차 발사 ('18.10)      2차 발사 ('19.10)      1차·2차 발사 ('21)

소형발사체 이용  
500kg 이하 소형 위성 자력발사 ('25~'30)

대형발사체 이용  
3ton이상 정지궤도·저궤도 대형위성 자력발사 ('30~)

항우연 중심 발사체 기술 확보 ('10~'22)      항우연-민간 공동 발사·기술이전 ('21~'25)      민간중심 국내개발위성 발사 전담 ('26~)

**위성개발**

**우주탐사**

달·소행성 탐사

정지궤도 위성      한반도 상시 모니터링

다목적 실용위성      초정밀 위성영상

차세대 중형위성      국토·기상·산림·수자원

차세대 소형위성      기술검증·과하임무

1단계(~'20)      착수조건 확보      2단계(~'30)      3단계(~'35)

달 궤도선 ('20, 해외발사체)      달 착륙선 (~'30, 한국형발사체)      소행성 샘플귀환선 (~'35, 한국형발사체 개량)

① 한국형발사체 안정성 확보  
② 차질 없는 부품 공급  
③ 선행기술 확보

소행성 귀환 관련 전략기술 조기확보 추진('21~)

1호('19) 국토종합관리용      2호('20)      4호('22) 산림관측      5호('22) 기상관측      3호('23) 발사체 검증용      6호('25) 수자원      추가 19기 (~'30)      추가 43기(~'40)

산업체 책임 개발(차중정 2호~)

1호('18) 기술검증      2호('20) 소형SAR(레이더)      3호('24) 기술검증      4호('26) 소형 SAR(레이더)      5호(미정) 기술검증      6호(미정) 레이저 관측      7·8호(미정) 영상분광기

달 탐사 늦어질 듯

KBS1

7  
KBS NEWS

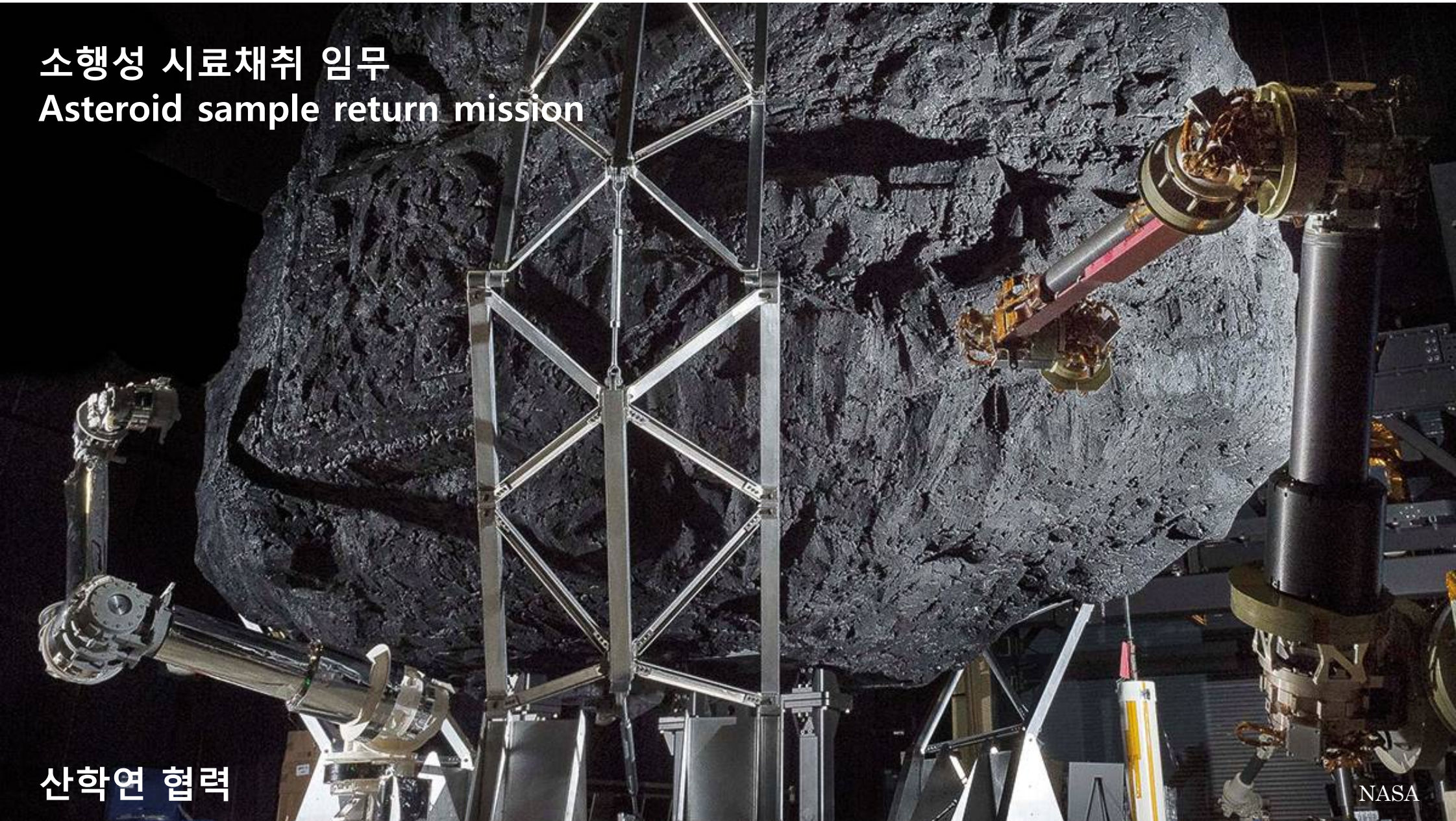
제3차 우주개발진흥 기본계획

KBS

소행성 시료채취 임무  
Asteroid sample return mission

산학연 협력

NASA



## 한국의 우주개발 체계 대분류

1. 우주 임무: "목적 "

Space Mission

M

2. 우주 기술: "수단"

Technology

T

3. 우주 정책: 정책

EducaPolicy

P

# 한국의 우주개발 체계: 중분류

## 1. 우주임무

- 1.1 과학임무
- 1.2 실용임무
- 1.3 유인임무
- 1.4 우주감시

Space **M**ission  
 Science **M**ission  
 Applications **M**ission  
 Human **M**ission  
 Space Situational **A**wareness

NASA-SMD  
 ~NASA-STMD  
 NASA-HEOMD  
 ESA-SSA

M  
 SM  
 AMN  
 HM  
 SA

## 2. 우주기술

- 2.1 선체기술
- 2.2 비행기술
- 2.3 착륙기술
- 2.4 차량기술
- 2.5 건설기술
- 2.6 항행관제

Space Technology  
 Spacecraft **T**echnology  
 Launch and **F**light **T**echnology  
**L**anding Technology  
**R**over Technology  
**H**abitat Technology  
**N**avigation **C**ontrol

T  
 ST  
 FT  
 LT  
 RT  
 HT  
 NC

## 3. 우주정책

- 3.1 장기계획
- 3.2 연구지원
- 3.3 교육홍보
- 3.4 산업정책
- 3.5 국제협력

Education  
 Long-term **P**lan  
 Research **S**upport  
 Education and **O**utreach  
 Space **I**ndustry **P**olicy  
 International **C**ooperation

P  
 LP  
 RS  
 EO  
 IP  
 IC





# 한국의 우주개발 체계: 우주임무

## 1.1 과학임무

1.1.1 천체물리

Science Mission

1.1.2 행성과학

Astrophysics Mission

1.1.3 태양권물리

Planetary Science Mission

1.1.4 지구과학

Heliospheric Physics Mission

1.1.5 탑재기술협력  
소형위성협력

Earth Science Mission

Joint Payload Development

Joint Small Satellite Development

COSPAR-E; NASA-SMD-APD  
COSPAR-B/C; NASA-SMD-PSD  
COSPAR-D; NASA-SMD-SPD  
COSPAR-A; NASA-SMD-ESD  
~NASA-SMD-JASD

SM

APM

PSM

HPM

ESM

JPD

JSD

## 1.2 현업임무

1.2.1 지구관측

Applications Mission

1.2.2 재난감시

Earth Observation Mission

1.2.3 국가안보

Disaster Monitoring Mission

1.2.4 방송통신

National Security Mission

1.2.5 우주측지

Communications and Broadcasting Mission

1.2.6 무인기지

Space Geodesy Mission

1.2.7 우주법

Unmanned Station Mission

Space Law Studies

M

EOM

DMM

NSM

CBM

SGM

USM

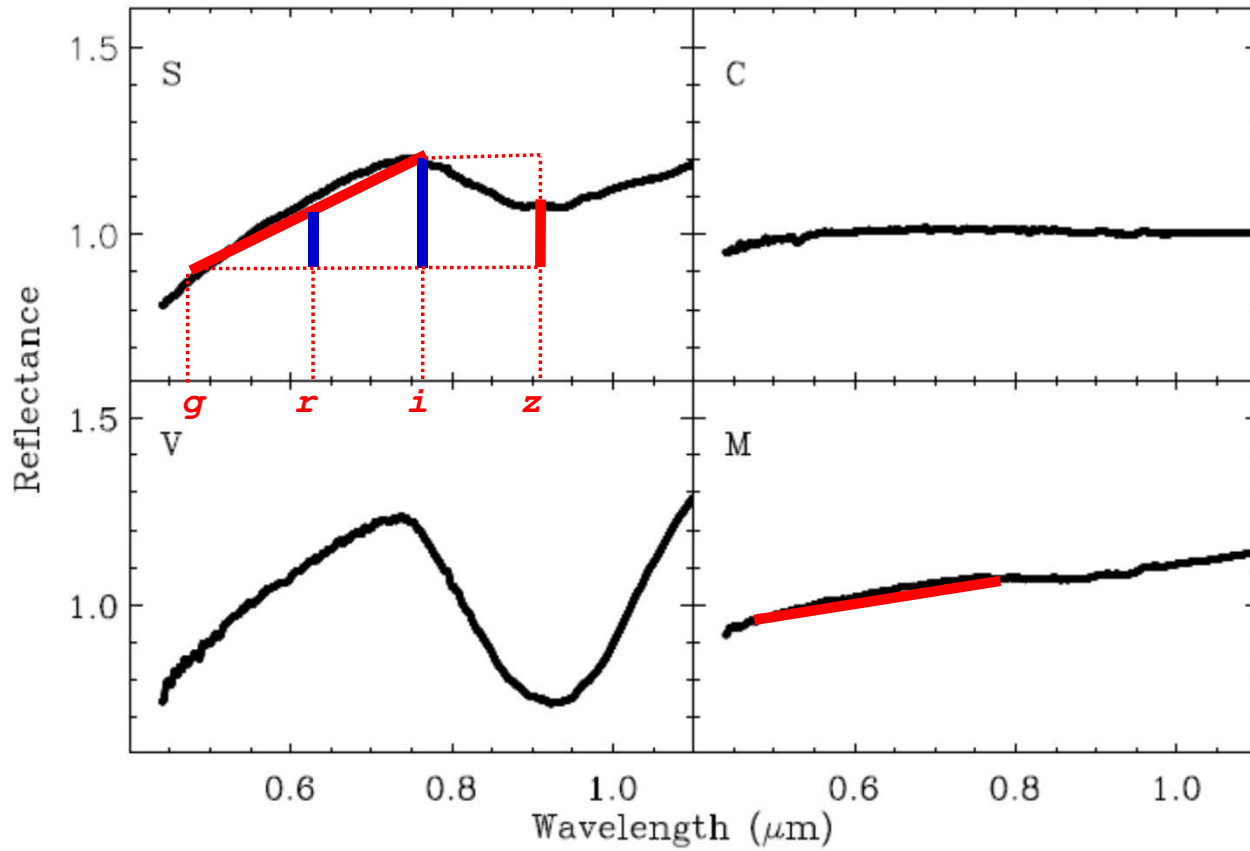
SLS

우주채굴기업  
Space mining companies



# 소행성 물질 분류법

## Asteroid taxonomy based on their visible colors





A LUXEMBOURG SPACE AGENCY study predicts a market revenue of up to **170 billion EUR** generated by the space resources utilization industry over the 2018-2045 period.



LUXEMBOURG  
SPACE AGENCY

## OPPORTUNITIES FOR SPACE RESOURCES UTILIZATION

### FUTURE MARKETS & VALUE CHAINS

Study Summary - December 2018

Interstellar: 2014

INTERSTELLAR

한국 관객: 1019만 명

Paramount Pictures

Martian: 2015

한국 관객: 488만 명

20<sup>th</sup> Century Fox

