JAXA Status of Exploration and Human Space Program

November 14, 2011

Japan Aerospace Exploration Agency
JAXA Space Exploration Center (JSPEC)

Naoki Sato
Outline of Japan’s Space Policy and Organization

Cabinet

The Strategic Headquarters for Space Policy
Head by Prime Minister
Deputy by Minister of State for Space Policy

Cabinet Office
Council for S&T Policy (CSTP)

Ministry of Education, Culture, Sports, Science and Technology (MEXT)
Space Activities Commission (SAC)

Ministry of Internal Affairs & Communications

The Space Basic Law (Aug. 2008)
The Space Basic Plan (June 2009)

Japan Aerospace Exploration Agency

JAXA Mid-term Plan
JAXA Organization and Activities

President

Executive Directors

Policy Coordination

Admin. Management

Technical Management

- Space Transportation Mission Directorate
- Space Applications Mission Directorate
- Human Space Systems and Utilization Mission Directorate
- Aerospace R&D Directorate
- Aviation Program Group
- Inst. of Space & Astro. Science
- Lunar & Planetary Exploration Program Group

(Tsukuba) (Chofu) (Sagamihara)
Space Basic Plan

[System] Satellite Applications System
- Land, Sea Observing Satellite contributing to Asian Region
- Earth Environment, Weather Observing Satellite
- Advanced Communication Satellite
- Positioning Satellite
- National Security Satellite

[Program] Research & Development Program
- Space Science Program
- Manned Program
- Space Solar Power System (SSPS) R&D Program
- Satellite Technology Demonstration Program

Calls for one year study of Japan’s strategy for lunar exploration by robotic and possibly human
Overview of one year study of Japan’s strategy for Lunar Exploration

- Objectives:
  - Clarify the exploration objectives and roadmap for technology development
  - Propose concrete plan for robotic lunar exploration for science and utilization, foreseeing manned lunar exploration afterward.
  - Establish the strategy for international cooperation

- Study group was organized under the Minister of state for Space Policy in August 2009 and completed the activities in July 2010.
  - Members: Reps. from industry, jurist, academy, astronaut, sociologist, etc

- A report was published and also was translated in English. (available upon request)

- Still need budget requests to implement the proposals in the report in the yearly budgetary cycle.
Robotic Exploration

Proposed Approaches:
- 2015: First lunar landing and short-term investigation
- 2020: Assembly of the base, long-term investigation and sample return
- Demonstrate leadership in the international collaboration

Images of robotic exploration in 2015 (SELENE-2)

Images of robotic exploration in 2020 (SELENE-X)

Image of soft landing

Image of sample return

Image of one of the candidates for landing point

Image of the moon's inner structure investigation by seismometers and so on

Image of an exploration base near the south pole and a lunar robot

Image of collecting rocks
Human Space Activity

Proposed Approaches:

- Research and development of basic technologies for human transportation system by around 2020
  - Safety enhancement of rocket engine
  - Emergent escape technology
  - Human rated re-entry technology
  - Environment Control and Life Support technology

- Efficient technology development leveraging other space activities such as
  - Robotic lunar exploration
  - H-IIA/B launch operation
  - ISS utilization and operation for technology demonstration

- International cooperation is mandatory for human space exploration
JAXA’s Roadmap and Current Project Status
JAXA’s Roadmap for Space Exploration

- **Robotic Lunar Exploration Mission**
  - 2007~2009: KAGUYA (SELENE) Orbiter
  - 2016~: SELENE-2 Lander & Rover
  - 2020~: SELENE-X Advanced Lander for South Pole missions
  - Participation in international lunar exploration missions with Japanese crew

- **Human Lunar Exploration Mission**
  - Acquisition and Development of Human-related basic technology through the operation and utilization of ISS, HTV, etc.

- **Primitive Body Exploration**
  - 2003~2010: HAYABUSA (MUSES-C) Sample return S-type asteroid
  - 2010: IKAROS (Small Solar Power Sail) World first solar power sail
  - 1998: NOZOMI (PLANET-B) Japan first Mars explorer
  - 2010: PLANET-C World first Venus Climate Orbiter
  - 2010: HAYABUSA-2 Sample return C-type asteroid
  - HAYABUSA-Mk2 Sample return D-type asteroid
  - BepiColombo Mercury exploration ESA and JAXA
  - MELOS Next Martian Orbiter
  - MELOS Jupiter and Torojan asteroids exploration International Joint Mission
  - Robotics exploration for further expansion of frontier

Bold blue squares show the projects conducted.
ISS Japanese Elements and Astronauts’ Flight Plan

Kibo Assembly

- 1JA: 2008.3
- 1J: 2008.5
- 2JA: 2009.7

HTV1 2009.9

HTV2 2011.1

HTV3

HTV4

HTV5

HTV6

HTV7

“KIBO” Operation and Utilization

“Doi” (1JA)

“Hoshide” 1J

“Wakata” Exped. 18-20 Crew

“Noguchi” Exped. 22, 23 Crew

“Furukawa” Exped. 28, 29

“Hoshide” Exped. 32, 33 Crew

“Wakata” Exped. 38, 39 Crew/Commander

“Yamazaki” STS-131

---TBD

---TBD
**SELENE (Kaguya)**

**Mission Objectives:**
The major objectives of the KAGUYA mission are to obtain scientific data on lunar origins and evolution, and to develop the technology for future lunar exploration. The scientific data will be also used for exploring the possibility of future utilization of the Moon.

**Mission Profile:**
- **Launch:** Sep. 2007
- **LOI to 100km:** Oct. 2007
- **Landing (Hard):** Jun. 2009

![High Definition TV image](image1)

![Internal view of Shackleton crater](image2)

- Global gravity distribution
- Global terrain map
- Global illumination map
HAYABUSA
- World 1st Sample Return from Asteroid -

Launch in 2003

Arrival in 2005

Return to Earth in 2010

JAXA
**HAYABUSA**
- Current status of curation activity -

- Samples were collected by a special spatula in the Curation Facility in Sagamihara.
- Scanning Electron Microscope (SEM) observations and analyses (up to Nov. 2010)
  - About 1,500 grains were identified as rocky particles.
  - Most of them were judged to be of extraterrestrial origin (Asteroid Itokawa).
IKAROS
(Interplanetary Kite-craft Accelerated by Radiation Of Sun)

- Solar sailing (thrust by photon) demonstration - COMPLETED
- Demonstration of attitude control by LCD reflection ratio change - COMPLETED

Image from deployed camera
HAYABUSA-2

Target: 1999JU3 (C type)
Launch: Jul. 2014
Arrival: Jun. 2018
Earth Return: Dec. 2020

New Experiment

Sample analysis
Earth Return
Create Crater
Impactor
Further interior exploration
Major Technology Development in JAXA
Human Re-entry and Return

- Thermal protection and lifting flight control of human vehicle during the atmosphere re-entry.
- Slow descent, soft and precision land at the predetermined area of the earth.

<table>
<thead>
<tr>
<th>2010</th>
<th>2020</th>
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<tbody>
<tr>
<td>HTV-R</td>
<td>Tech. Demo</td>
</tr>
</tbody>
</table>

- **Key Tech. Dev. for human return from ISS**
  - lifting flight control
  - thermal protection
  - less toxic thruster

- **Sub-system Dev. for human return vehicle from ISS**
  - safe and precise landing
  - parachute / parafoil

**Past Project**

- Hayabusa
- OREX
- HYFLEX
- HTV-R

**Development of spaceship**

- Human Space Ship (TBD)
**Human Rated Launcher**

- The human safety technologies are key for human launch vehicle.
  - Simple, reliable, and low cost cryogenic engine
  - FDIR (fault detection, isolation & recovery) technologies
  - Launch abort system for emergency escape

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<tr>
<td>Key Tech. Dev. for launch vehicle - High reliability design method - Simplified system integration - Inherent fail-safe cycle rocket engine</td>
<td>Next Primary Launch Vehicle Human Launch Vehicle (TBD)</td>
</tr>
<tr>
<td><img src="image" alt="LE-7A Engine" /> LE-X Engine</td>
<td><img src="image" alt="System Dev. of next primary launch vehicle" /></td>
</tr>
<tr>
<td><img src="image" alt="System Dev. of next primary launch vehicle" /></td>
<td><img src="image" alt="System Dev. of human launch vehicle" /></td>
</tr>
<tr>
<td>Element Tech. Dev. for human launch vehicle - FDIR technologies - Launch abort system</td>
<td></td>
</tr>
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![Image of rocket engines](image)
**ECLSS System**

✓ The regenerative life support system for long habitation requires water recycle and air revitalization with small sized, light-weight and low power consumption.

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<tr>
<td>ISS Tech.Demo</td>
<td>ISS Tech.Demo #2</td>
</tr>
<tr>
<td>Key Tech. Dev. for Air and Water Revitalization - light-weight - low power</td>
<td></td>
</tr>
<tr>
<td>System Dev. for high performance ECLSS - CO2 removal - water recovery - toilet &amp; shower</td>
<td>Human Space Ship, etc (TBD)</td>
</tr>
<tr>
<td>Human System Dev. for Spaceship and lunar exploration - Human spaceship - Human lander - Pressurized rover</td>
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The human orbital transfer vehicle requires high performance in-space propulsion, such as cryogenic in-space propulsion, etc.

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<tr>
<td>Key Tech. Dev. for human orbital transfer</td>
<td>Tech. Demo (TBD)</td>
</tr>
<tr>
<td>- System integration technologies</td>
<td>Human Orbital Transfer Vehicle (TBD)</td>
</tr>
<tr>
<td>- In-space operation technologies</td>
<td></td>
</tr>
<tr>
<td>- Low boil off cryogenic propulsion</td>
<td></td>
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<tr>
<td>- LNG propulsion (TBD)</td>
<td></td>
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<tr>
<td>- Electrical propulsion (TBD)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>System Dev. for human orbital transfer</td>
</tr>
<tr>
<td></td>
<td>- Orbital transfer vehicle</td>
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EVA Suit

✓ The advanced EVA suit requires short preparation period, high workability, and less weight comparing to the conventional EVA suit.

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<td>Key Tech. Dev. for EVA suit</td>
<td>System Dev. for high performance EVA suit</td>
</tr>
<tr>
<td>- light-weight suit</td>
<td>- light-weight ECLSS</td>
</tr>
<tr>
<td>- high movability</td>
<td>- 1/6 g adaption</td>
</tr>
<tr>
<td>- pre-breath-less</td>
<td>Human System Dev. for Spaceship and lunar exploration</td>
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<tr>
<td></td>
<td>- human spaceship</td>
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<td>- human lander</td>
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<td>- pressurized rover</td>
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Human Space Ship, etc (TBD)
The space medicine verifies medical safety technique needed for human presence and establish long duration stay on the lunar surface.

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**Key Tech. Dev. of medicine for human sys.**
- Verification of medical safety technique on ISS
- Medical requirement for long duration stay

**System Dev. of medicine for human sys.**
- Medical requirement for long duration stay

**Focused R&D in space medical**
- Space radiation monitor
- Prevention of bone loss
- Regolith and lunar dust control
- Mental & psychological support
- Telemedicine care, space food

**Human System Dev. for Spaceship and lunar exploration**
- Verification of medical safety technique for long duration stay

**Human Space Ship, Lunar Base, etc (TBD)**
**Human Landing on and Ascent from Moon**

- Safe and reliable landing with hazard avoidance.
- Accurate pin-point navigation for landing.
- Ascending from moon and Earth return technologies.

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<td><img src="image2.png" alt="SELENE-X" /></td>
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</table>
| Tech. Dev. for soft precision landing  
  - navigation sensors  
  - obstacle detection  
  - landing legs | System Dev. for large-scaled landing & ascending  
  - landing on polar region  
  - large-scaled lander  
  - sample and return |
| ![Human Lunar Exploration](image3.png) (TBD) | Human System Dev. for landing & ascending  
  - cargo / human lander  
  - human ascent module |
**Power Technology for Night Survival**

- Provide energy to human elements for long duration including night survival by combining solar power generation, regenerative fuel and Li-ion battery.

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**Key Tech. Dev. for night survival**
- high efficiency battery
- thermal insulation

**System Dev. for night survival power**
- regenerative fuel cell
- high performance solar cell

**Human System Dev. for spacecraft and lunar element**
- Human spaceship
- Pressurized rover
- Lunar habitation module

**Human Lunar Exploration (TB1)**
**Human Surface Mobility**

- Robotic surface mobility requiring traction mechanism, efficient power and communication, navigation and manipulation
- Pressurized rover providing long range mobility and habitation capabilities in addition to mobility.

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| Key Tech. Dev. for mobility & manipulation  
- mobility against rough terrain  
- surface navigation  
- power and thermal control | Human Lunar Exploration (TBD) |
| ![System Dev. for advanced mobile robot](image3.png) | ![Human System Dev. for mobility](image4.png) |
| - long range mobility  
- night survival  
- sample manipulation | - mobile platform  
- exposed rover  
- pressurized rover |