International Human Lunar Mission Architecture / System and its Technologies

2014.4.10
Hiroshi Ueno
Systems Engineering Office(SEO)
Lunar and Planetary Exploration Program Group(JSPEC)
Japan Aerospace Exploration Agency(JAXA)
Human Lunar Access Architecture (1/2)

MOON

Human Robot Coordination
Exploration Phase

LLO
(100 km)

EML Spacecraft

MPCV

Crew Teleoperation

Lunar Lander

Lunar Surface Rover

Sample Robot

Sample Return

Advanced Cargo Supply

H-X+
Launch Vehicle

H-X
Launch Vehicle

SLS

Cargo Supply

ISS

Earth

Human Robot Coordination
Exploration Phase

Sample Return
Logistic Needs for EML Habitation
(Conditions)
• 4 Crews, 50 days stay, 4 EVAs,
• 75% Water Recycle, 80% Oxygen Production,
• 75% Urine Recycle
(preliminary study result)
• Total of 1.8 tons for Crew related, Food, Water, Oxygen, Toilet/Filter Insert, CO2 Removal

Supply Capability of HTV Next Generation
• To provide cargo transport capability to EML spacecraft in addition to ISS
  (preliminary study result)
  • Can carry 1.8 tons to EML2 in case of the launch by H-X Heavy

Advantage of the use of the modified HTV
• Verified and demonstrated system
• Safety proven
• Well known, familiar system to international partners

Modification from HTV
• Addition of Solar Electric Paddle
• Extension of propulsion tank
High Efficiency Cargo Concept to EML by Electrical Propulsion

- **Supply Capability by Electric Propulsion**
  - (conditions)
  - H-X heavy+ Class Launch Vehicle, GTO separation
  - 40kw 2N Hall Thruster, 1.7 ton for Fuel
  - (preliminary study result)
  - 3ton Cargo to EML, 230 days for delivery

- **Characteristics**
  - Longer Delivery Duration
  - Efficient Mass Delivery
  - Possible Transportation of EML Spacecraft to LLO

---

1st Trial Estimation: 12ton
Preliminary sizing

Heritage

Hayabusa2 (2014)
Cargo to Lunar Surface, Human Lander Concept

Cargo to Lunar Surface

- Payload: 1 ton (TBD)

Potential Heritage

Human Lander to/from Lunar Surface

- Payload: hundreds kg

Potential Heritage (from Sample Return and Lunar Cargo)

Next Generation of SELENE
- Safe and Accurate Landing
- Night Survival
- Surface Mobility

Next of the Next Generation of SELENE
- Sample Return and etc.
Lunar Surface System

- **Surface Mobility System**
  - Pressurized Rover For Lunar Exploration
    - Crew Operation
  - Next generation of SELENE
    - Provide Surface Mobility
  - Lunar Exploration from EML Station
    - Crew Teleopration
    - Longer duration and larger area

- **Surface Power System**
  - Power System for Lunar Exploration
    - Night Survival Power
    - Contingency Energy Resources
  - (Potential Candidates) Regenerative Fuel Cell (kW Class)
  - Power System for Robotic Lunar Mission
    - 100W-class regenerative fuel cell
  - Regenerative Full Cell Technology Demonstration at ISS
Rendezvous and Docking in Deep Space

- Characteristics of EML RVD
  - No GPS is available in Hallo orbit
  - No use of approach using orbital mechanics

- Technical Candidate Solution
  - Ground Based VLBI
  - Laser Distance Measurement
  - Optical Navigation

Potential Heritage

Rendezvous and Capture/Berthing at ISS (2009-)
Autonomous RVD Experiment at LEO (1997)
Fuel Station Concept and Cryogenic Propulsion Stage

- Refueling Human Lander Prop at Station
  - Separate Lander and its fuel during Launch
  - Extensity to Re-usable Concept

- Possibility to the type of fuel
  - LO2/LH2, LO2/CH4, Storable

<Technical Challenges>

- Fuel Management and Fuel Transfer under zero G
- High Power System to maintain the temperature of the fuel
Investigation of Human lunar vicinities missions

1. Air Recycle
   - Small, light and low power recycle system
   - Demonstration Object: Performance of CO2 reactor and water electrolysis cell under microgravity without natural convection

2. Water Recycle
   - Processing both urine and condensate water
   - High recovery rate using electrolysis basis
   - Demonstration Object: electrolysis performance under microgravity

3. Radiation Measurement
   - Measure radiation environment necessary for management of crew’s radiation exposure and system maintenance
   - 3D tracking, real-time and simultaneous measurement of Linear Energy Transfer (LET) and absorbed dose
Thank you for your attention

2\textsuperscript{nd} Symposium on International Space Exploration at July 31 near Tokyo in Japan