



9th ILEWG International Conference on Exploration and
Utilization of the Moon (ICEUM9/ILC2007)



Japan's Lunar Exploration Programme

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Space Exploration Events, This Year

International

- NASA's Lunar Architecture Team Report
- GES framework document agreed
 - GES : Global space Exploration Strategy
- Edinburgh, Kyoto, Spineto, IAC, Houston, Berlin, . . .
 - ESA NEXT selection

JAXA

- JSPEC
 - New JAXA organization established from April, 2007
- Lunar Exploration WG in SAC (Space Activity Commission)
 - long-term strategy for space development and utilization
- Two Phase-A teams were built.
 - SELENE-2
 - Hayabusa-2
- Launch of SELENE ('Kaguya') on Sep. 14th,

KAGUYA (SELENE) Completion of the Critical Phase (October 21, 2007 (JST))

The Japan Aerospace Exploration Agency (JAXA) injected the KAGUYA main satellite in its scheduled orbit and shifted its operation mode to the regular control mode. Both the KAGUYA main satellite and its two baby satellites are in good health.

KAGUYA's critical phase and are now moving to the initial functional verification phase.

Critical phase: a period starting from launch through being ready for initial functional verification including payload separation from the launch vehicle, injection into the lunar orbit, and shift to a regular control mode.

Regular control mode: attitude control method of a satellite with three axis control to observe the Moon's surface by having the observation equipment face the moon at all times.

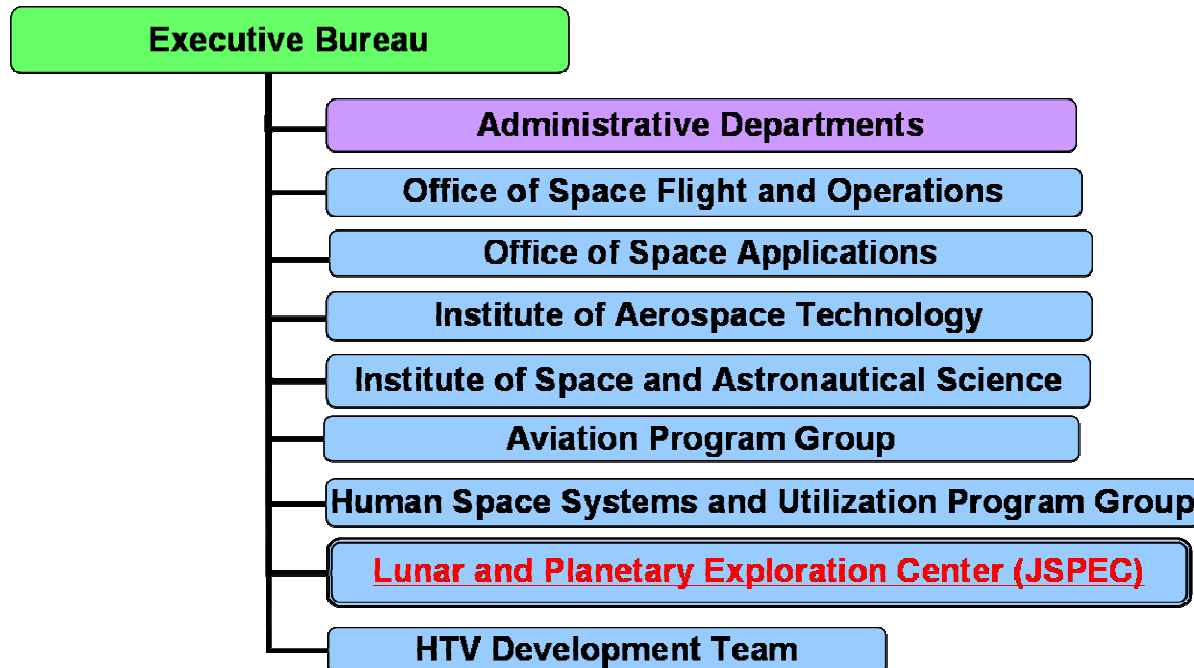


Status Regarding 'Exploration' at JAXA

- JSPEC: AXA built its Lunar and Planetary Exploration Center (JSPEC) this April.
JSPEC is doing not only the moon but planetary exploration encompassing from science to so-called exploration.
- Science WG under SAC (Space Activity Commission, J.gov) concluded and made a recommendation the Japan's Lunar and Planetary Exploration to be performed in Programmatic Manner at a certain interval. (Jan. 2007)
Solar Exploration Road Map was completed.
The Lunar Architecture Study at JAXA was preliminary done.
- Lunar Exploration WG under SAC (Space Activity Commission, J.gov) was established and started the strategic discussion in government level (Sept. 2007), will issue a Report in November.
- JAXA will start its next 5-year plan from 2008.
Any of the projects starting this period needs to commence the Phase-A study now and relevant teams were established.

JSPEC (JAXA Space Exploration Center)

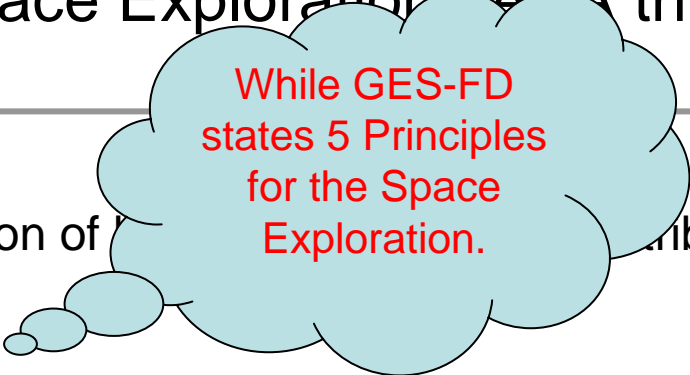
- Elaborate **strategies** of science and technology, **program** planning and promotion of Space Exploration activities through domestic and international collaborations.
- Specific **R&D** activities for engineering and science
- **Development**, operation and other related activities for spacecraft
- **Research** and analysis of scientific and technical aspects for future missions



Principle & Objectives for Space Exploration JAXA thinks

Principle for Space Exploration

Achieve lofty themes such as expansion of human activities and contribute to evolution of civilization.



(1) Strategic & Political Objectives:

- To contribute and sustain to the **nation's economy and industry growth** to commensurate with its position in science & technology,
- To **expand human activities** as a stepping stone to Mars and beyond,
- To **foster human resources** of next generation for science and technologies in future.
- To contribute and formulate international collaboration and framework,

(2) Objectives from Technology and Innovation Point of View:

- To **develop fundamental systems skills** such as landing, return, mobility, etc enabling autonomous and perfectly controllable missions.
- Through the challenges, to **induce technological innovation and to promote spin-offs** so as to bring welfare and evolution to society.

(3) Objectives from Science and knowledge point of view :

- To **lead the top science, and to obtain new knowledge**, and to contribute for the creation of new culture,
- To investigate the environment **for full scale manned exploration to the moon and beyond.**

Exploration or Science ?

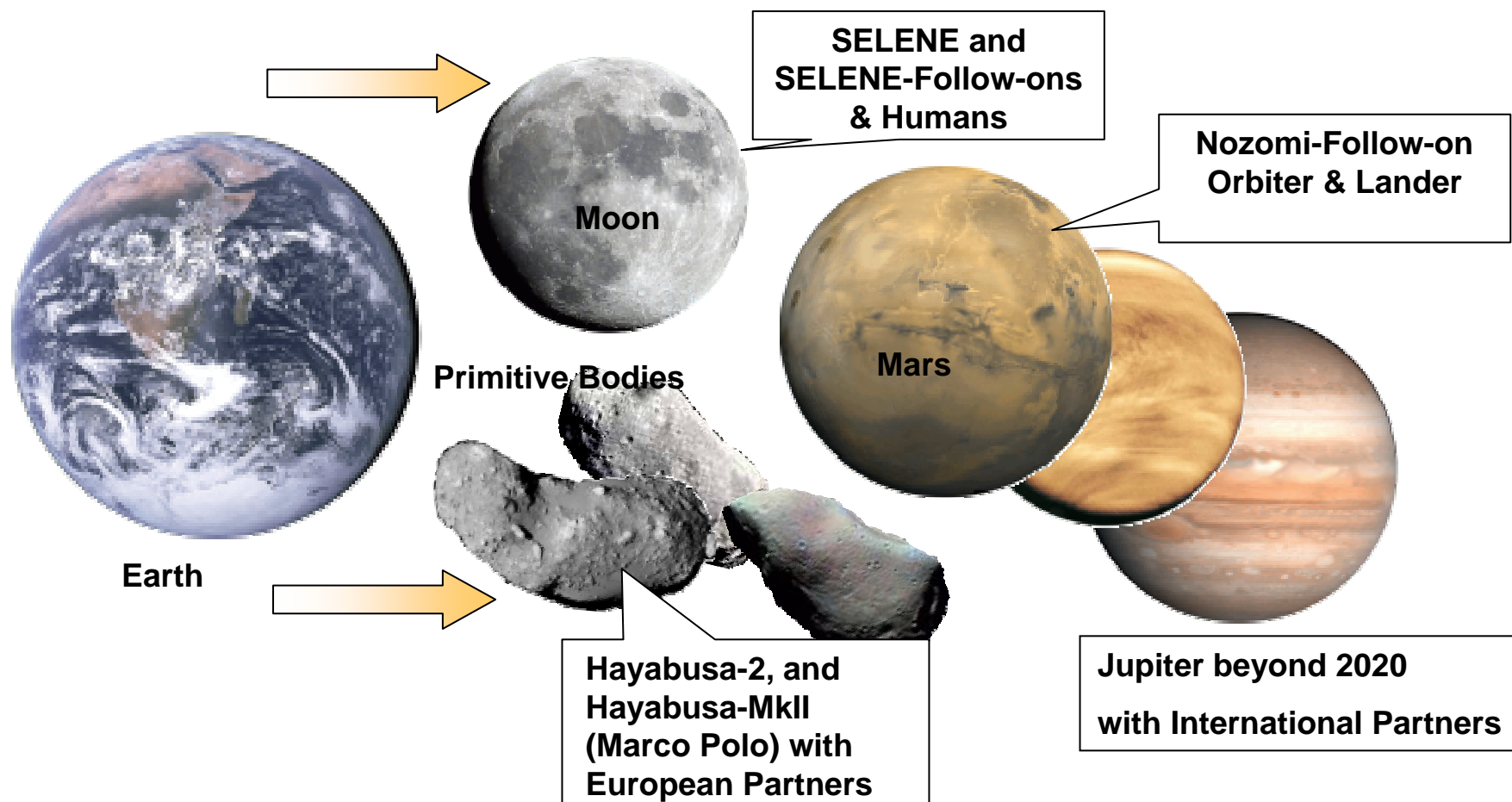
- JSPEC/JAXA looks at both Exploration together with Science Missions for Lunar & Planetary Destinations.
- JAXA's Exploration includes :
Moon, Mars and NEOs,
Plus
Primitive Bodies, and Atmospheric, Plasma and
Surface Missions.
- JAXA intends to contribute to coordination bridging
between Exploration and Science.
Through ECG-GES team activity among agencies.
with existing IMEWG, ILEWG, COSPAR....

JSPEC/JAXA Initiative for Solar System Exploration

Concentrates to:

Primitive Bodies Exploration, and
Planetary Environmental Exploration

Putting each Mission in Programmatic way every several years.



JAXA's Lunar Exploration Strategy

Lunar Exploration Program : leading to International Cooperation, Discovery and Innovation

- Robotic Lunar Missions:
Until the middle of 2010s, in-depth scientific measurements and utilization.
- Human Lunar Missions:
Autonomous missions with its own objectives, making use of humans related technologies.
Pursuing the Japanese astronaut on the moon as early as possible in international activity to commensurate with its international status.
Lunar Surface activity by Japan's own space systems awaits for the governmental decision in the middle of 2010s.

Robotic Lunar Missions concentrate:

- Untrodden, New Missions.
- Establish Technology Means to contribute international efforts.

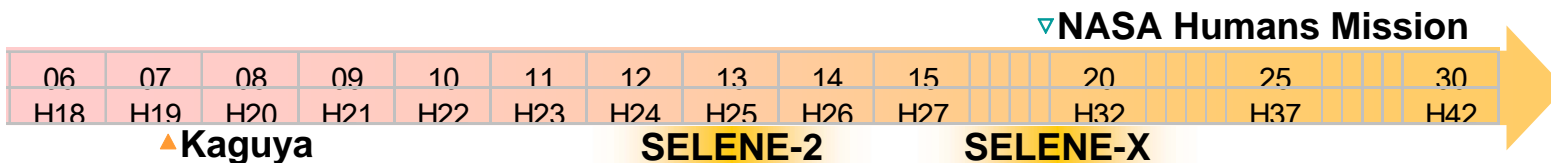
Human Lunar Missions concentrate:

- The Japanese astronaut on the surface for human in-situ operations, to distill experience for further destinations.

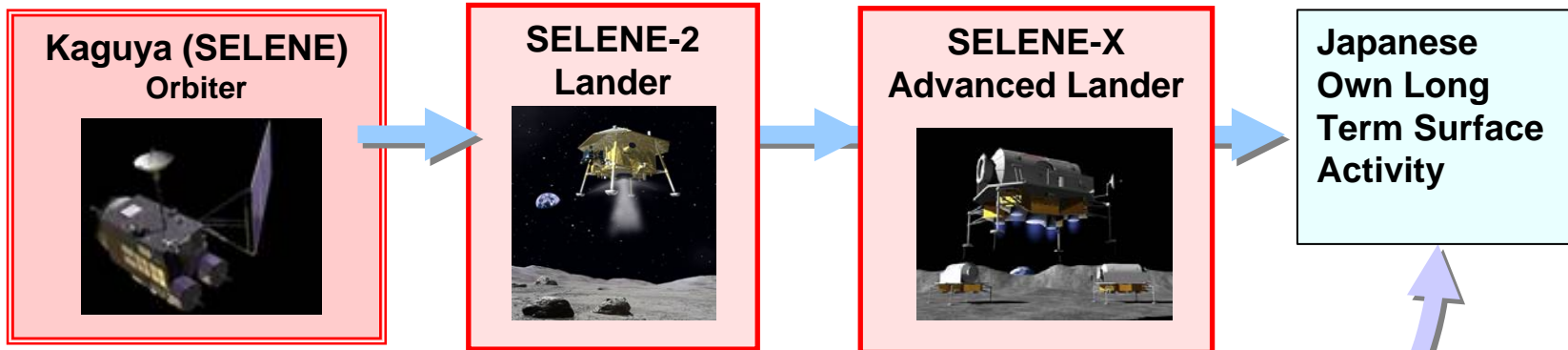
**Robotic Lander
for Surface Exploration**

**Japanese Astronaut on the Surface
among International Crews**

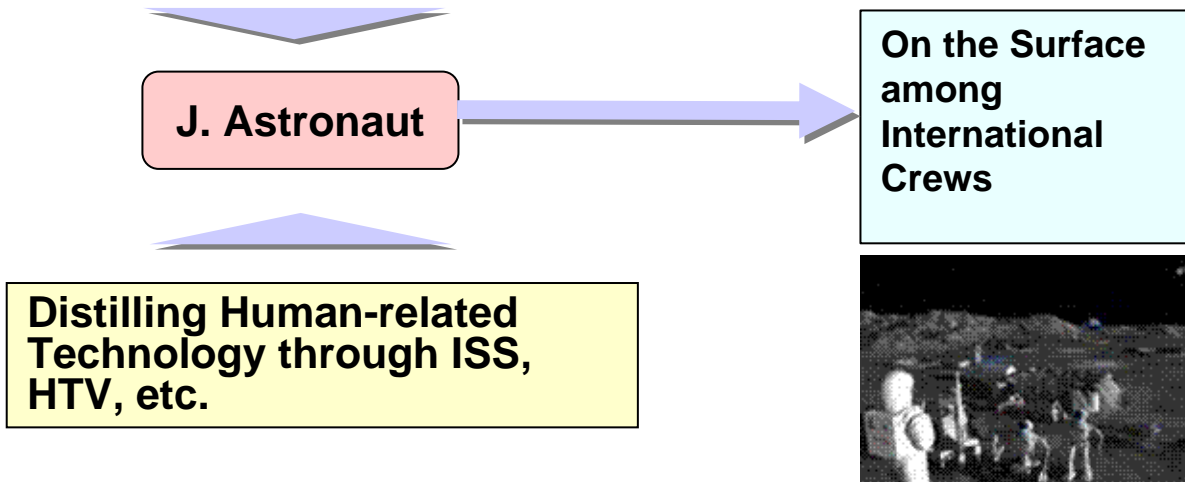
JAXA's Lunar Exploration Roadmap



■ Robotic



■ Human



Overview of JAXA Lunar Exploration Program

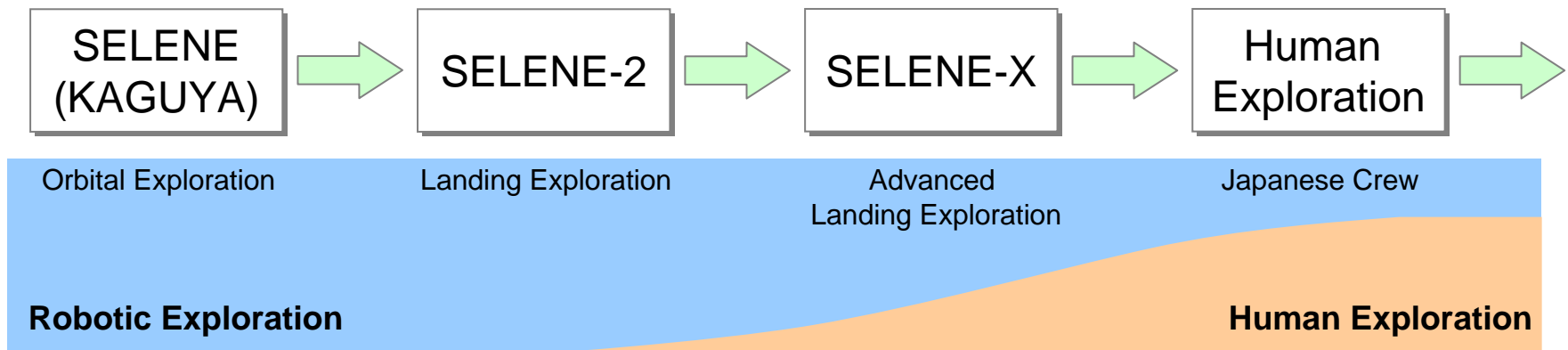
Robotic Lunar Exploration

- Up to the middle of 2010s, science observation and utilization study shall be done thoroughly by robotic mission.

Human Lunar Exploration

- In order to commensurate with its international position and to send Japanese astronaut to the moon, foster human space technologies through JEM and HTV projects.
 - Decision will be required shortly for participation of Japanese crew to the international human lunar exploration.
 - For independent human lunar exploration, seek for political decision in an appropriate timeframe.

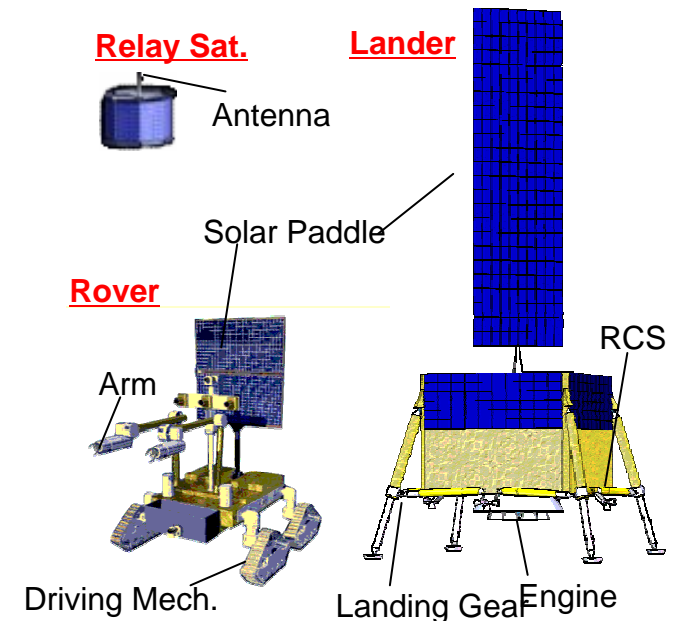
Steps of Lunar Exploration



SELENE-2 (plan)

Japan will intensify its first robotic mission to the lunar surface

- Launch : 2012-14 by H2A (or H2B) rocket.
- Total spacecraft mass :
4000 - 2000 kg (Wet)
- Lander including rover (ca 100 kg) :
500 -1,000 kg (Dry)
- Orbiter for communication relay (TBC)
approx. 100kg
- Landing area
such as Quasi- eternal sun-lit area
in polar region, or some other
locations
- Mission life (Lander)
one month at least



Now Phase-A Study started.

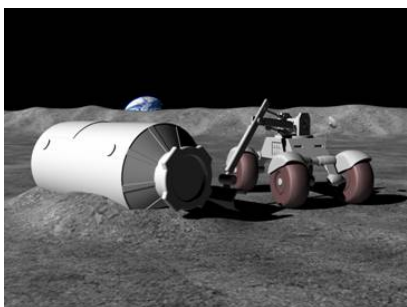
SELENE-X Under Study (Examples) Bridging to Humans Exploration

Appears in late 2010s, in view of the Japan's participation in Humans Lunar Activity foreseen:

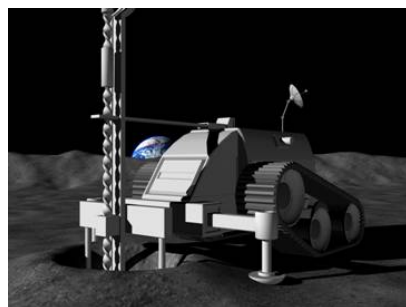
SELENE-X may perform either of the following demonstrations.

- Option-1 : Technology Demonstration for Building Outpost
Excavation, ... Construction of Infrastructure
- Option-2 : Logistics Capability Demonstration
Building Common Landers for both Transportation and
JAXA's own robotic missions.
- Option-3 : Highly sophisticated In-situ Robotic Lander
or Returning Sample of the Surface Soil to the Earth,
including the Development of High Speed Reentry Capsule.

Excavation



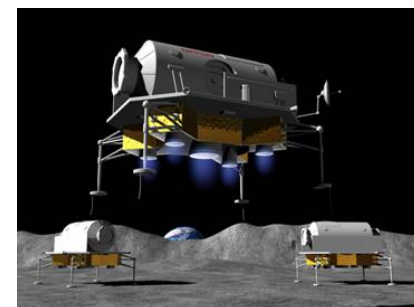
Drilling



Logistics



Common Landers



Japan's Humans Lunar Mission (2020 or beyond)

Global space exploration Direction

- Humans Lunar Exploration and to the Mars and beyond.
- Humans exploration is a fundamental character toward the lofty expansion of its sphere of activity toward advancing the culture.

Significance of Human Exploration

- An **ultimate in-situ operation and observation** beyond robotic capability,
- Japan shall make its **active contribution** to acquiring the human related technologies,
- And shall play a key and **appropriate Governance role** in lunar exploration.

Japan's policy as to the Humans Lunar Mission

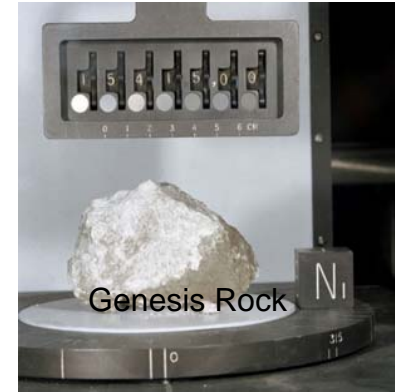
- Having an astronaut be present on the surface as an international crew member,
- And may start its independent humans lunar mission if the government acknowledge and identify its significance.
- Toward it, Japan will nurture and accumulate human-related technologies through JEM/ISS and HTV.

Ultimate Human's Capability Examples

Genesis Rock (Apollo 15)

The Genesis Rock proved to be a chunk of anorthosite, part of the original lunar crust and older than any Moon rock previously found. This one rock helped revolutionize ideas about lunar formation, and gave us new insights into the age of the solar system.

For the first time, the astronauts were extensively trained as geologists and could make scientific observations, both on the surface and from orbit.



Seatbelt Basalt (Apollo 15)

As they were driving along Scott spotted a piece of basalt that looked different to anything around it and decided to pick it up for the collection. It was sitting out there, all by itself with no other fragments around. Very vesicular; very black and rounded. Scott felt, "That one, I could not pass up. It was just too different." Knowing Houston would not agree to their stopping to pick it up, they pretended they were having trouble with their seatbelts, when in actual fact Scott had stopped the Rover to pick up the sample. It was a scoriaceous basalt with lots and lots of vesicles, or bubbles, and was nicknamed the 'seatbelt basalt.'

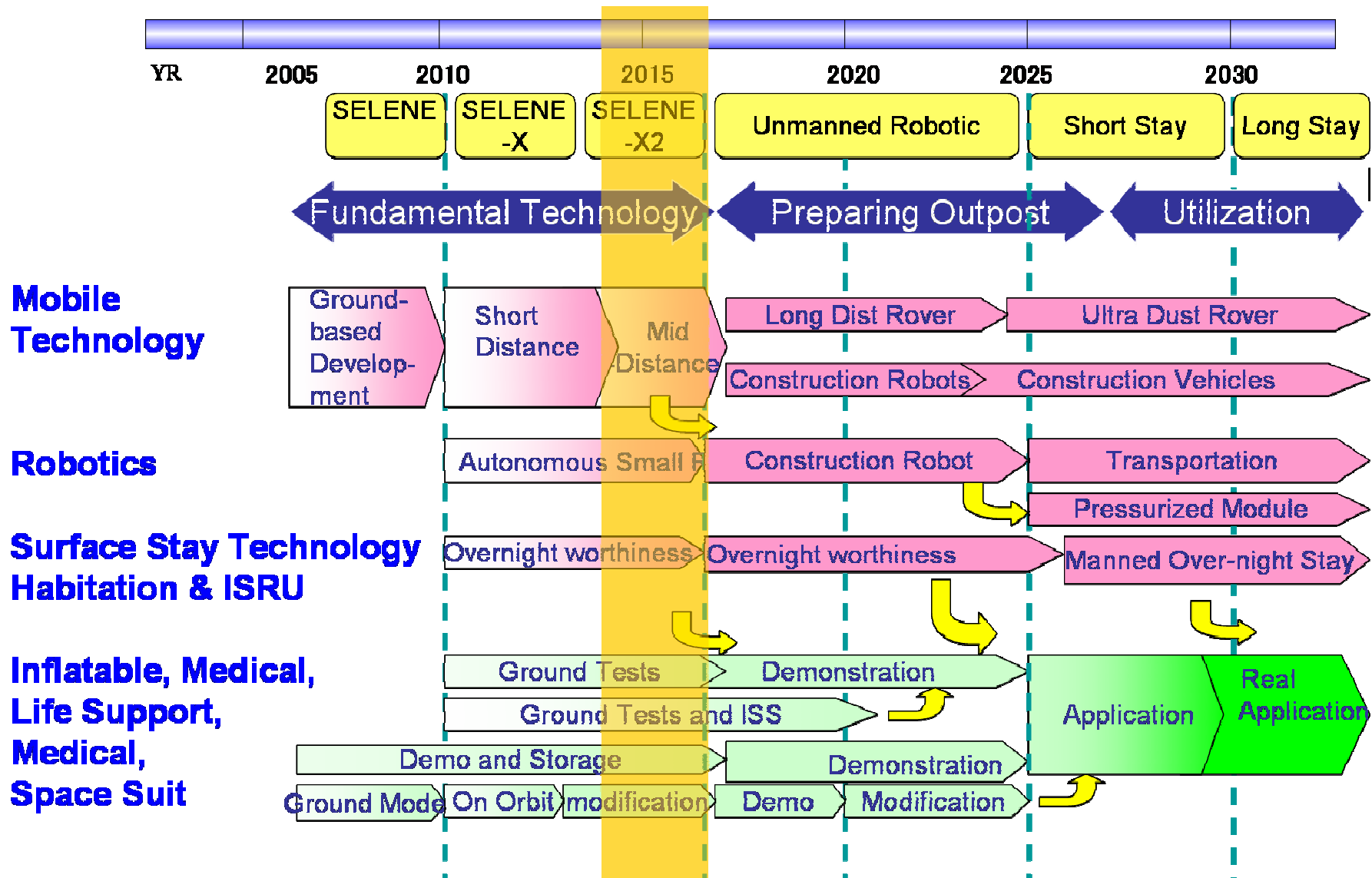
Orange Soil (Apollo 17)

Scientist-Astronaut Harrison J. Schmitt discovered the orange soil at Shorty Crater. The orange soil is probably of volcanic origin and not the product of meteorite impact.



Orange Soil

JAXA's Technology Development Roadmap for Moon



ICM (International Coordination Mechanism) Organizational References

- 1) GEOSS type - A Certain Binding
Program of Programs (System of Systems)
Permanent Secretariat
Earth Observation fits for this. Regional Responsibility.
- 2) Conference type - No obligation. No binding.
Joint Statement. Weak.
- 3) COSPAR / IAA / IACG type - Less binding.
Indication via Resolution.
Recommendation to Member Countries & Organization. Weak?
- 4) ISS type - Legal Binding
Single Program, Not welcome?
- 5) CCSDS type - No obligation. Bottom-Up approach.
Merit-driven Binding. No resource flow is assumed.

JAXA's Role in ECG ('Exploration Coordination Group')

- JAXA will host next Exploration ECG-GES meeting next January (Jan. 15-17) in Okinawa, Japan.
- It accompanies the IPEWG (International Primitive Bodies Working Group meeting) and the discussion on the Data Archiving, Sharing and Distribution mechanism (Discussing how science data in Exploration are archived and accessed to scientists community, in relation to IPDA activity.)
- JAXA has proposed a 'Code-Share Payload' concept among the agencies, and it will encourage the payload opportunities exchanged among agencies.

JAXA welcomes Collaborative Missions with International Partners for Lunar & Planetary Exploration missions.

Summary of JAXA Lunar Exploration Strategy

1. Principle of Lunar Exploration

- Strategic Objectives including international contribution, attributing Japan's sustainable evolution, and education of next generation.
- Technology development and innovation
- Science and knowledge

2. SELENE & SELENE-follow-on Program

Up to the middle of 2010 decade, technology demonstration, science observation, investigation for utilization will be thoroughly done by robotic exploration program, "SELENE series".

3. Foster Human Exploration Technologies

Key technologies for human exploration will be developed and demonstrated gradually through SELENE series, ISS/HTV, etc.

4. Japanese Astronaut participation

As a leading country in lunar exploration and space development, participation of Japanese Astronaut in the international human lunar exploration is strongly craved.

Now JAXA started its Phase-A Study for SELENE-2, leading a new Luner Robotic Exploration Era.

Summary of Strategy

1. Principle of Lunar Exploration

Political Objectives including international contribution, attributing Japan's sustainable evolution, and education of next generation.

Technology development and innovation

Science and knowledge

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Solar System Exploration Road Map

▼ Hayabusa

Hayabusa			Hayabusa-2										Hayabusa Mk-II						
03	04	05	06	07	08	09	10	11	12	13	14	15		20		25		30	
H15	H16	H17	H18	H19	H20	H21	H22	H23	H24	H25	H26	H27		H32		H37		H42	


Primitive Body Exploration

PLANET-C
ソーラ電カセイル

BepiColombo

Jupiter combined probe

Hayabusa
Sample Return S-type asteroid



■ 小型実証機

ソーラ電カセイル


7つの世界初の工学実証機



Hayabusa-2
Sample Return C-type asteroid



Hayabusa Mk-II
Sample Return
CAT/D/P-type asteroid



Planetary Environment Measurement

NOZOMI
Martian Orbiter



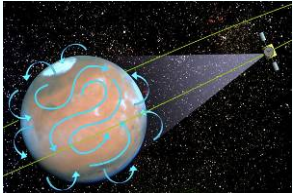
PLANET-C
Venus Climate Orbiter



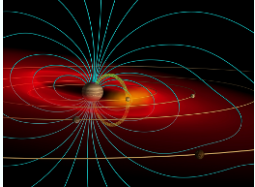
BepiColombo
Mercury exploration ESA and JAXA



PLANET-X
Next Martian Orbiter



Jupiter combined probe
International Joint Mission



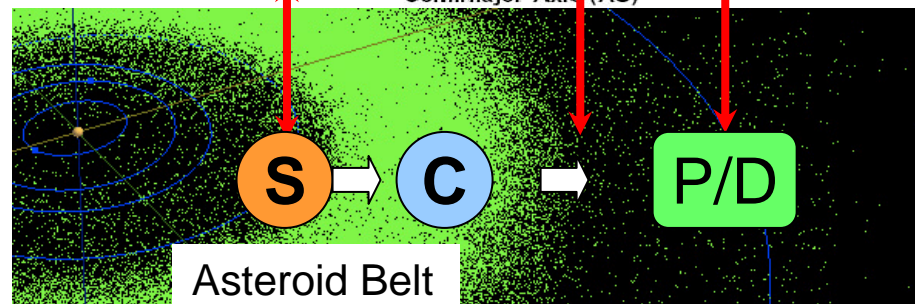
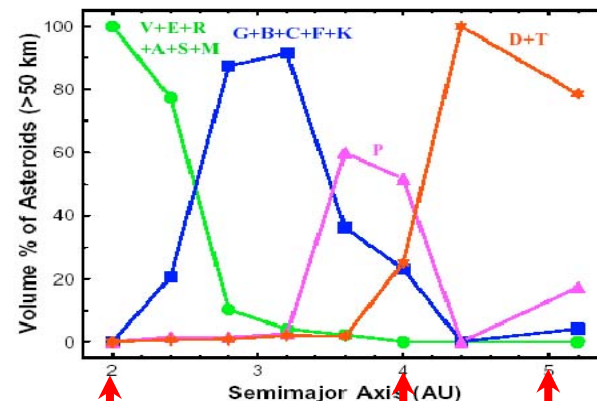
Hayabusa-2: Sample Return from Primitive Body

Hayabusa-2:

- Primitive body exploration
 - Programmatic follow-on of Hayabusa
 - from Type-S to Type-C
 - Hayabusa-Mk2 for Type-P,D
 - from asteroid belt
- Sample return
 - from type-C asteroid 1999 JU3
- Window 2010-2012
- Possible Missions for
 - Science
 - Human exploration
 - Earth protection
 - In-situ resource utilization
- International collaboration based on JAXA's experience

start of Phase-A team

**Mission of
unique &
autonomy**



KAGUYA releases VRAD satellite.

"OKINA" and "OUNA" were selected as the nicknames

- The lunar explorer "KAGUYA" (SELENE) released one of its onboard baby satellites, the VRAD satellite, at 1:28 p.m. on Oct. 12 (JST).
- "OKINA" and "OUNA" were respectively chosen as nicknames for the Relay satellite and the VRAD satellite in relation with Princess KAGUYA from the Japanese old tale "Taketeri Monogatari" (The Tale of the Bamboo Cutter.)

Before Separation



After Separation



Lunar Exploration WG in SAC

Japan's governmental Lunar Exploration study status

Space Activities Commission (SAC)

- Japan's long-term strategy for space development and utilization for next decade
- JAXA's next mid-term plan will start from 2008

Lunar Exploration WG under SAC

- Define Japan's lunar and planetary exploration
 - Position in Japan's long-term strategy for space until Oct.
 - Mid-term target and plan for exploration
 - International collaboration and cooperation
- Stakeholders from
 - Science, Technology, Politics, ...

Possible International collaborations and benefit

1. Obstacles against space exploration

- Cost

- Safety (for human space exploration)

- Legal agreement

 - ⇒ International collaboration and cooperation is needed to overcome these obstacles

2. Possible International collaboration

- identification of standards to promote interoperability;

- identification of methods for sharing scientific data and related analyses;

- common services, allowing for the development of shared infrastructures;

- mechanism(s) to allow the provision of payload opportunities;

What Kaguya (SELENE) is.

Kaguya (14th Sept. 2007 10:31:01)

- Largest Moon Orbiter after Apollo

- Missions :

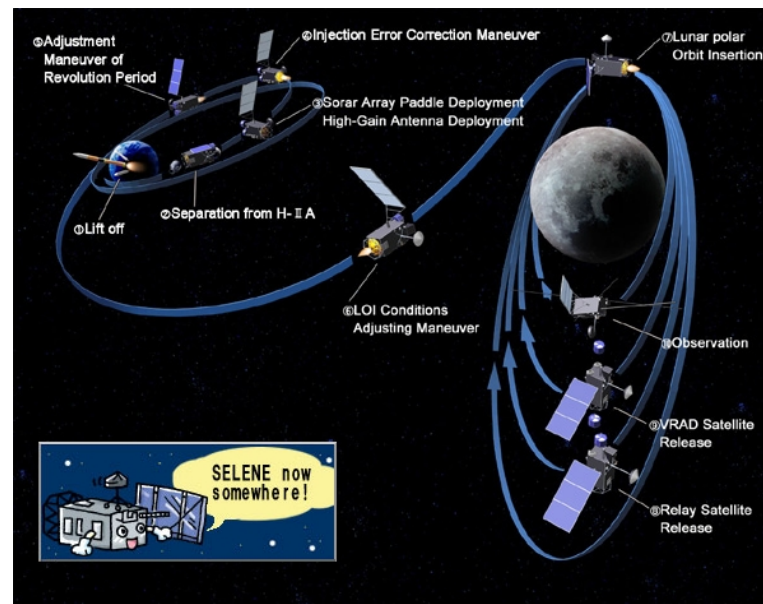
- **Origin & Evolution :**

- ✧ Global Map of Lunar topography, gravity, soil, material, magnetics, sub-surface structure

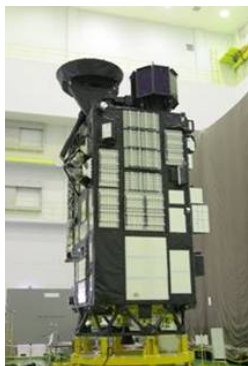
- **Lunar orbiter :**

- ✧ Guidance & navigation, thermal control, and so on

- **Data for future lunar lander**



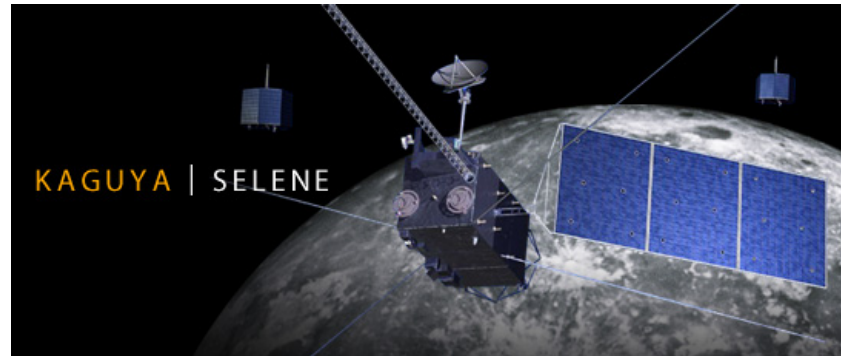
Mission sequence of Kaguya



Kaguya at Tanegashima



Launcher H-IIA 13



KAGUYA Flight Schedule Ahead

Event	Date	Time
Completion of the initial checkout and regular observation start.	Mid-December	
Injection into the regular observation orbit and initial checkout of the bus and mission equipment.	Early November	
Injection into the lunar orbit which is the regular observation orbit (at an altitude of 100 km)	October 19	
VRAD satellite separation	October 12	
Relay satellite separation	October 9	
Lunar orbit injection maneuver (LOI1)	October 4	
Period Adjustment Maneuver	September 19	

14 (15) Instruments Aboard

- ▣ X-ray Spectrometer (XRS)
- ▣ Multi band Imager (MI)
- ▣ Terrain Camera (TC)
- ▣ Laser Altimeter (LALT)
- ▣ Charged Particle Spectrometer (GPS)
- ▣ Radio science (RS)
- ▣ Four way Doppler measurements by Relay satellite and Main Orbiter transponder (RSAT)
- ▣ High Definition Television (HDTV)
- ▣ Gamma Ray Spectrometer (GRS)
- ▣ Spectral Profiler (SP)
- ▣ Lunar Radar Sounder (LRS)
- ▣ Lunar Magnetometer (LMAG)
- ▣ Plasma energy Angle and Composition Experiment (PACE)
- ▣ Upper-atmosphere and Plasma Imager (UPI)
- ▣ Differential VLBI Radio Source (VRAD)