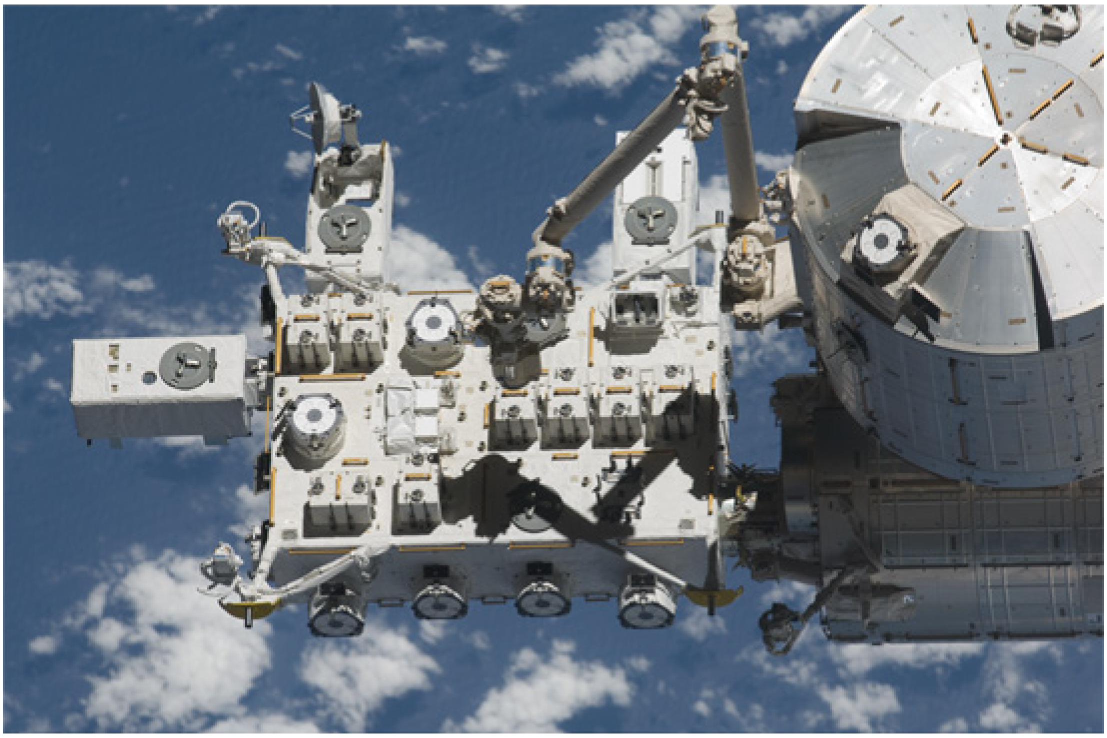
JDX-2012303 NC

Kibo Exposed Facility
User Handbook



September, 2010

JAXA
Human Space Systems Utilization Mission Directorate
Space Environment Utilization Center

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0. Introduction

This handbook provides information of KIBO Exposed Facility (EF) environment, on-orbit and ground services, and guidelines for payloads development for the people who are planning to perform experiments on the EF.

When you start developing EF payloads, please make sure to refer and apply “JEM Payload Accommodation Handbook” and other specification documents. Also, the payloads need to meet interface requirements with JEM systems such as JEM Remote Manipulator Systems and need to clear the Safety Review.

This handbook is written based on the latest information but please double check if the data is the latest when you start developing your payloads. We hope this handbook help you to understand the EF and its services.

September 2010

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Feel free to contact below if you have any questions or comments.

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1. General Information

This section describes the overall summaries about KIBO Exposed Facility (EF) and contact information if users plan to launch their payloads and perform experiments.

1.1 What is KIBO Exposed Facility

The Exposed Facility (EF) provides a multipurpose platform where science experiments can be deployed and operated in the exposed environment. The payloads attached to the EF can be exchanged or retrieved by KIBO's robotics arm, the JEM Remote Manipulator System (JEMRMS).

There are total 12 attach points (port) on the EF for the payload, and the EF provides various resources to each port to support the experiments such as power, cooling system, and communications.

The EF was launched on July 16, 2009 (Japanese Time) by the Space Shuttle Endeavour（STS-127 Flight 2J/A）and berthed and activated. There are 4 payloads on the EF and they are operated nominally as of August 2010.

The EF attached location on the ISS is as follows.

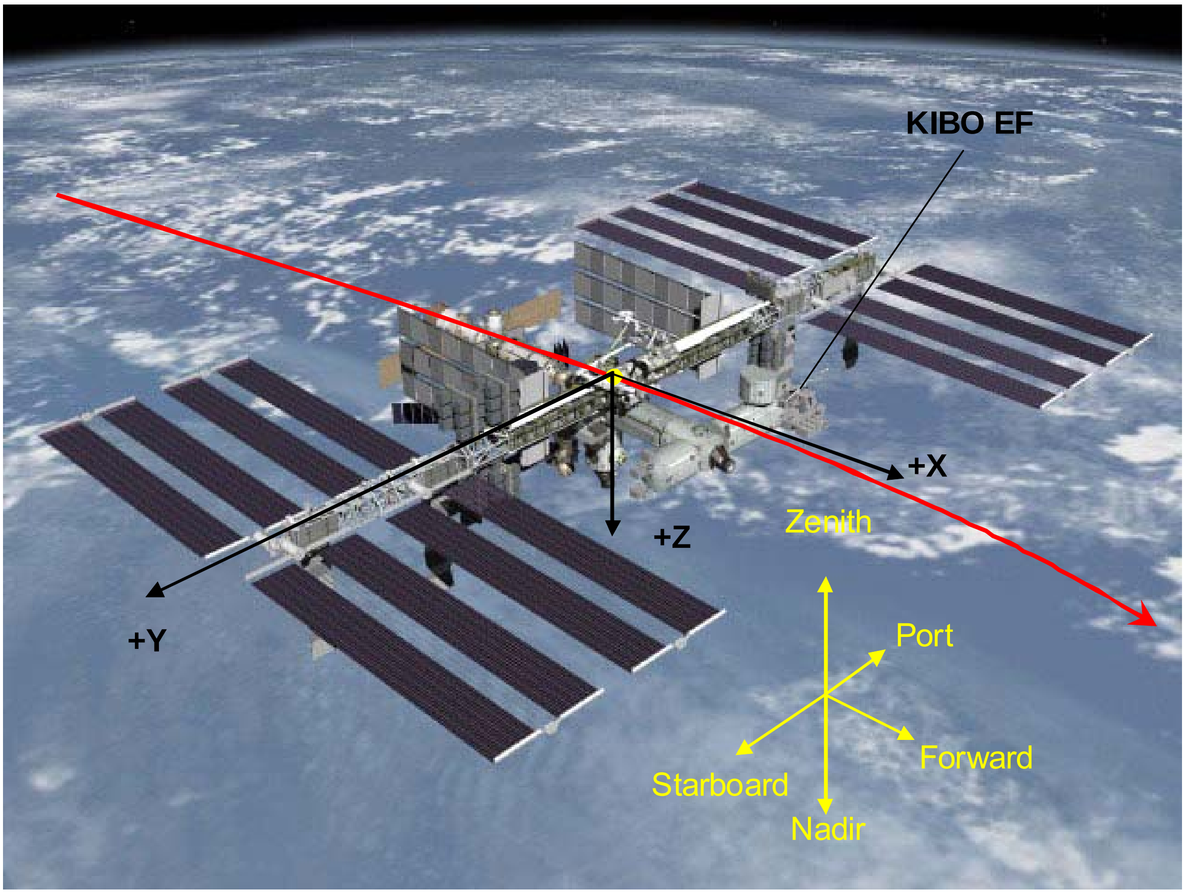


Fig 1.1-1 EF and the ISS

As shown in this figure, KIBO is attached the front side of the ISS. The Red allow shows the ISS flying direction and +X, +Y, and +Z show the axes of LVLH (Local Vertical Local Horizontal) reference frames.

Here is the ISS overall figure to show the EF and other module location.

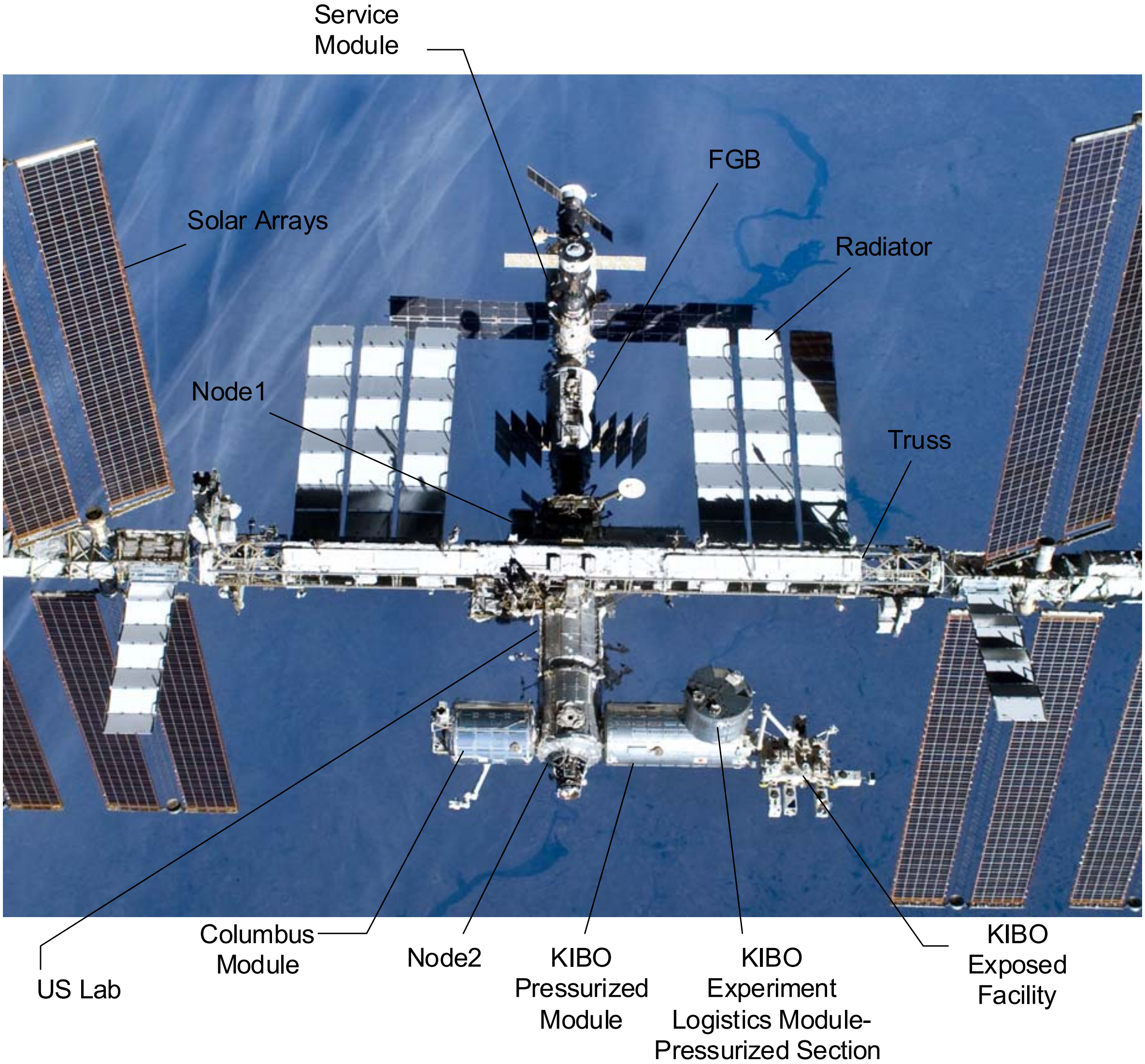


Fig 1.1-2 EF and the Other Modules

Table 1.1-1 shows the EF specification, Fig 1.1-3 shows the EF and its payload attach location.

	Specification
Shape	Box Type
Size	5.0m(Width) x 5.2m(Length) x 3.8m(Height)
Weight	4.1t
Number of payload attachment locations	12 (including 2 for JEM system and 1 for temporary storage)
Power	Max. 11kW (System : Max. 1kW. Payload : Max. 10kW in total, 3kW for each) 120V(Direct Current)
Communication	16 bit computer、Data Transfer Speed : Max. 100Mbps
Environment Control	-
Life Time	More than 10 years

Table 1.1-1 EF Specification

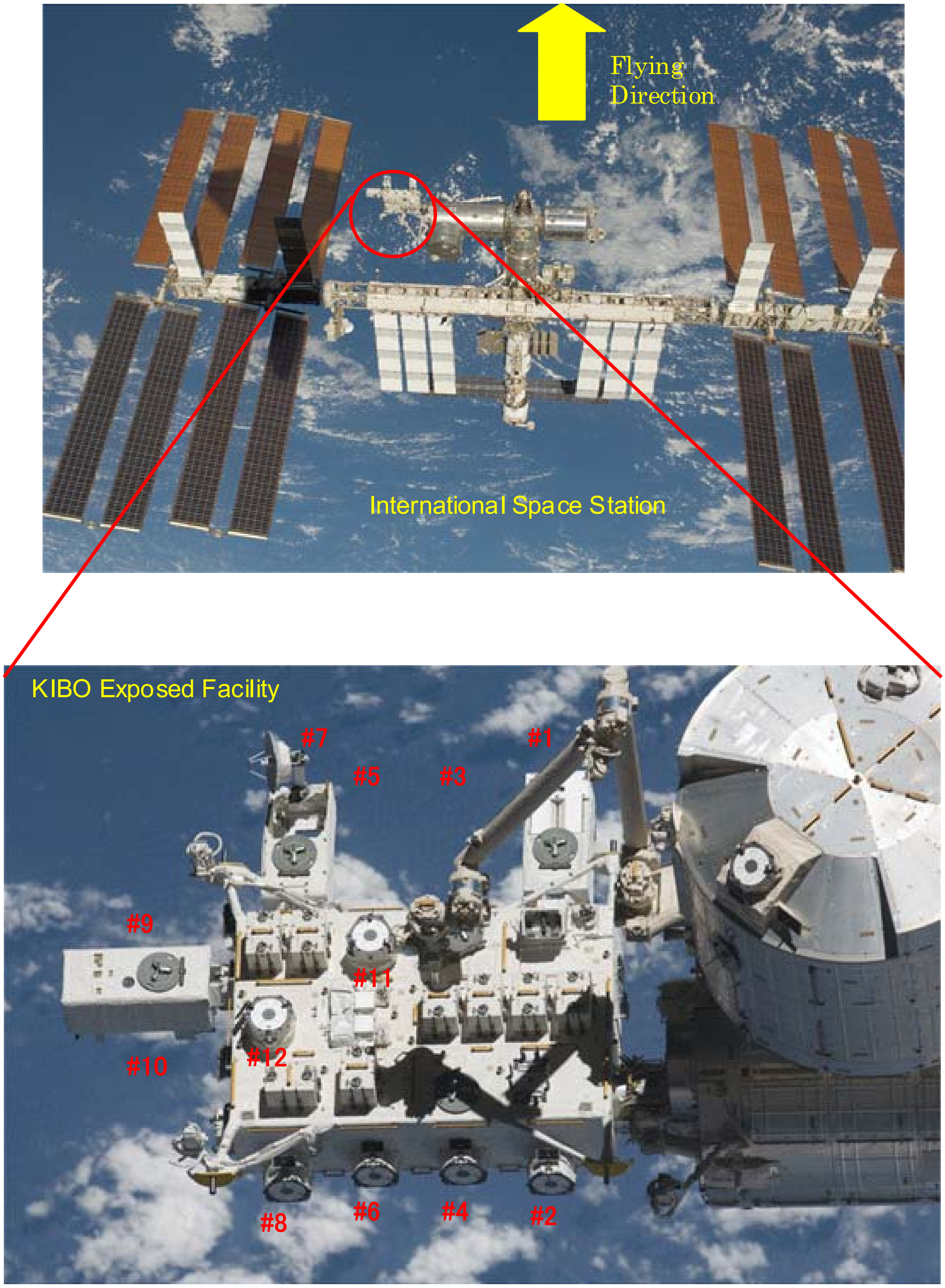


Fig 1.1-3 EF and Payload Attach Point

(The Red Number shows the Payload Attach Point)

Note : As of July 2009

1.2 What you can do on the Exposed Facility

Again, the EF provides a multipurpose platform where science experiments can be deployed and operated in the exposed environment such as micro-gravity, high vacuum, and space radiation. Users can perform a variety of experiments such as earth observation, communication test, material science, engineering experiments, and astronomical observation.

There have been already operating some payloads on the EF. For example, one payload is investigating the global warming and the ozone layer depletion, one is observing the galaxy via wide-view X-ray camera, and measure space environment (neutrons, plasma, heavy ions, high-energy light particles, atomic oxygen, and cosmic dust) in ISS orbit and environmental effects on materials and electronic devices to investigate the interaction with and from the space environment.

The more details for the current payloads operations are introduced in the Section 3.3.

1.3 Contact Point

KIBO Pressurized Module (PM) and Exposed Facility is the first Japanese manned space facilities. People can try to have various science, research technologies, human space technologies, and educational and cultural investigation and experiments. Please feel free to contact us as follows to support your idea of the missions.

Contact : kibo-promotion@jaxa.jp

2. ENVIRONMENT AND SERVICES

This section describes,

- the space environments and their impacts
- the services from the Exposed Facility,
- the other on-orbit services and ground services

for the payloads on the KIBO Exposed Facility.

2.1 Space Environment on the KIBO Exposed Facility

The space environment on the EF will have various impacts on your payload. It is good to understand what the space environment is and how impacts will your payload have on the EF. Table 2.1-1 shows the summary of the Space environment and their details are shown from Section 2.1.1.

	Environment	Impacts
1	Microgravity	Approximately 10^{-6}g
2	Atmosphere	Approximately 10^{-5}Pa
3	Plasma	Cause of unexpected charge/discharge, unexpected abnormal action, and possible surface damage
4	Ionized Radiation	Single event effect
5	Electromagnetic Waves	Cause of degradation of equipment and tarnishing the surface
6	Meteoroids and Space Debris	Destroy the vehicle or payload
7	Thermal	Direct/reflected Solar right, cosmic microwave background
8	Contamination	Depends on the location but potentially contaminated
9	Viewing	Depends on the location. See 2.1.9

Table 2.1-1 Space Environment and Impact Summary

2.1.1 Microgravity - Approximately 10^{-6} g

The Microgravity environment on the EF is confirmed to have very good condition and to reach approximately 10^{-6} g (1g = 9.8m/s^2). This condition may variable by any disturbance such as atmospheric drag, exhaust gas from pressurized module, Crew activity, and ISS attitude maneuver.

The Microgravity environment on the EF provides as same microgravity condition as the JEM Pressurized Module (PM) at more than half attach point for over a half year.

There are 3 Microgravity Measurement Equipments (MME) in the EF. The nominal data shows about from 200 μg to 0.01 g since it comes on board in 2009 and the results from the One Third Octave Frequency Bands process is about 1 x 10^{-3} - 1 x 10^{-6} [Grms]. These values are expected and show good microgravity environment on the EF.

Fig 2.1.1-1 shows a MME data after One Third Octave Frequency Bands process.

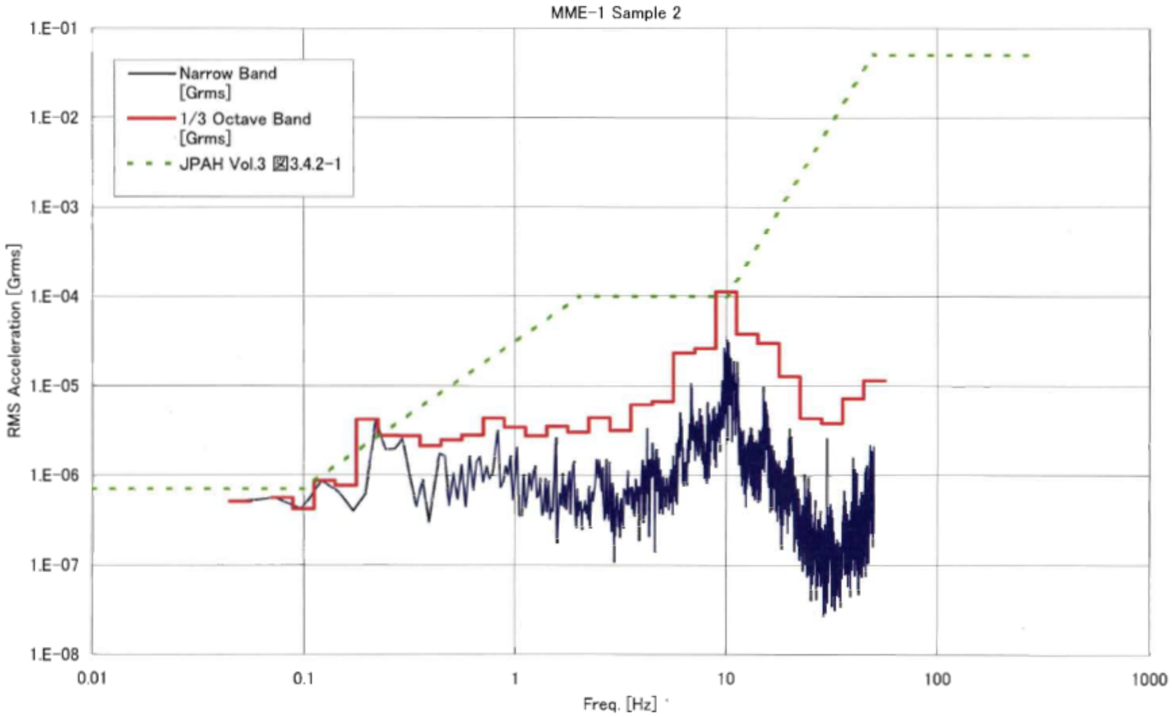


Fig2.1.1-1 MME Data（One Third Octave Frequency Bands Processed）

2.1.2 Atmosphere - Approximately 10^{-5}Pa

The atmospheric density around the Earth surface is variable by the solar activity, the geomagnetic activity, day and night, seasons, and the latitude but the density is approximately 10^{-5} Pa at the altitude of 400 kilometers. The atmospheric constituents are Oxygen, Nitrogen, Helium, and Hydrogen.

The exhaust gas from the ISS pressurized module may cause of degradation.

The atmosphere is the reason of the ISS altitude decreases and the attitude disturbances.

The atomic oxygen in the atmosphere is known as the element of causing the oxidation and erosion of the material surface.

Here is the ISS altitude profile of 2010 for your reference, blue shows estimation and red shows as flown. The ISS altitude decreasing slowly by the atmospheric drag and then have periodic reboosts to keep the appropriate altitude.

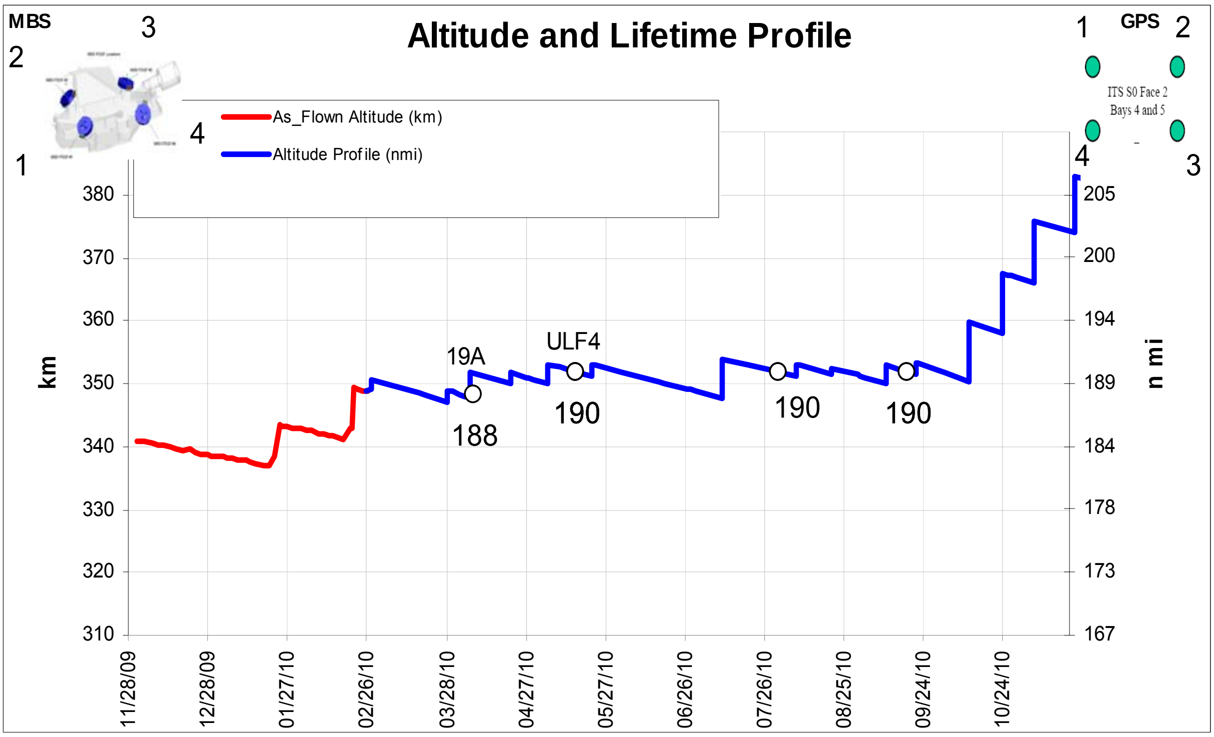


Fig 2.1.2-1 ISS Altitude Profile

2.1.3 Plasma - Cause of unexpected charge/discharge, unexpected abnormal action, and possible surface damage

Plasma is a gas in which a certain portion of the particles are ionized. The atmosphere is ionized by cosmic radiation and solar ray and the electron density become maximum at the altitude of 250 - 300 kilometers (approximately 10^{12} particles/ m^3).

Plasma interact with the surface of the vehicle or payloads and may cause of charge/discharge, degradation of the surface, and unexpected electronic device abnormal action.

2.1.4 Ionized Radiation - Single event effect

The particles which are categorized as Ionized Radiation are radiation belt particle, galactic cosmic ray, and solar flare particle.

(1) Radiation belt particle

The Radiation belt particles are electrically charged particles by the earth's magnetic fields and they encircle the earth like a donut. The Radiation belt particles are consisted from electron, proton, alpha particle, and baryon but the most of them are electron and proton. The energy range of these particles is wide, the electron has tens of Kev and the proton has tens of Mev. The energetic particles flux is extremely increased at South Atlantic Anomaly (SAA).

These particles may cause of Single Event Effects(SEEs).

SEDA-AP payload on the EF have been observing the Electron and Proton in the ISS orbit from 2009. Here is the feedback from its actual observation data.

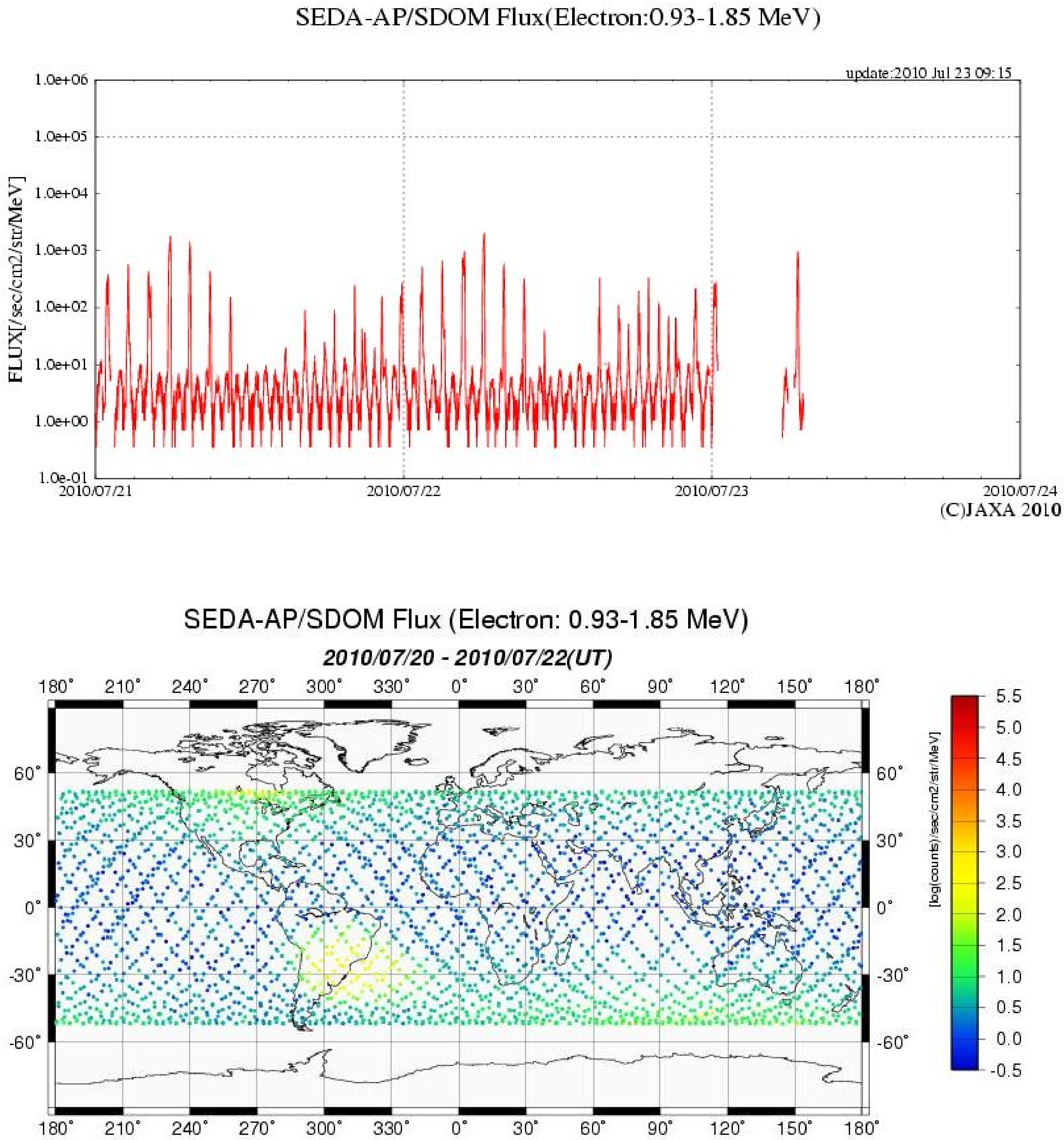
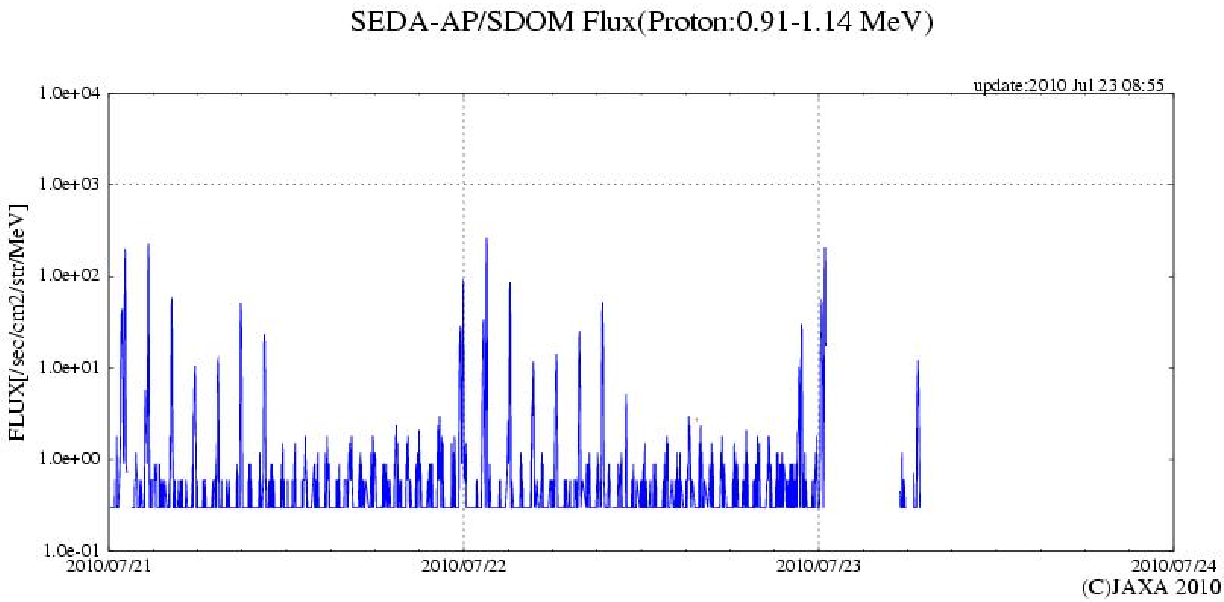


Fig 2.1.4-1 Electron Flux in the ISS orbit

July 20 – 22, 2010

(http://seesproxy.tksc.jaxa.jp/fw/dfw/SEES/Japanese/Data/docs_ja/SEDAAP/SEDAAP_RealTimeGraph_world_map.htm)



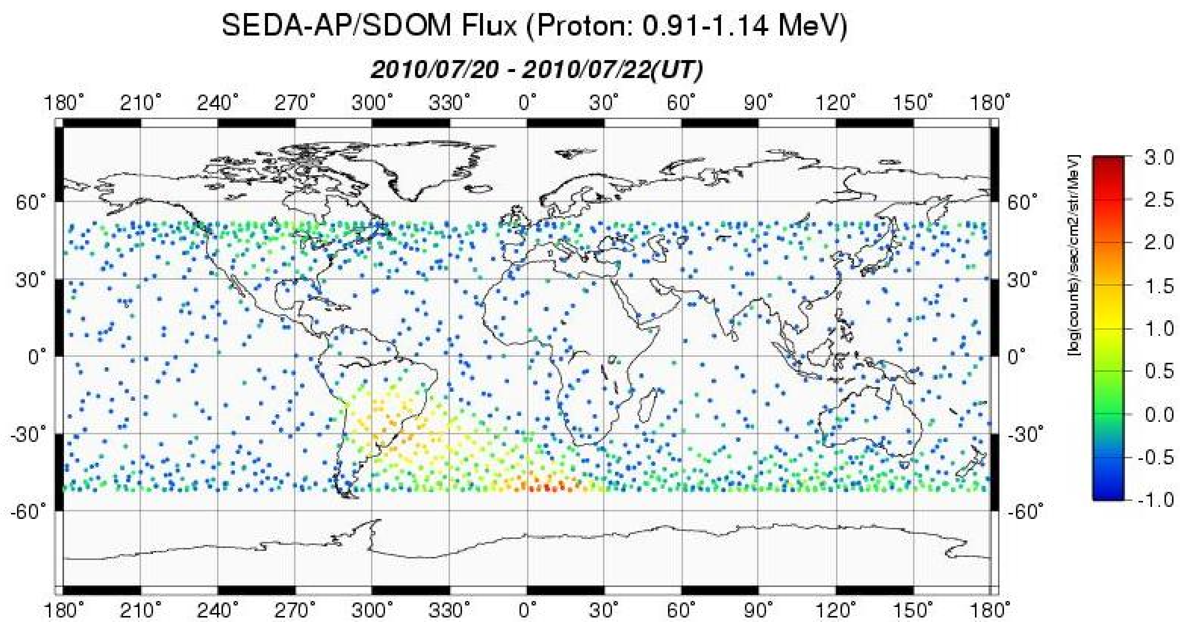


Fig 2.1.4-2 Proton Flux in the ISS Orbit

July 20 – 22, 2010

(http://seesproxy.tksc.jaxa.jp/fw/dfw/SEES/Japanese/Data/docs_ja/SEDAAP/SEDAAP_RealTimeGraph_world_map.htm)

(2) Galactic cosmic ray

The Galactic cosmic ray nuclide is proton, Helium, Carbon, Oxygen, and Iron. The energy range is from 10 to 10^{16} MeV/nucleon. The nucleon flux which has under 10 Gev varies with the solar activities and the flux decreases during solar maximum. This Galactic cosmic ray may also cause of SSEs.

(3) Solar flare particle

The Solar flare particles caused by the solar flare are almost protons with a few or hundreds of Mev energies. The protons cause the total dose effect (the radiation damages and degrades the semiconductor permanently) and also may cause SSEs.

Here is the Solar Flux profile analyzed by NASA and black line shows the actual measured value as of June 2010.

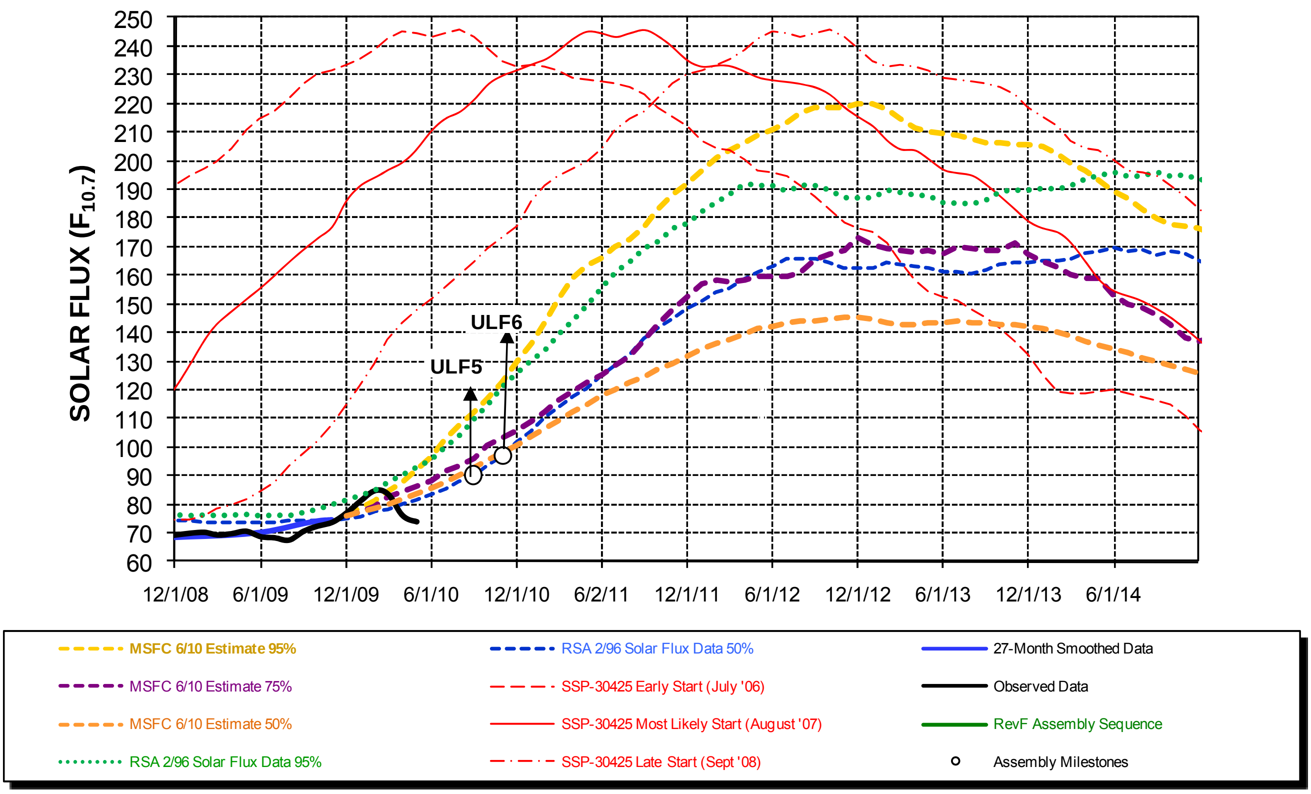


Fig 2.1.4-1 Solar Flux Analysis by NASA

2.1.5 Electromagnetic Waves - Cause of degradation of equipment and tarnishing the surface

There are two types of the natural electromagnetic waves around the earth, one is the electromagnetic wave from space and the other is from the earth.

The electromagnetic wave from the space is mainly from the Sun but also from the deep space such as X-ray and infrared ray from galaxy, quasar, and pulsar. The electromagnetic wave from the earth is caused by lightning and aurora.

The spectrums of the electromagnetic waves from the sun are consisted from gamma ray, X ray, ultraviolet ray, and infrared ray. Some of them may have interaction with the spacecrafts systems, especially, the X ray may cause the total dose effects with the semiconductor and the ultraviolet ray may tarnish the paint.

The electromagnetic waves from the ground or the other spacecrafts also need to be considered.

2.1.6 Meteoroids and Space Debris - Destroy the vehicle or payload

The origin of the meteoroids is considered from comet dusts and asteroids and their constituents are Iron, Oxygen, Silicon, and Magnesium. The diameter of the meteoroids under the altitude of 2000 km is about 0.1mm and the total amounts of their weight are about 200 kg.

The origin of the space debris is discarded spacecrafts, peeled surface, and the parts from the multistage rockets. It is confirmed that there are approximately 11000 space debris with the diameter over 10 cm under the altitude of 2000 km. It is considered that there are over a hundred thousands space debris with the diameter from 1 to 10 cm, and are over ten millions with the diameter under 1 cm.

The average collision velocity of the meteoroid to the spacecrafts is about 20 km/s, and 10 km/sec for the space debris. The collision of the meteoroid or space debris may destroy the outer shield of the spacecrafts and the payloads, so the design and development of EF payloads need to be taken account of them.

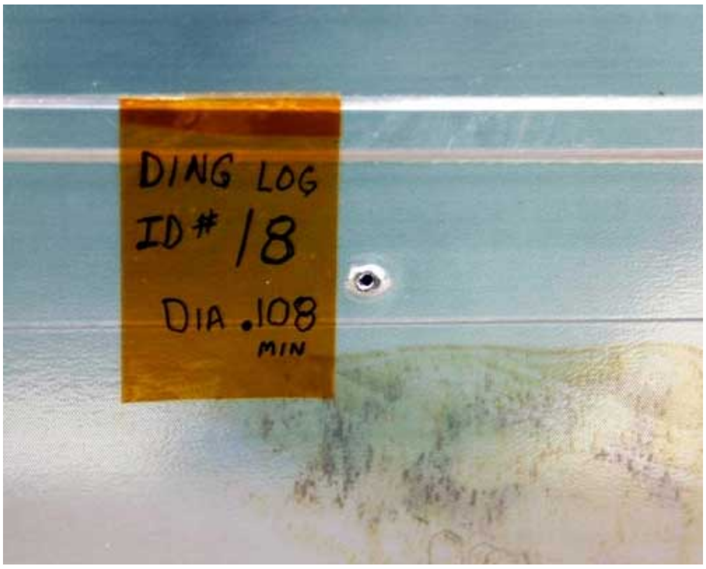


Fig 2.1.6-1 The space debris impact on the Space Shuttle Atlantis's right payload bay door (2.5mm in diameter)

2.1.7 Thermal - Direct/Reflected Solar Right, Cosmic Microwave Background

The EF payloads on the ISS are exposed under the direct solar right, reflected solar right from the earth atmosphere (Albedo), infrared radiation from the earth (Outgoing Longwave Radiation : OLR), and cosmic microwave background.

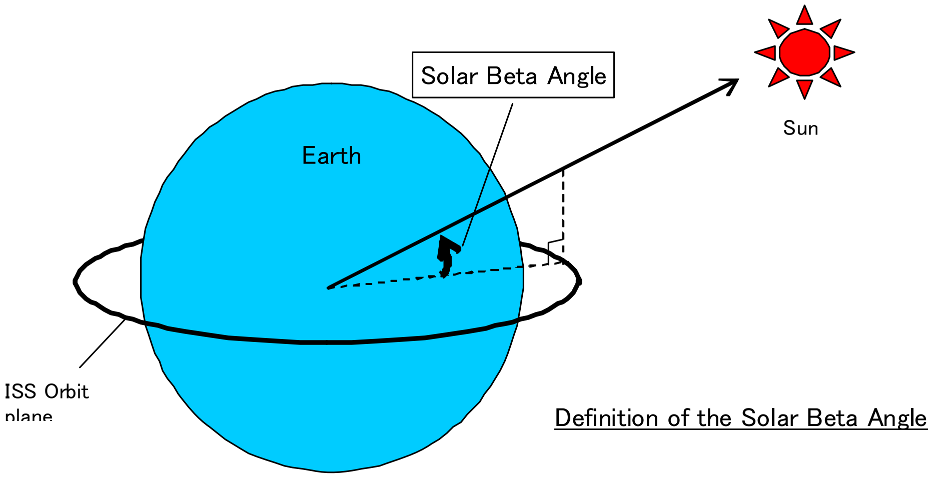
The thermal conditions which need to be taken considered for developing the EF payloads,

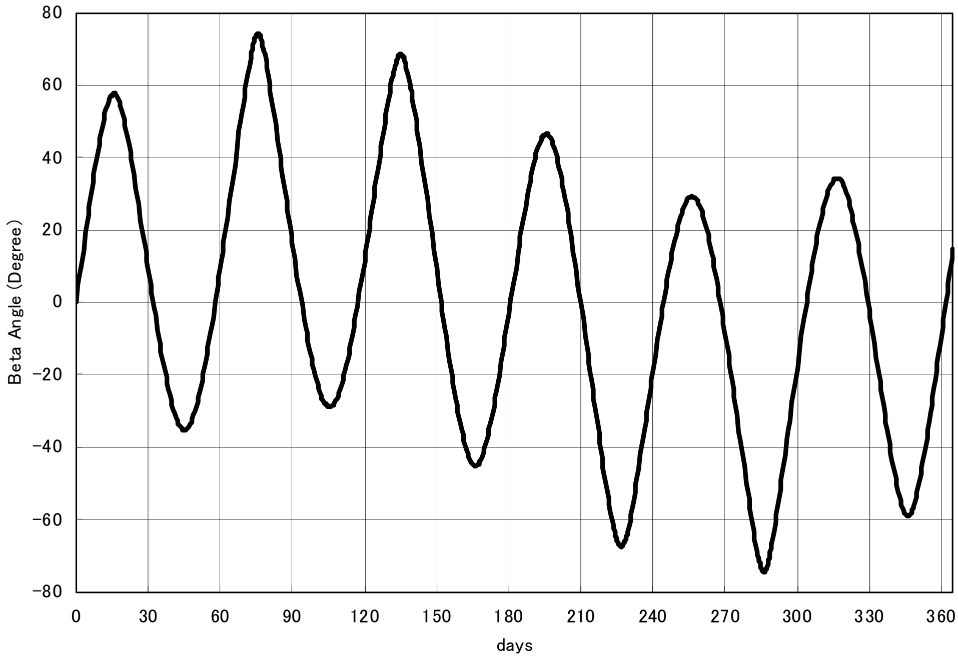
Solar constant	: 1321～1423W/m^2
Albedo at the altitude of 30 km	: 0.08～0.4
OLR at the altitude of 30 km	: 177～307 W/m^2
Cosmic microwave background	: 3K

Also, the thermal design for the EF payloads needs to be taken account the other ISS structure and reflection.

The ISS orbital inclination is 51.6 degrees to have direct communication between the ISS and the Russian ground site, the solar beta angle varies from -75 degrees to +75 degrees with dynamic thermal condition changes.

(Source : SSP 30425 Space Station Program Natural Environment Definition for Design)





Assumption :

*1 ISS flies at nominal attitude (407km) and its orbital inclination is 51.6 degree
*2 Spring Equinox Day is the start day and right ascension of ascending node is 0 de
*3 The Earth flattening is only considered for the ISS orbital displacement

Fig 2.1.7-1 ISS Solar Beta Angle Profile (Analysis sample)

Here is the Solar beta angle analysis by NASA for August 2010 to July 2011.

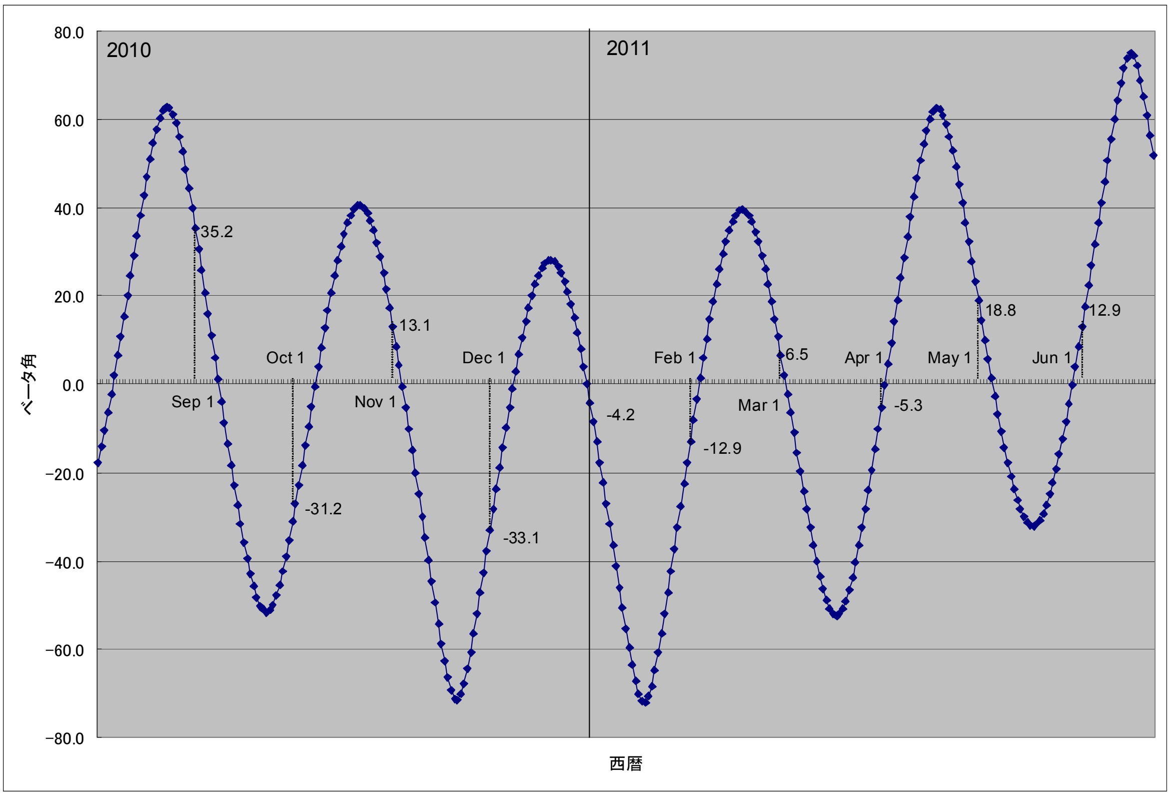


Fig 2.1.7-2 Solar Beta Angle Analysis from 2010to 2011

2.1.8 Contamination - depends on the location but potentially contaminated

The EF payloads are potentially contaminated. The cause of the contamination is molecular contamination and particle contamination. The molecular contamination is from outgas, the ISS thruster propellant, and the exhausted gas from the ISS. The particle contamination is from galling, dust, paint, and degradation of the organic materials and they are adhered to the payloads by the electrostatic force.

Table 2.1.8-1 shows the contamination class, source, and countermeasure. Table 2.1.8-2 shows the yearly contamination prediction for MAXI/SMILES/SEDA-AP.

Class	molecular contamination	particle contamination
Source	outgas, ISS thruster propellant, ISS exhausted gas,	galling, dust, paint, degradation of the organic materials,
Countermeasure	- To avoid any structure from coming into the view - To keep higher temperature	To cover the sensitive surface during development, assembly, stowage, launch phase, and to

	than the around - To use the less outgassing materials	select and use less wear materials

Table 2.1.8-1 Contamination class, source and provision

	Zenith	Forward
MAXI	16Å /242Å	5Å/5Å
SMILES	13Å/246Å	2Å/4Å
SEDA-AP	4Å/70Å	64Å/384Å

Note 1 : all numbers are analyzed yearly contamination value

Note 2 : X Å/Y Å shows X in 25 degree C, Y in -40 degree C

Note 3 : Å = 1.0 x 10^{-10} m

Note 4 : Zenith is the –Z direction and the Forward is the +X direction in the ISS LVLV frame of reference.

Table2.1.8-2 Yearly Contamination Prediction for MAXI/SMILES/SEDA-AP

JAXA experienced 900 Å contamination in 1403 days (234 Å/ year) on the SM/MPAC&SEED payload which had been deployed on the Russian Service Module.

2.1.9 Viewing

The viewing area from the EF payload depends on its attach point. Generally, the attach points on the ISS flying direction side have better viewing than the other side for the zenith direction viewing. However, the area of the viewing changes according to the ISS attitude or structure configurations. Especially, moving structures such as Robot Arm and Solar Array have impacts on the viewing. In the viewing analysis pictures in the Fig 2.1.9-2, the blocked area by the solar array is shown as moving envelop.

The Yellow allow of the Fig 2.1.9-1 shows the solar array rotation directions. The solar array is rotated to the appropriate position according to the solar position, and vehicle docking/undocking, etc. The pictures were taken from the Zenith side of the ISS at a different timing, the solar array and the radiator position are different in these pictures.

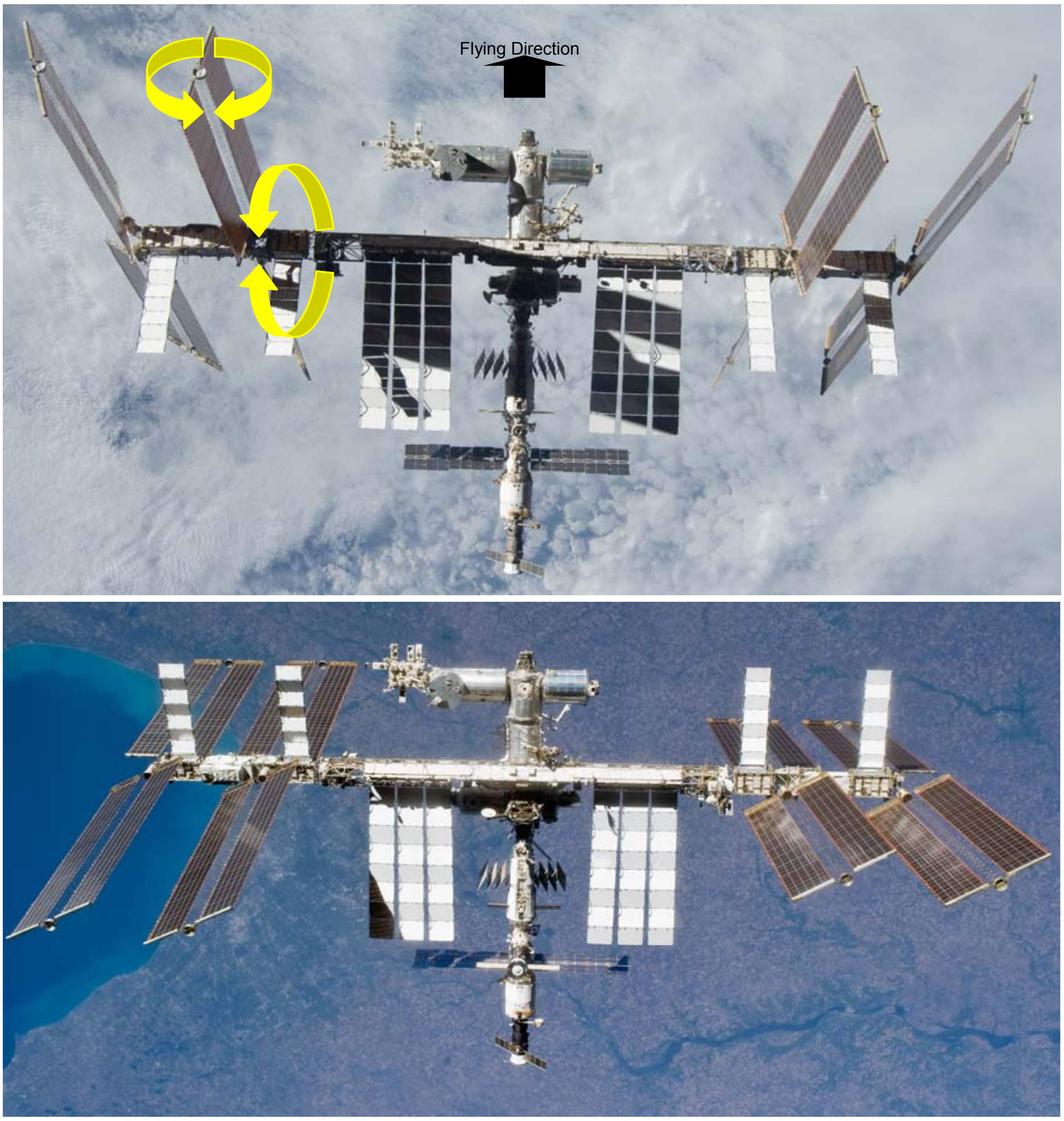
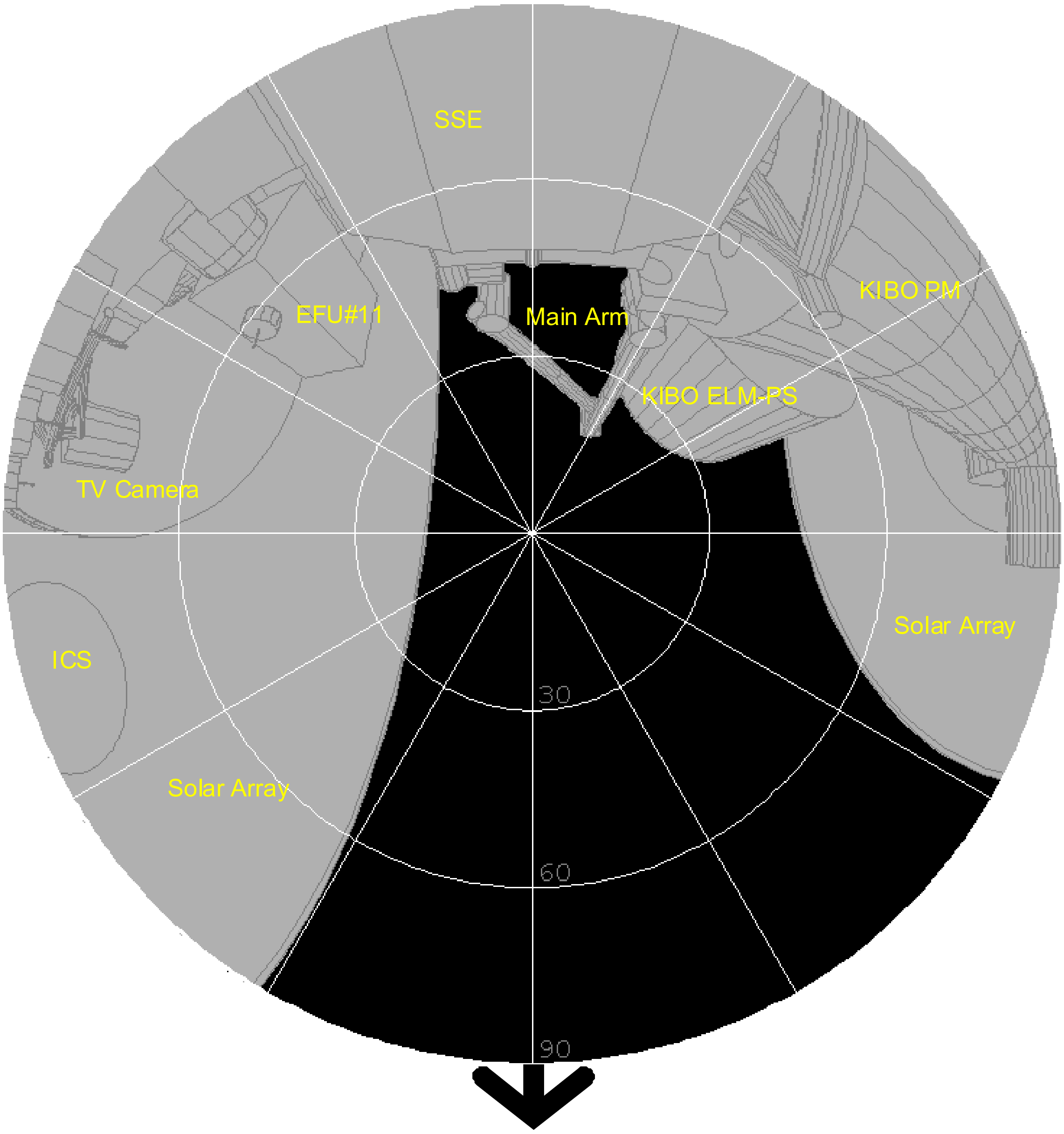


Fig 2.1.9-1 Solar Array Rotation Direction (Yellow Line)

The timeframe for having the direct solar ray to the EF payloads also depends on the attach point. The periodic solar beta angle changes and the ISS structural changes also have interact with the direct solar ray to the payloads.

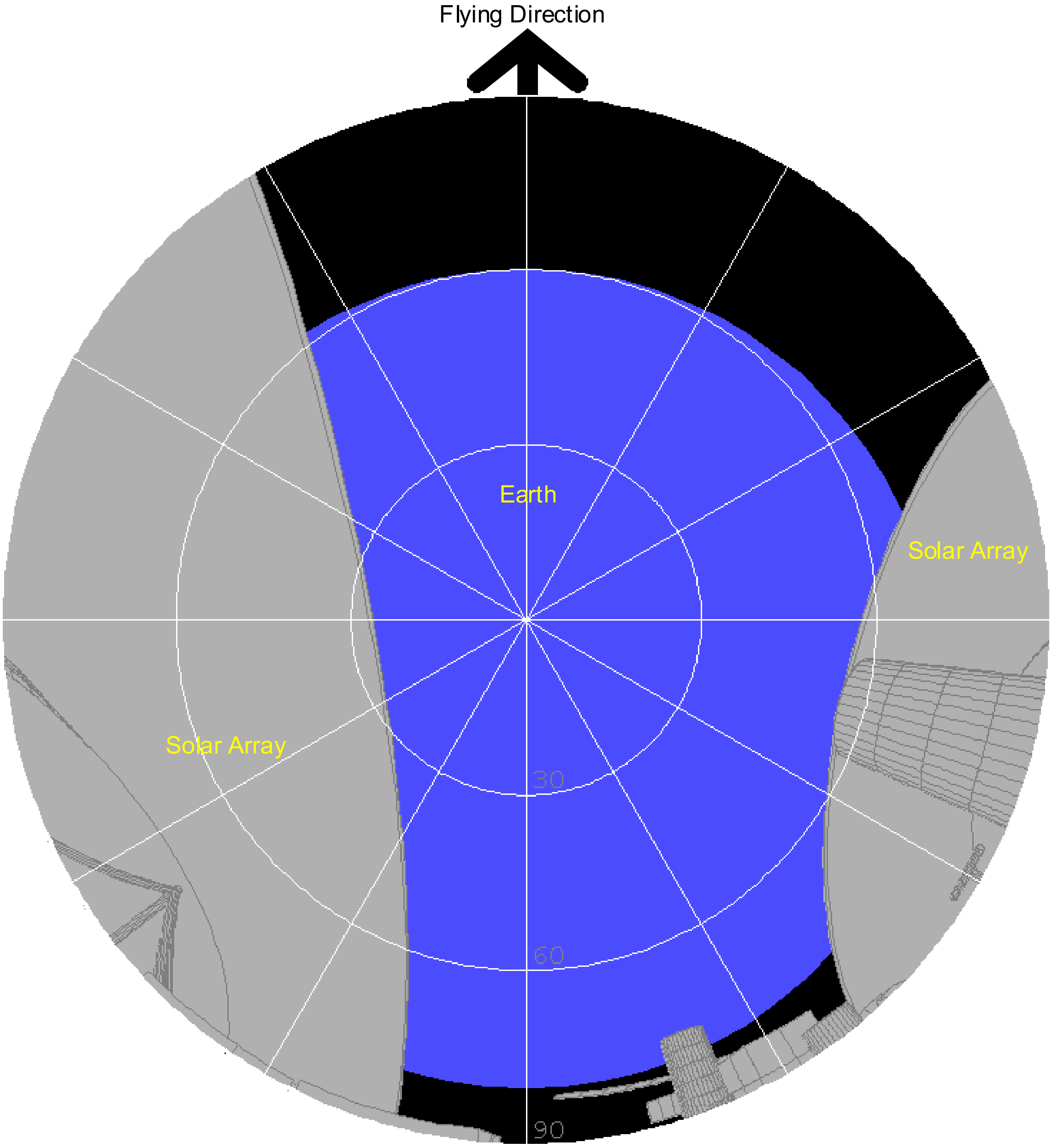


Viewing Point : Center of the top face of EFU#1 payload

Viewing Direction : Zenith

(Note 1) Refer Fig 1.1-1 for the location of EFU#.
(Note 2) ISS flies in LVLH attitude, and the altitude is 407 km.
(Note 3) Solar array is modeled as moving envelop.
(Note 4) KIBO Robot arm is in Stowed Position.
(Note 5) ICS antenna is modeled as moving envelop.

Fig 2.1.9-2(1/21) Viewing analysis from the EF payload

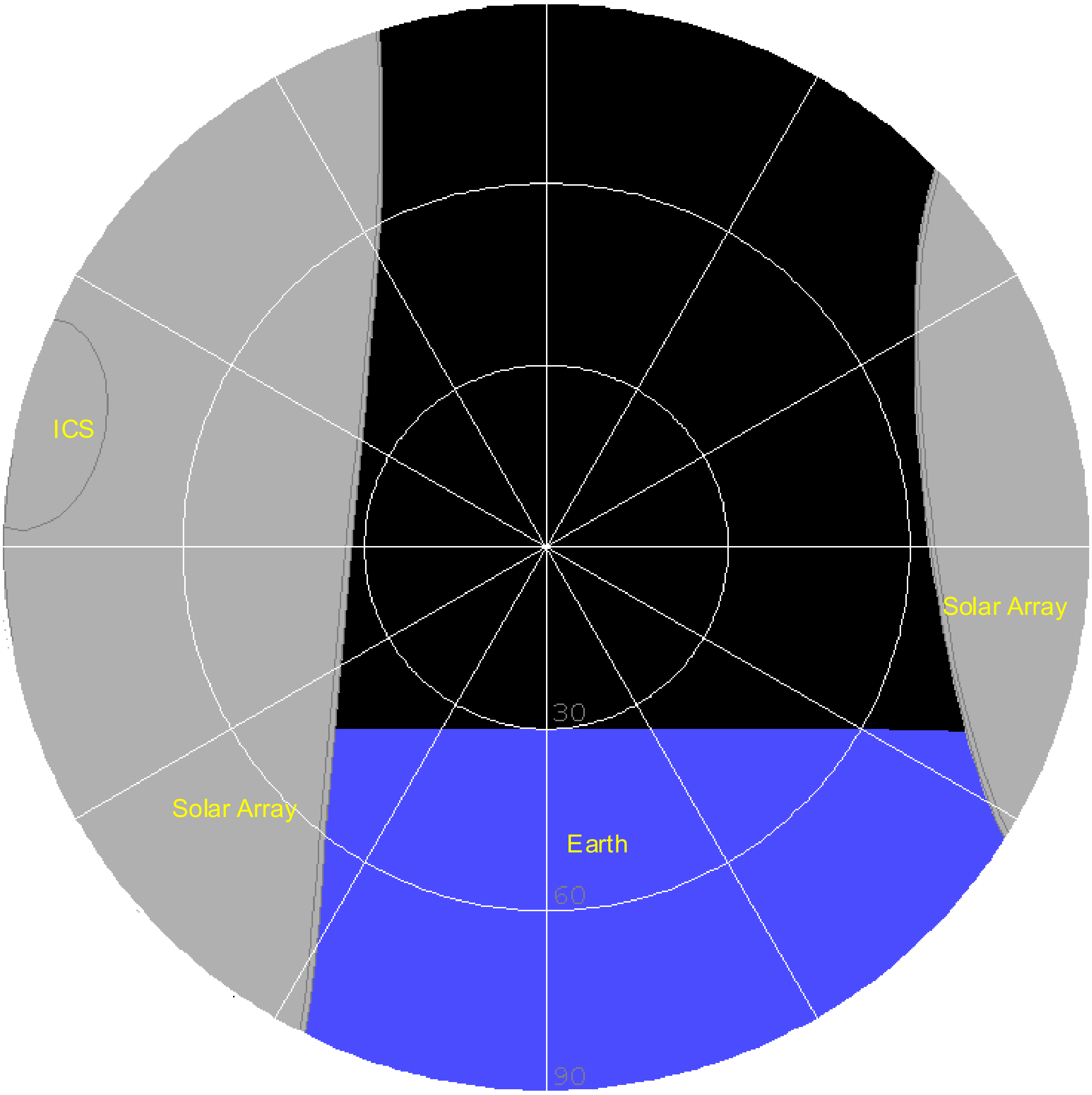


Viewing Point : Center of the lower face of EFU#1 payload

Viewing Direction : Nadir

(Note 1) Refer Fig 1.1-1 for the location of EFU#.
(Note 2) ISS flies in LVLH attitude, and the altitude is 407 km.
(Note 3) Solar array is modeled as moving envelop.
(Note 4) KIBO Robot arm is in Stowed Position.
(Note 5) ICS antenna is modeled as moving envelop.

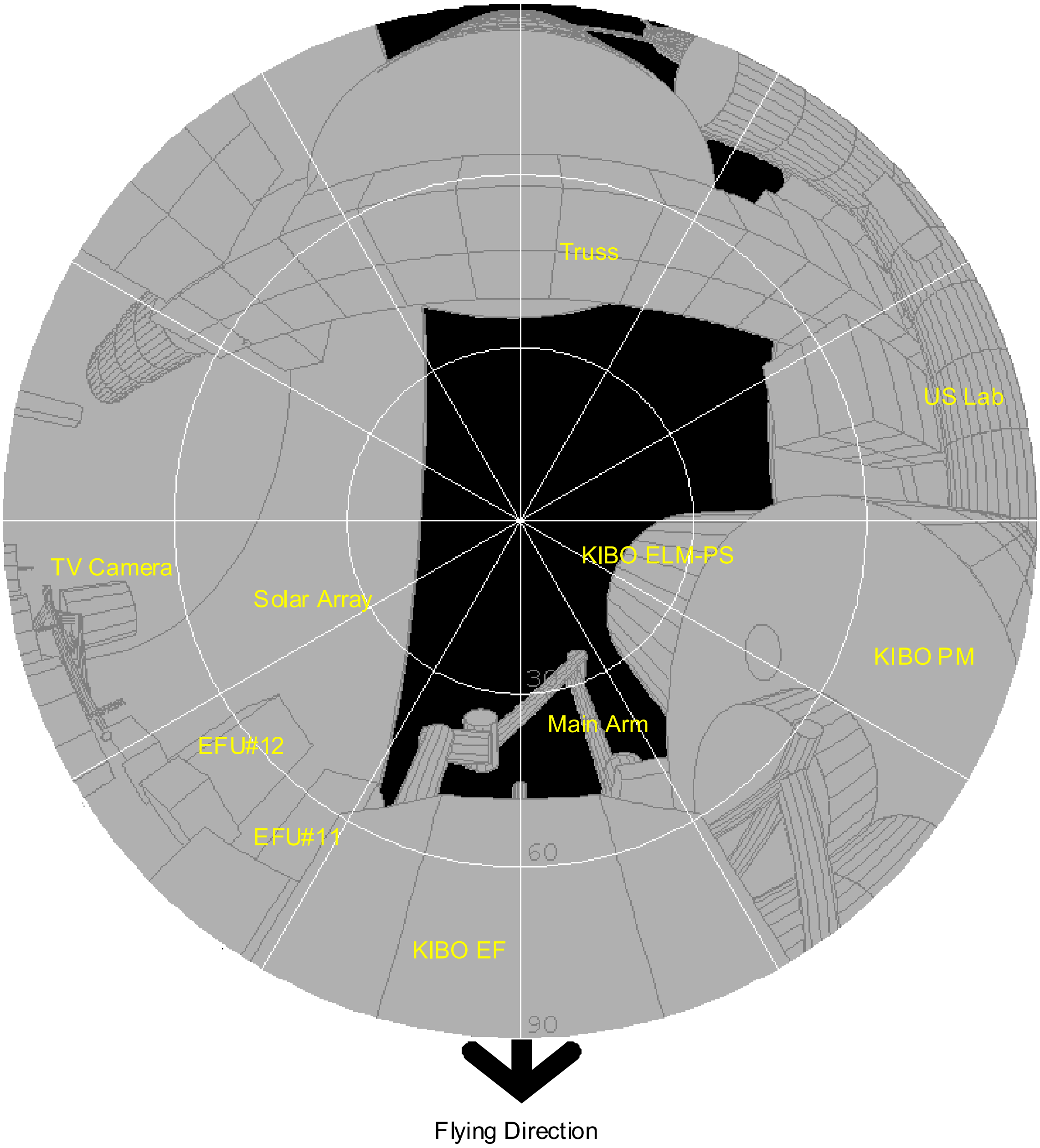
Fig 2.1.9-2(2/21) Viewing analysis from the EF payload



Viewing Point : Center of the front face of EFU#1 payload
Viewing Direction : Forward (+X direction in LVLH)

(Note 1) Refer Fig 1.1-1 for the location of EFU#.
(Note 2) ISS flies in LVLH attitude, and the altitude is 407 km.
(Note 3) Solar array is modeled as moving envelop.
(Note 4) KIBO Robot arm is in Stowed Position.
(Note 5) ICS antenna is modeled as moving envelop.

Fig 2.1.9-2(3/21) Viewing analysis from the EF payload

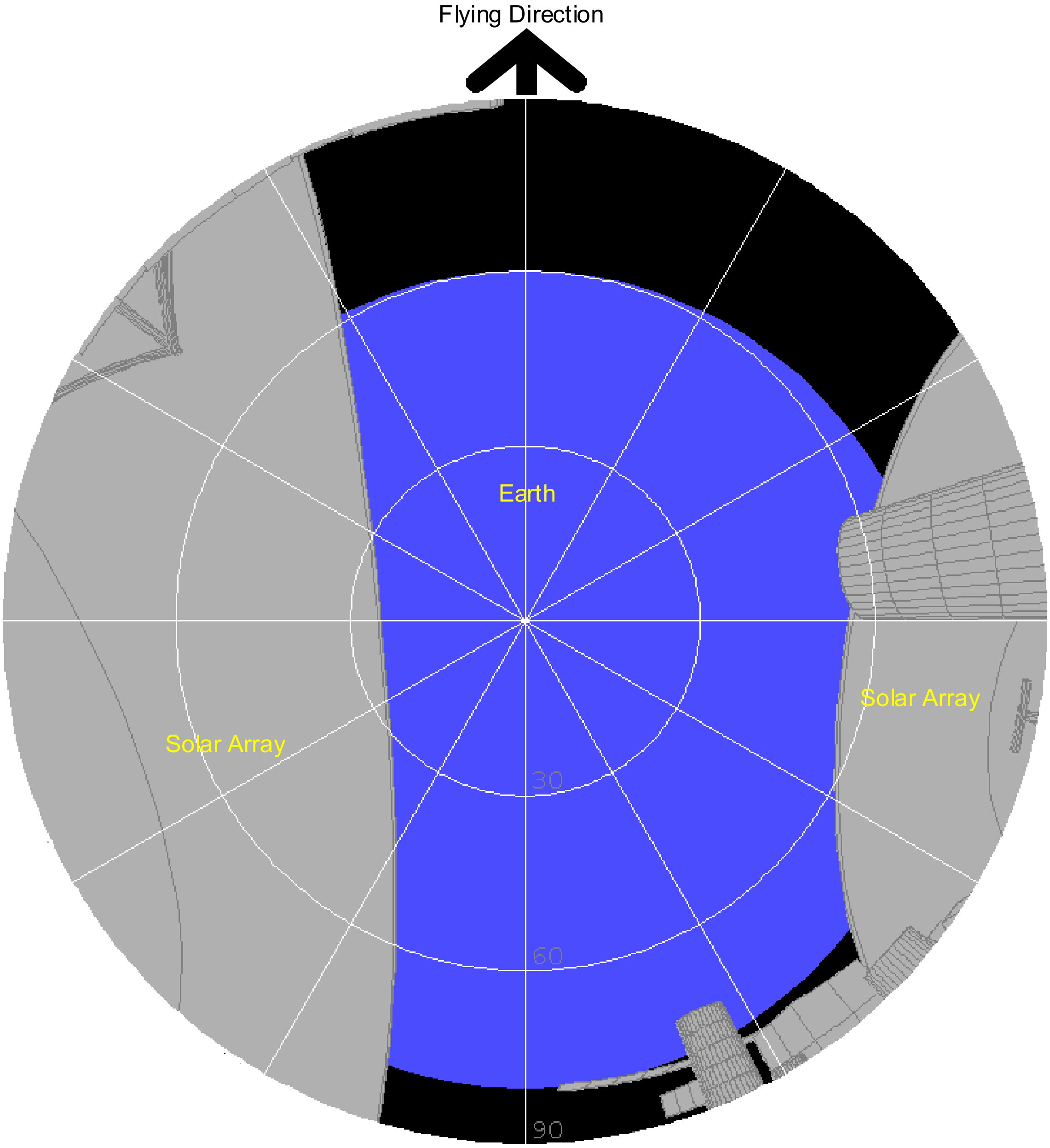


Viewing Point : Center of the top face of EFU#2 payload

Viewing Direction : Zenith

(Note 1) Refer Fig 1.1-1 for the location of EFU#.
(Note 2) ISS flies in LVLH attitude, and the altitude is 407 km.
(Note 3) Solar array is modeled as moving envelop.
(Note 4) KIBO Robot arm is in Stowed Position.
(Note 5) ICS antenna is modeled as moving envelop.

Fig 2.1.9-2(4/21) Viewing analysis from the EF payload

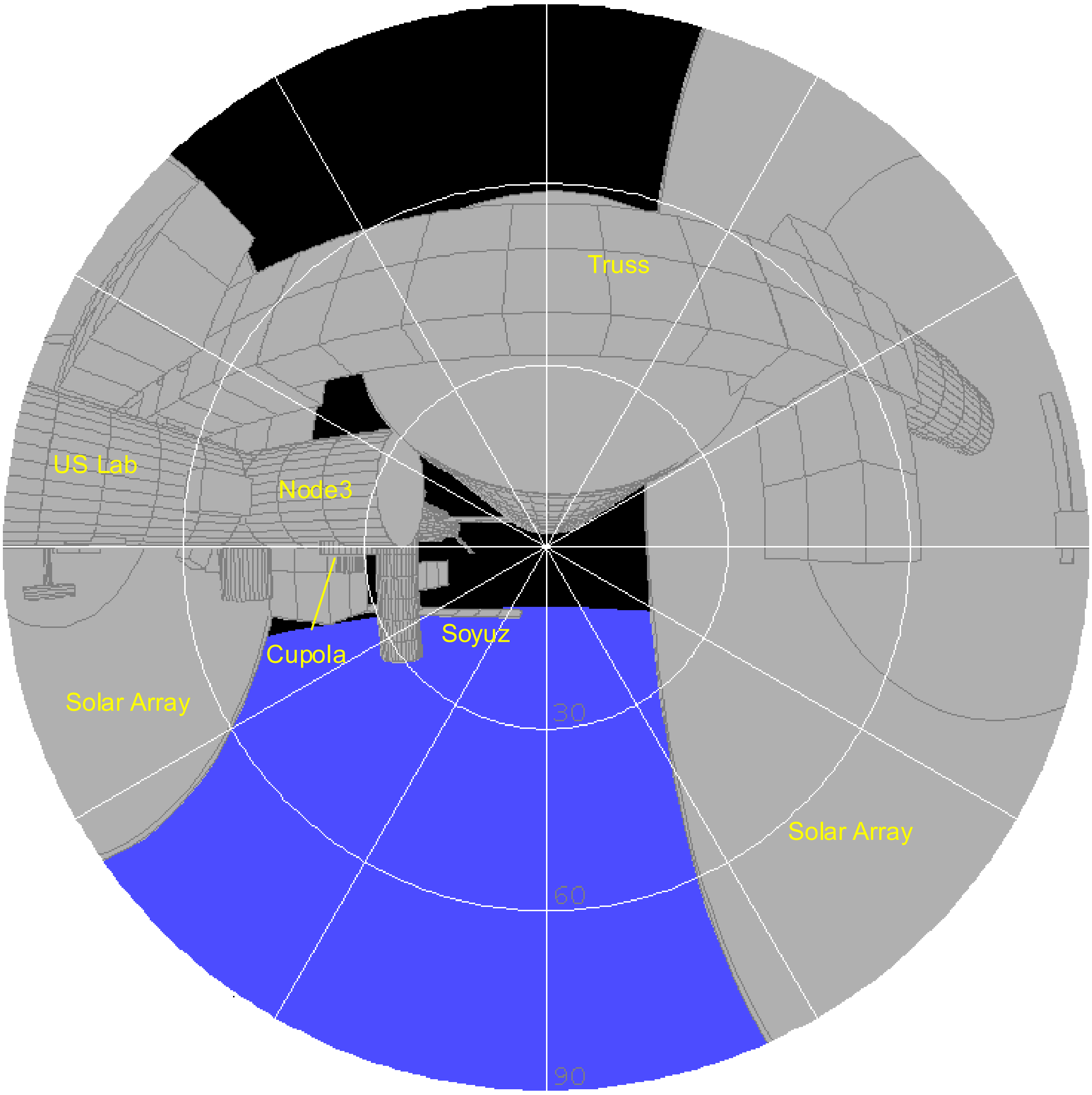


Viewing Point : Center of the lower face of EFU#2 payload

Viewing Direction : Nadir

(Note 1) Refer Fig 1.1-1 for the location of EFU#.
(Note 2) ISS flies in LVLH attitude, and the altitude is 407 km.
(Note 3) Solar array is modeled as moving envelop.
(Note 4) KIBO Robot arm is in Stowed Position.
(Note 5) ICS antenna is modeled as moving envelop.

Fig 2.1.9-2(5/21) Viewing analysis from the EF payload

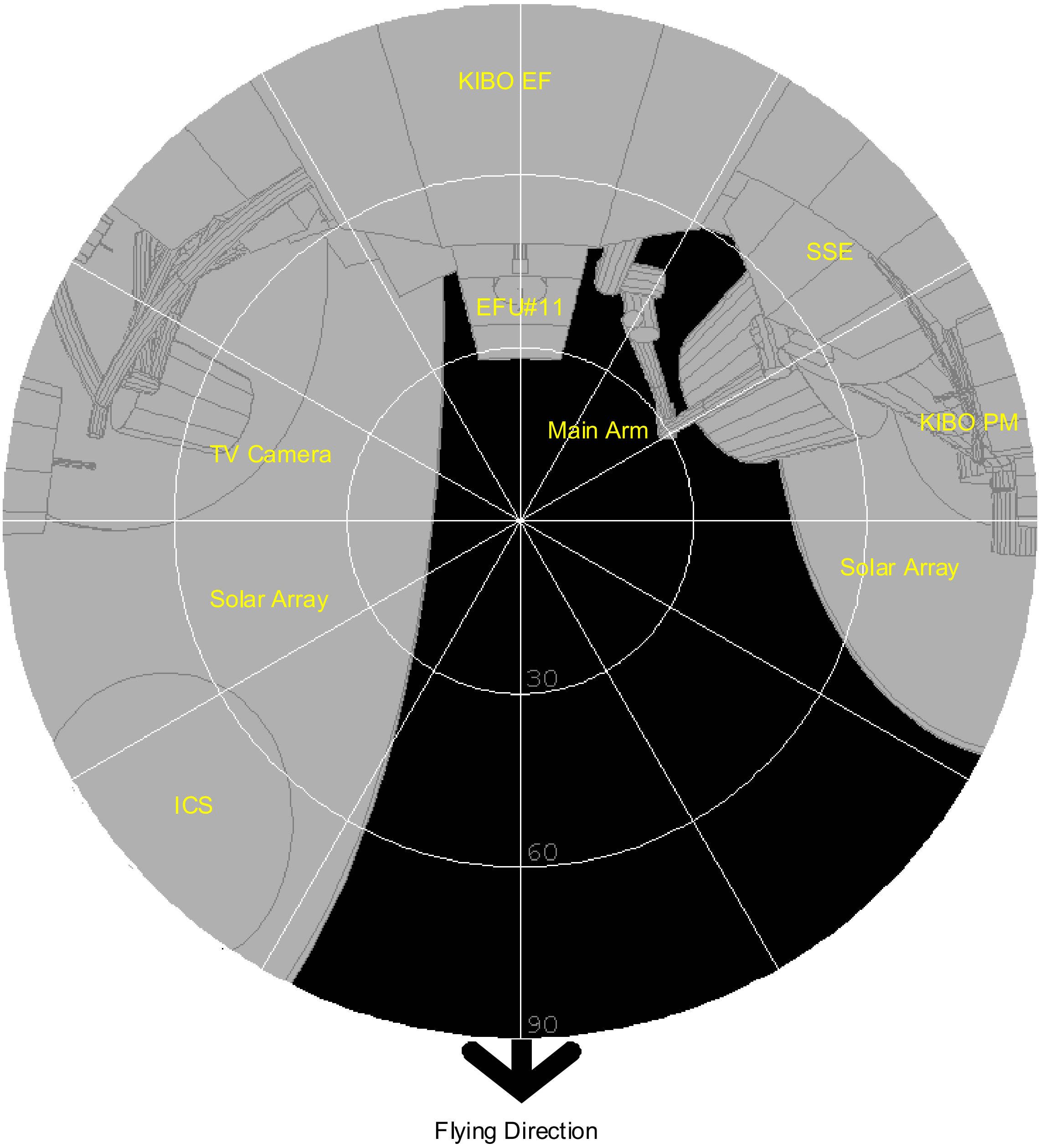


Viewing Point : Center of the front face of EFU#2 payload

Viewing Direction : Aft (-X direction in LVLH)

(Note 1) Refer Fig 1.1-1 for the location of EFU#.
(Note 2) ISS flies in LVLH attitude, and the altitude is 407 km.
(Note 3) Solar array is modeled as moving envelop.
(Note 4) KIBO Robot arm is in Stowed Position.
(Note 5) ICS antenna is modeled as moving envelop.

Fig 2.1.9-2(6/21) Viewing analysis from the EF payload

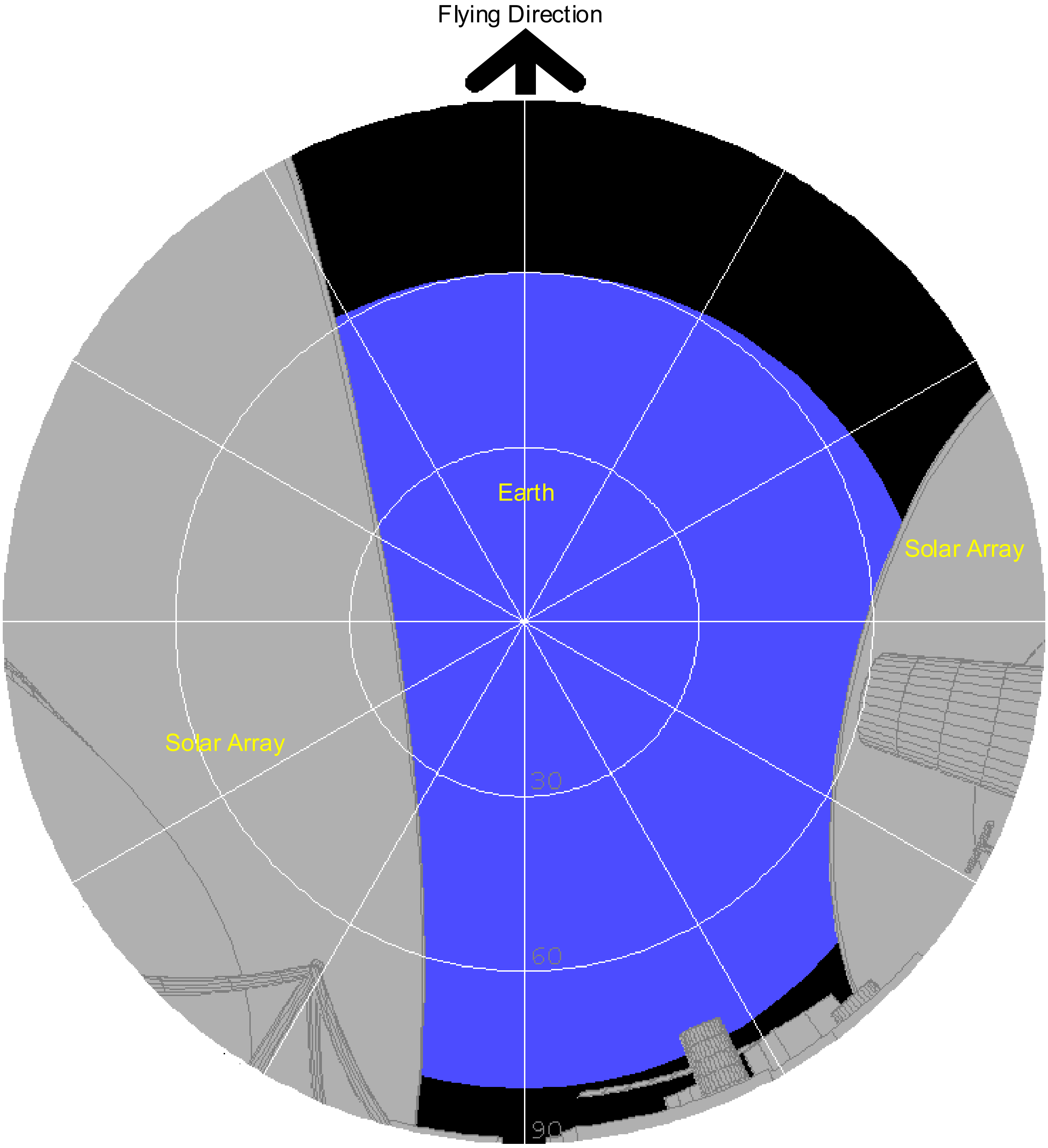


Viewing Point : Center of the top face of EFU#5 payload

Viewing Direction : Zenith

(Note 1) Refer Fig 1.1-1 for the location of EFU#.
(Note 2) ISS flies in LVLH attitude, and the altitude is 407 km.
(Note 3) Solar array is modeled as moving envelop.
(Note 4) KIBO Robot arm is in Stowed Position.
(Note 5) ICS antenna is modeled as moving envelop.

Fig 2.1.9-2(7/21) Viewing analysis from the EF payload

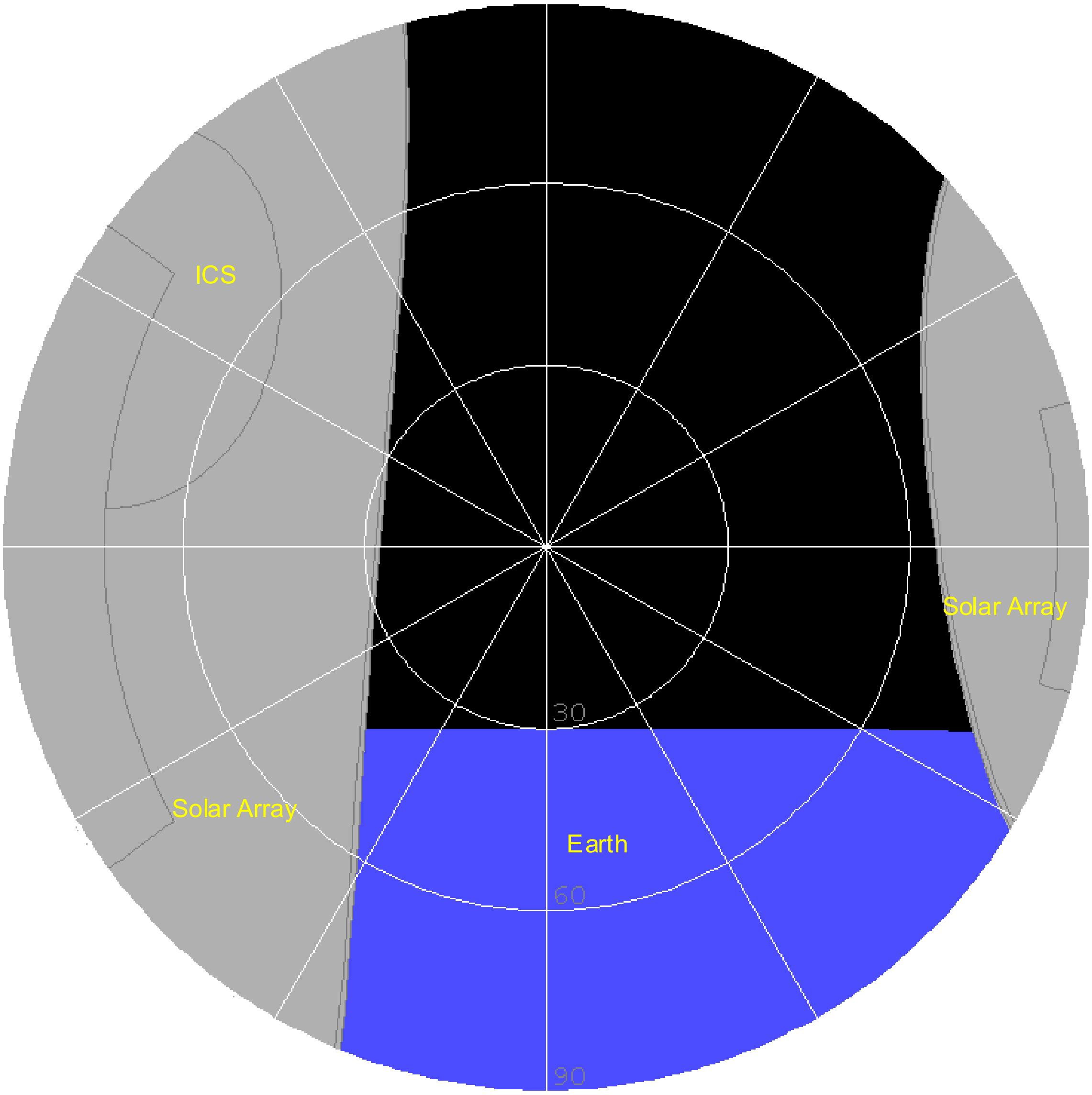


Viewing Point : Center of the lower face of EFU#5 payload

Viewing Direction : Nadir

(Note 1) Refer Fig 1.1-1 for the location of EFU#.
(Note 2) ISS flies in LVLH attitude, and the altitude is 407 km.
(Note 3) Solar array is modeled as moving envelop.
(Note 4) KIBO Robot arm is in Stowed Position.
(Note 5) ICS antenna is modeled as moving envelop.

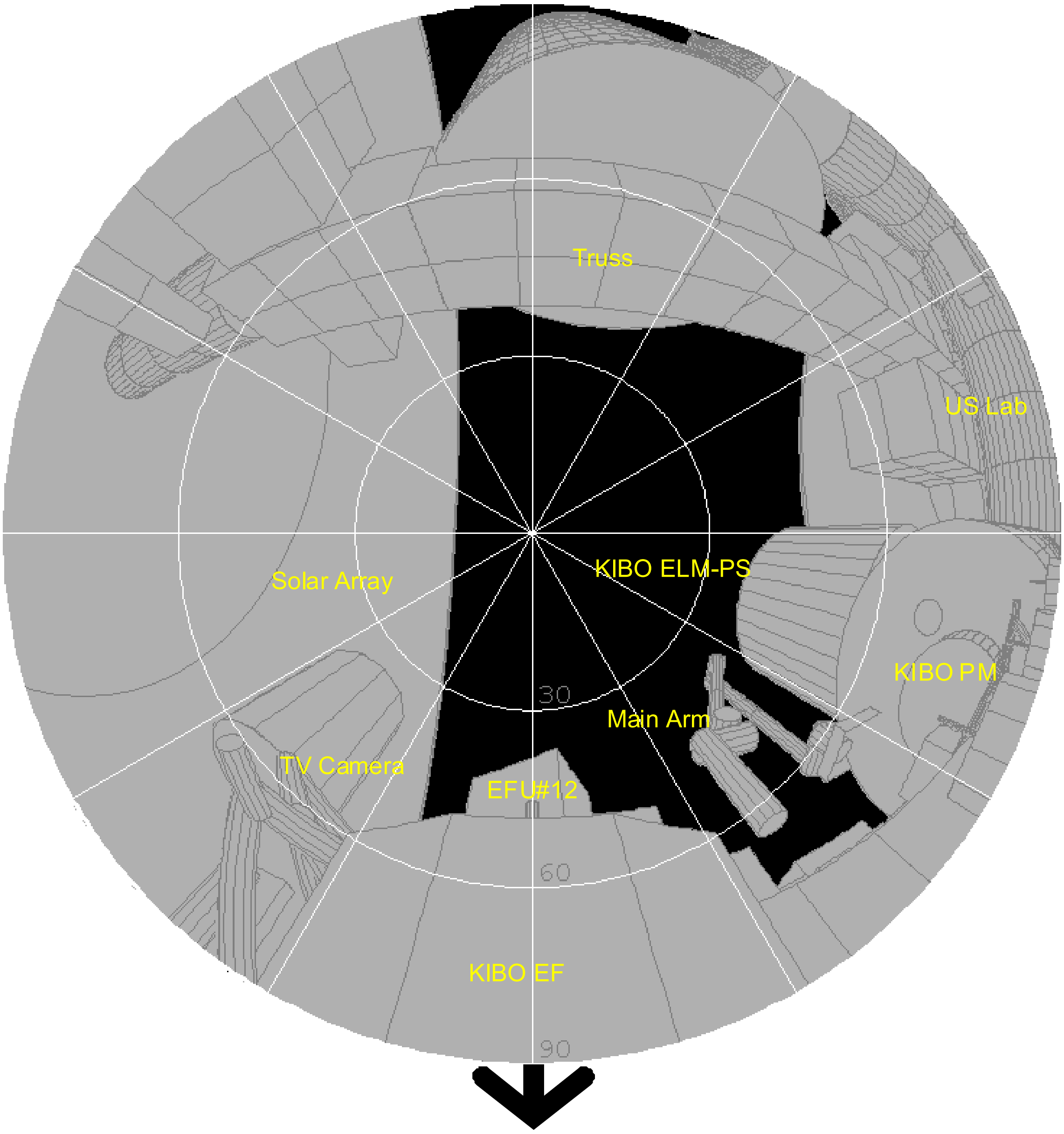
Fig 2.1.9-2(8/21) Viewing analysis from the EF payload



Viewing Point : Center of the front face of EFU#5 payload
Viewing Direction : Forward (+X direction in LVLH)

(Note 1) Refer Fig 1.1-1 for the location of EFU#.
(Note 2) ISS flies in LVLH attitude, and the altitude is 407 km.
(Note 3) Solar array is modeled as moving envelop.
(Note 4) KIBO Robot arm is in Stowed Position.
(Note 5) ICS antenna is modeled as moving envelop.

Fig 2.1.9-2(9/21) Viewing analysis from the EF payload

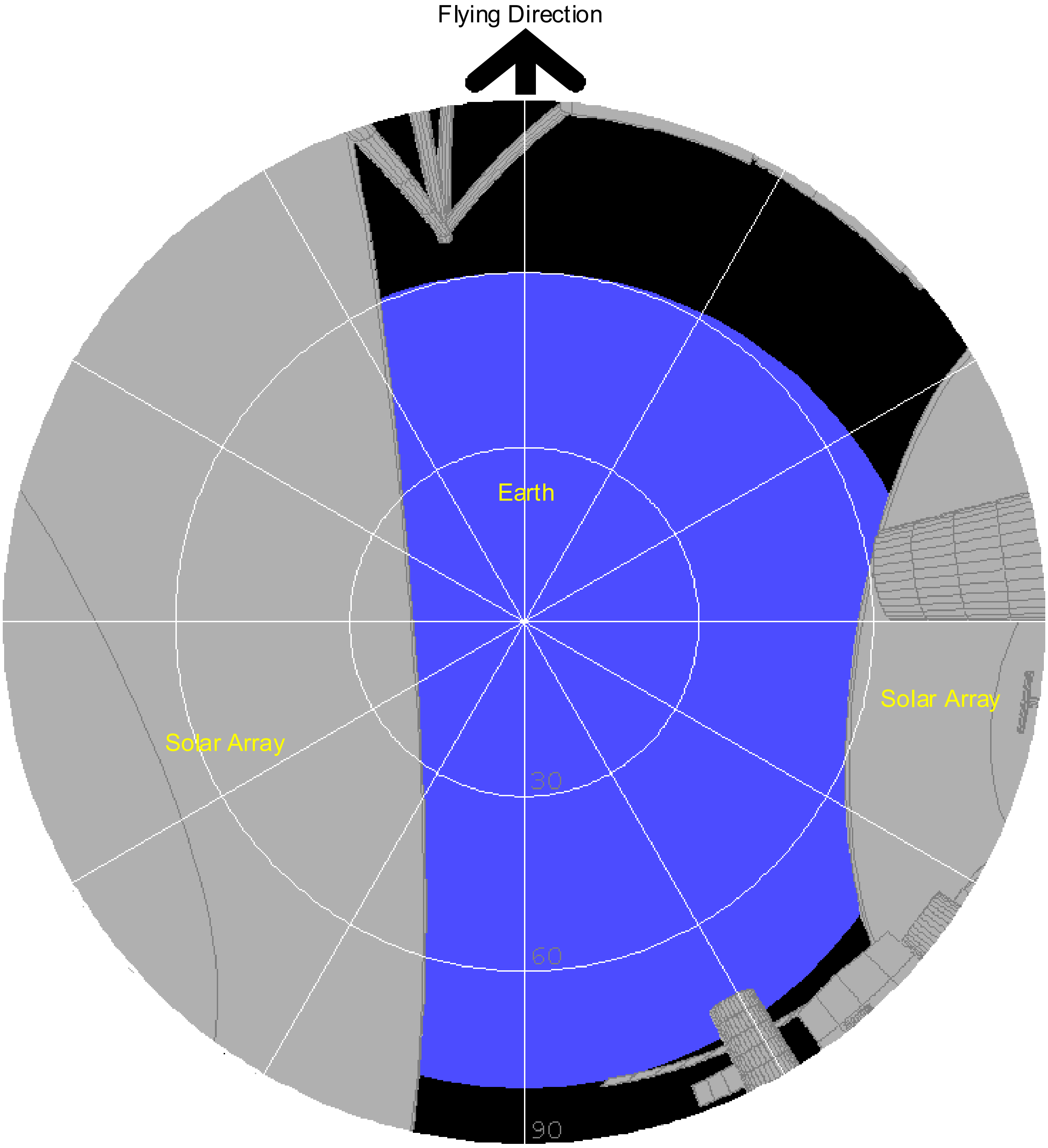


Viewing Point : Center of the top face of EFU#8 payload

Viewing Direction : Zenith

(Note 1) Refer Fig 1.1-1 for the location of EFU#.
(Note 2) ISS flies in LVLH attitude, and the altitude is 407 km.
(Note 3) Solar array is modeled as moving envelop.
(Note 4) KIBO Robot arm is in Stowed Position.
(Note 5) ICS antenna is modeled as moving envelop.

Fig 2.1.9-2(10/21) Viewing analysis from the EF payload

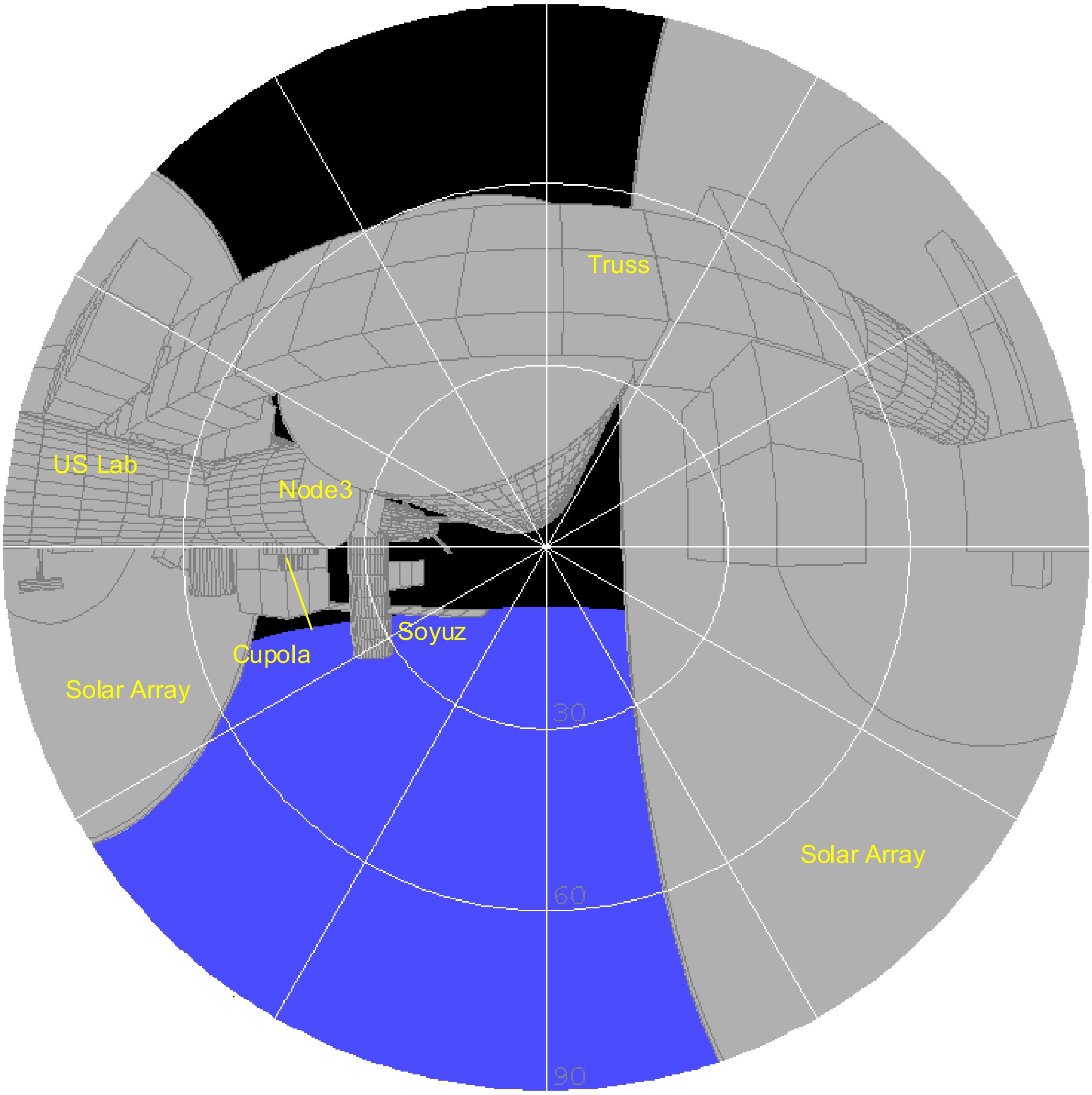


Viewing Point : Center of the lower face of EFU#8 payload

Viewing Direction : Nadir

(Note 1) Refer Fig 1.1-1 for the location of EFU#.
(Note 2) ISS flies in LVLH attitude, and the altitude is 407 km.
(Note 3) Solar array is modeled as moving envelop.
(Note 4) KIBO Robot arm is in Stowed Position.
(Note 5) ICS antenna is modeled as moving envelop.

Fig 2.1.9-2(11/21) Viewing analysis from the EF payload

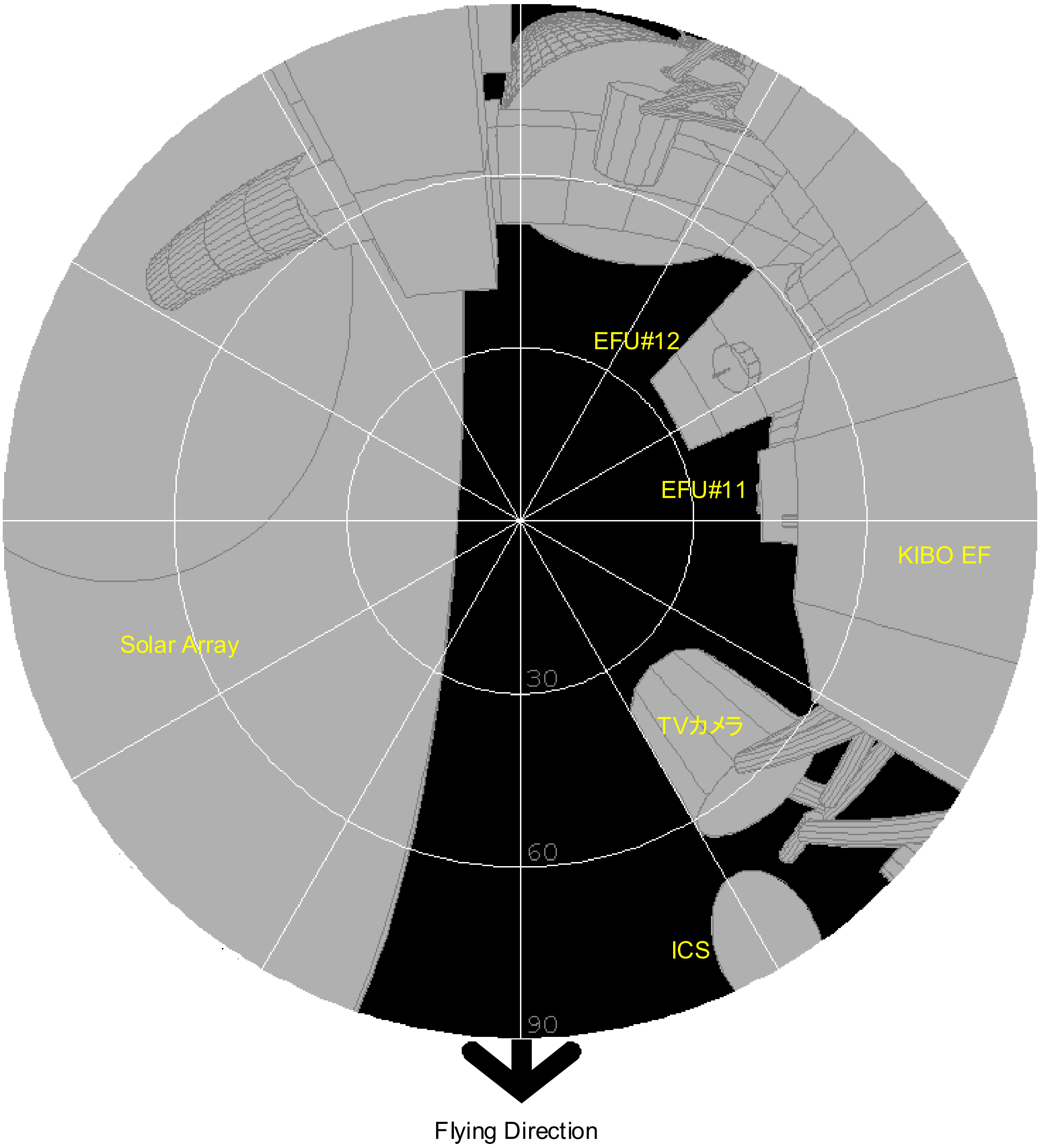


Viewing Point : Center of the front face of EFU#8 payload

Viewing Direction : Aft (-X direction in LVLH)

(Note 1) Refer Fig 1.1-1 for the location of EFU#.
(Note 2) ISS flies in LVLH attitude, and the altitude is 407 km.
(Note 3) Solar array is modeled as moving envelop.
(Note 4) KIBO Robot arm is in Stowed Position.
(Note 5) ICS antenna is modeled as moving envelop.

Fig 2.1.9-2(12/21) Viewing analysis from the EF payload

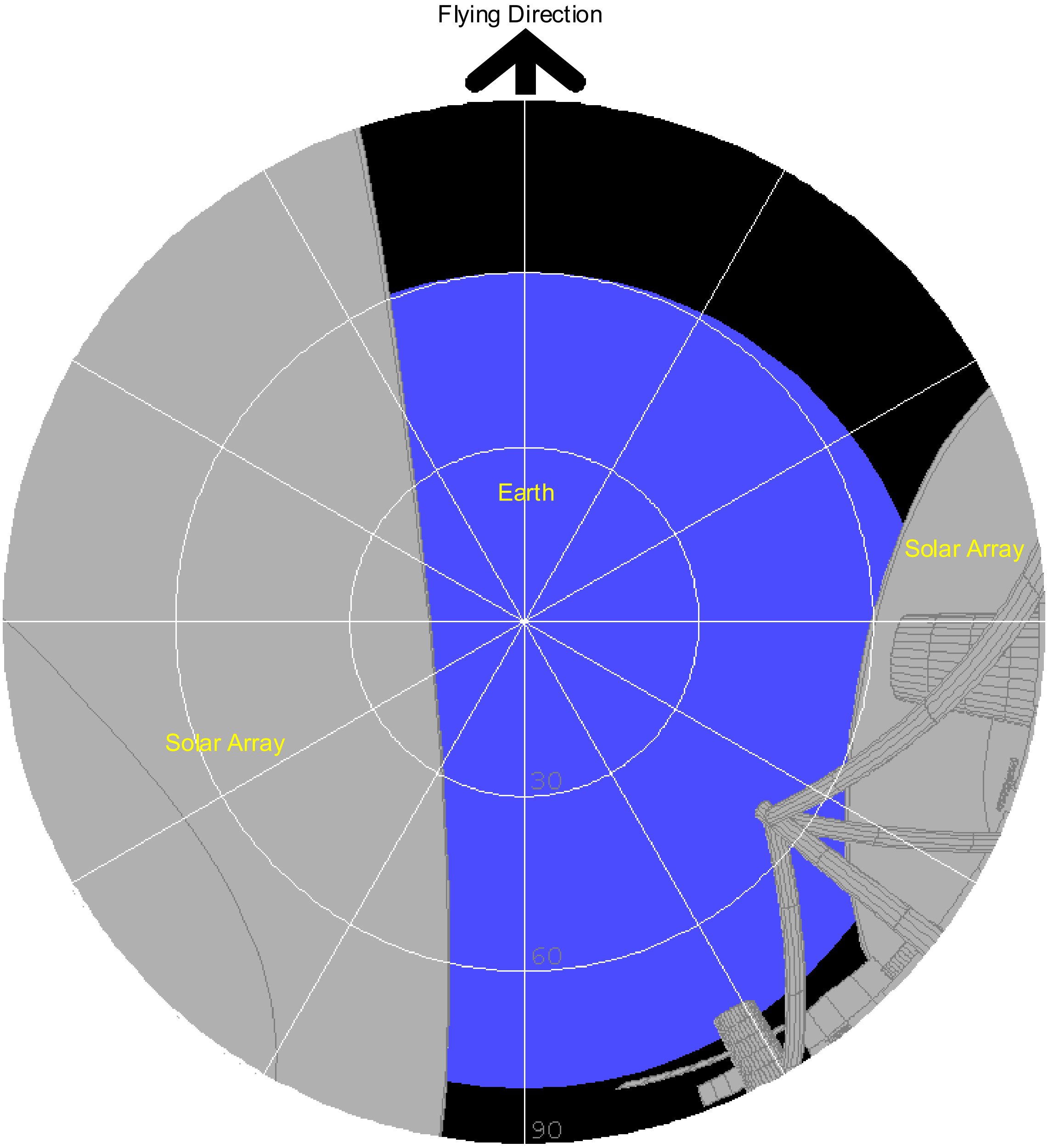


Viewing Point : Center of the top face of EFU#9 payload

Viewing Direction : Zenith

(Note 1) Refer Fig 1.1-1 for the location of EFU#.
(Note 2) ISS flies in LVLH attitude, and the altitude is 407 km.
(Note 3) Solar array is modeled as moving envelop.
(Note 4) KIBO Robot arm is in Stowed Position.
(Note 5) ICS antenna is modeled as moving envelop.

Fig 2.1.9-2(13/21) Viewing analysis from the EF payload

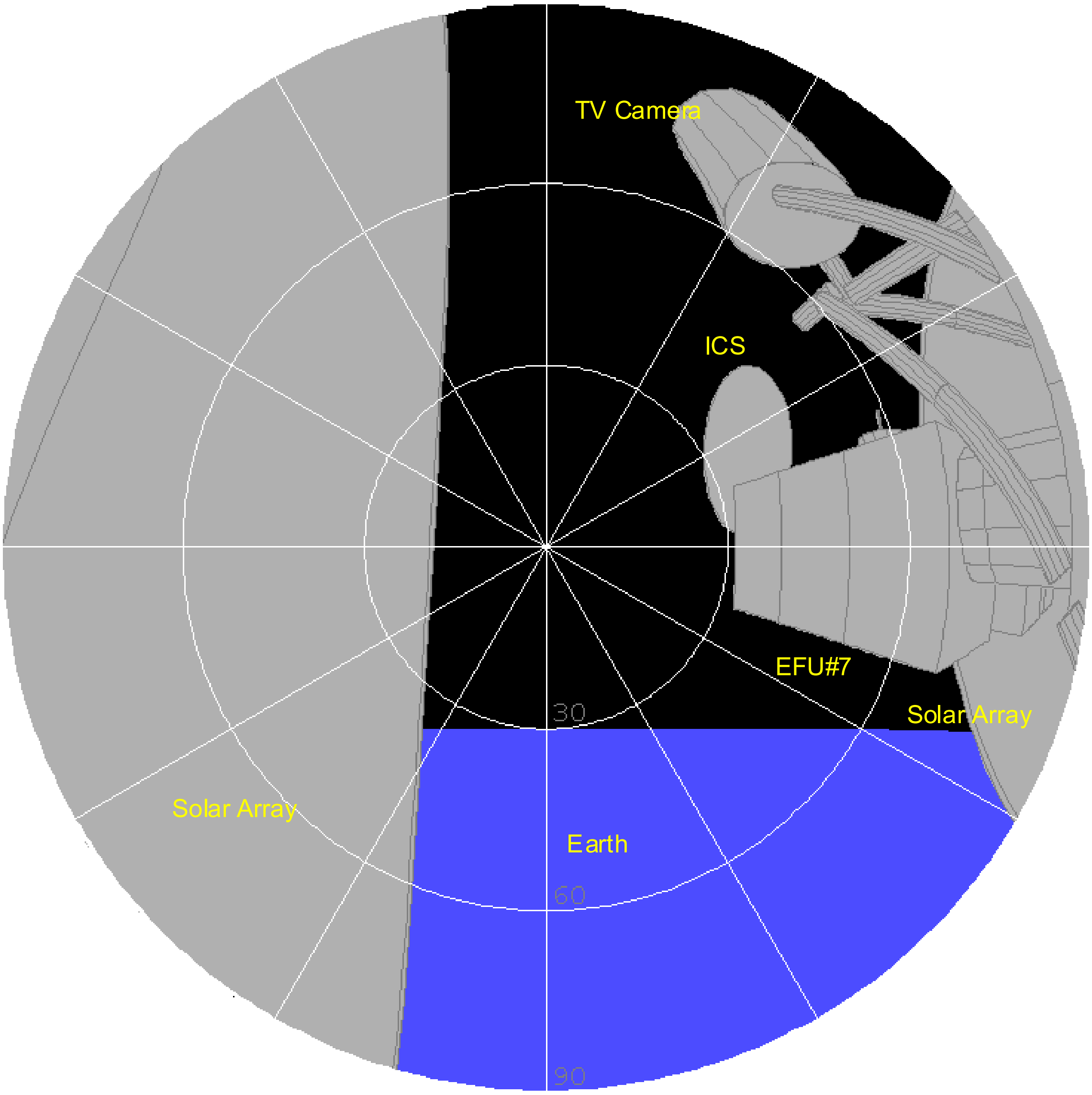


Viewing Point : Center of the lower face of EFU#9 payload

Viewing Direction : Nadir

(Note 1) Refer Fig 1.1-1 for the location of EFU#.
(Note 2) ISS flies in LVLH attitude, and the altitude is 407 km.
(Note 3) Solar array is modeled as moving envelop.
(Note 4) KIBO Robot arm is in Stowed Position.
(Note 5) ICS antenna is modeled as moving envelop.

Fig 2.1.9-2(14/21) Viewing analysis from the EF payload

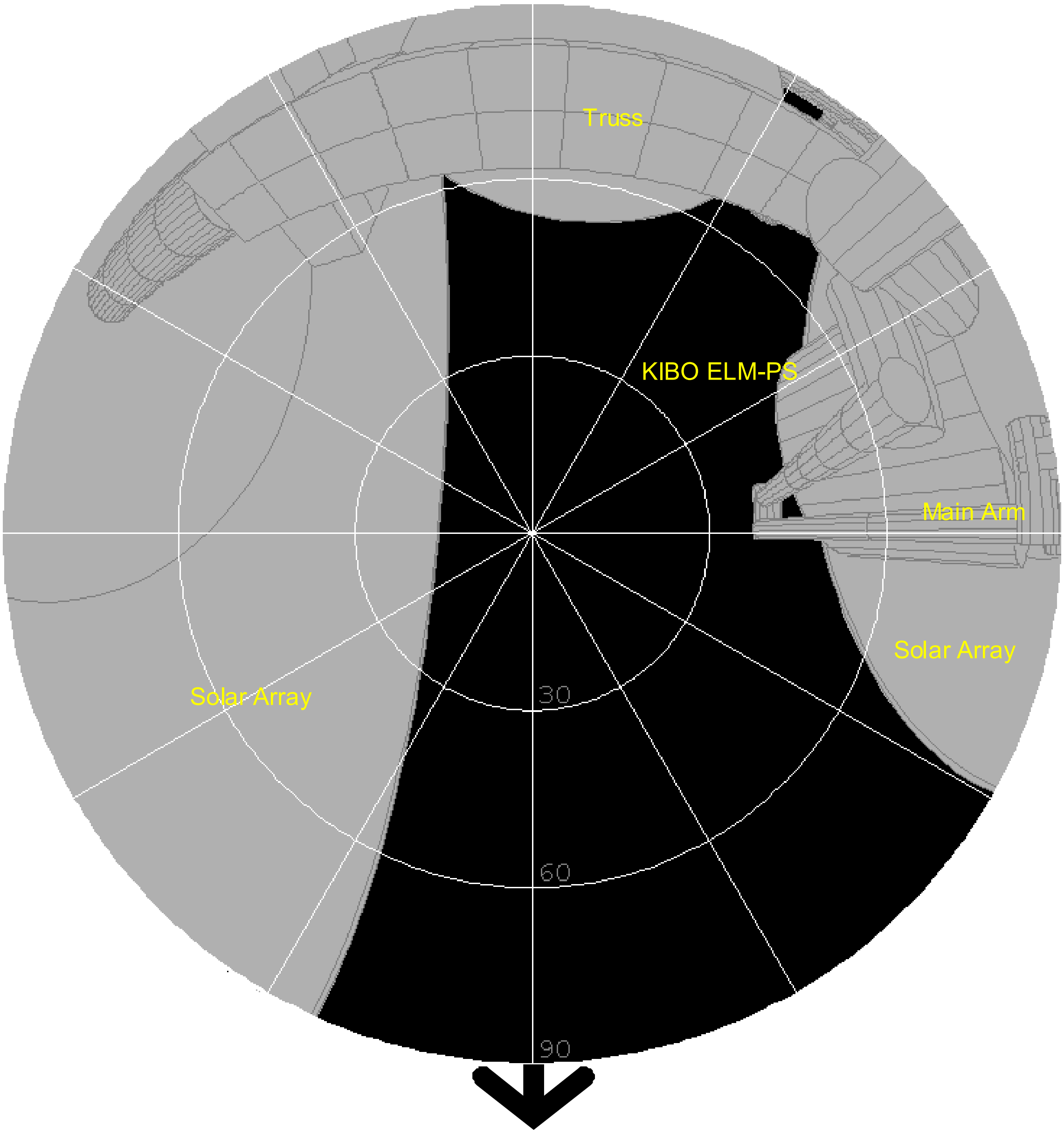


Viewing Point : Center of the front face of EFU#9 payload

Viewing Direction : Forward (+X direction in LVLH)

(Note 1) Refer Fig 1.1-1 for the location of EFU#.
(Note 2) ISS flies in LVLH attitude, and the altitude is 407 km.
(Note 3) Solar array is modeled as moving envelop.
(Note 4) KIBO Robot arm is in Stowed Position.
(Note 5) ICS antenna is modeled as moving envelop.

Fig 2.1.9-2(15/21) Viewing analysis from the EF payload

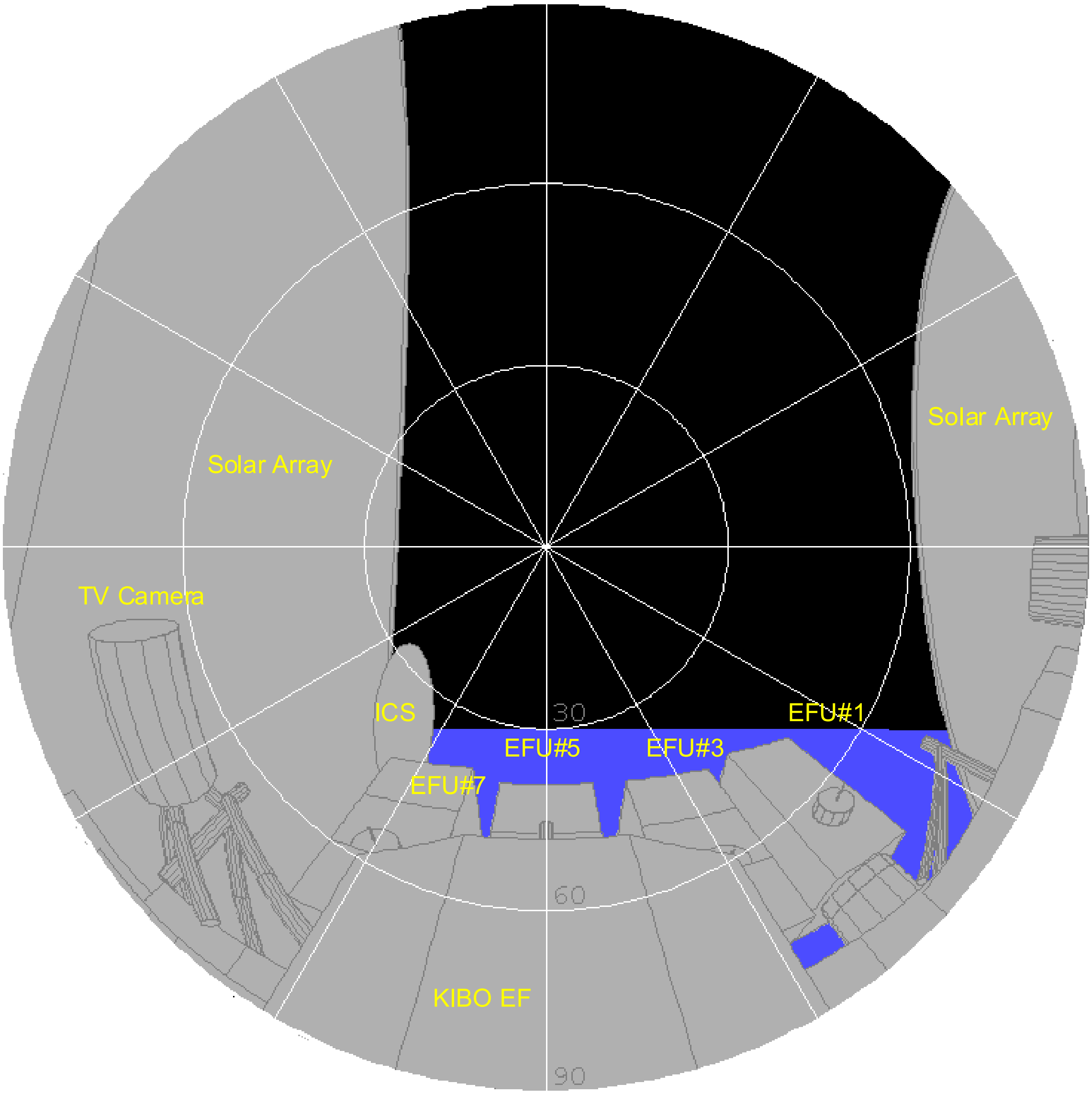


Viewing Point : Center of the top face of EFU#11 payload

Viewing Direction : Zenith

(Note 1) Refer Fig 1.1-1 for the location of EFU#.
(Note 2) ISS flies in LVLH attitude, and the altitude is 407 km.
(Note 3) Solar array is modeled as moving envelop.
(Note 4) KIBO Robot arm is in Stowed Position.
(Note 5) ICS antenna is modeled as moving envelop.

Fig 2.1.9-2(16/21) Viewing analysis from the EF payload

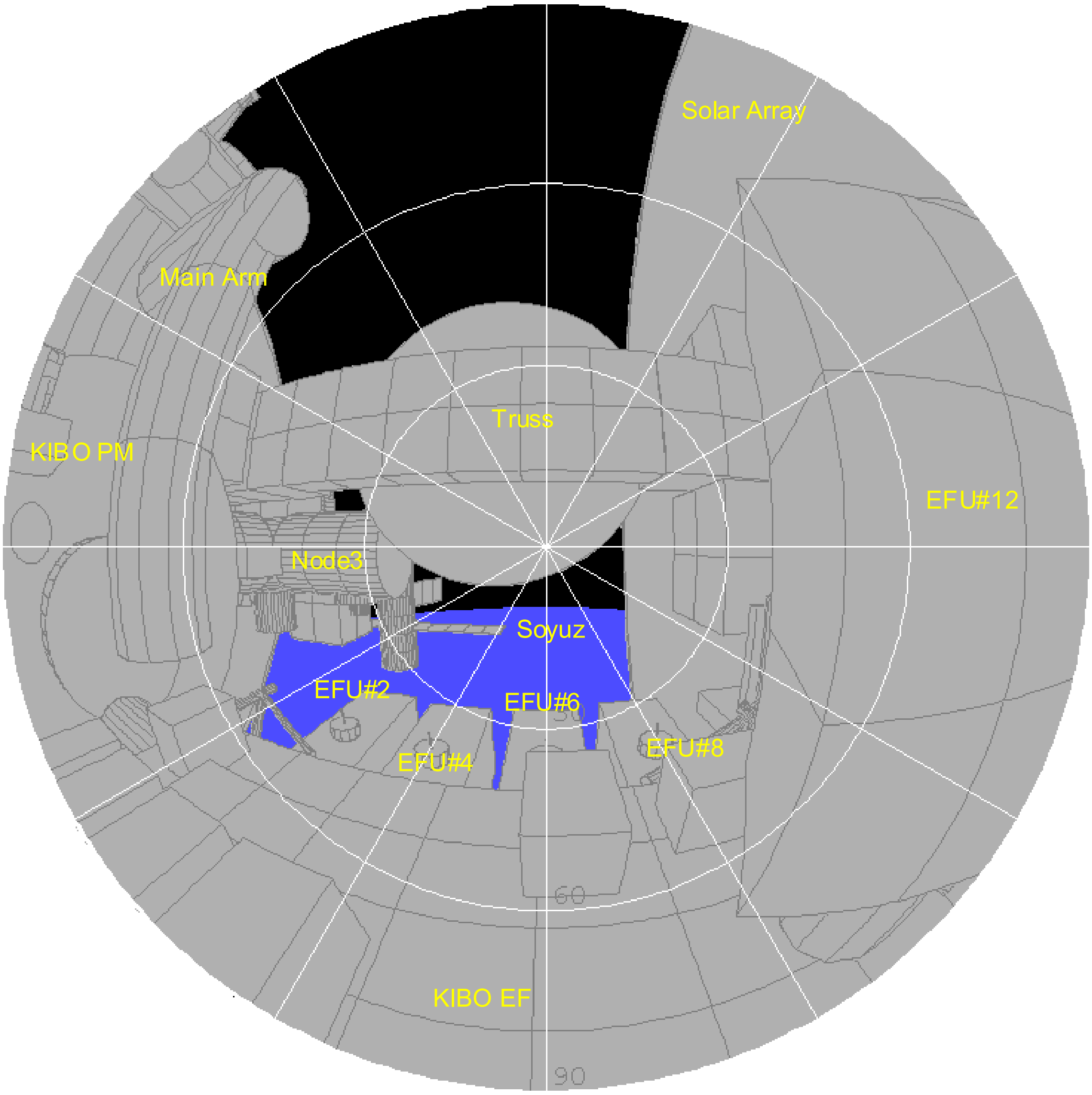


Viewing Point : Center of the front face of EFU#11 payload

Viewing Direction : Forward (+X direction in LVLH)

(Note 1) Refer Fig 1.1-1 for the location of EFU#.
(Note 2) ISS flies in LVLH attitude, and the altitude is 407 km.
(Note 3) Solar array is modeled as moving envelop.
(Note 4) KIBO Robot arm is in Stowed Position.
(Note 5) ICS antenna is modeled as moving envelop.

Fig 2.1.9-2(17/21) Viewing analysis from the EF payload

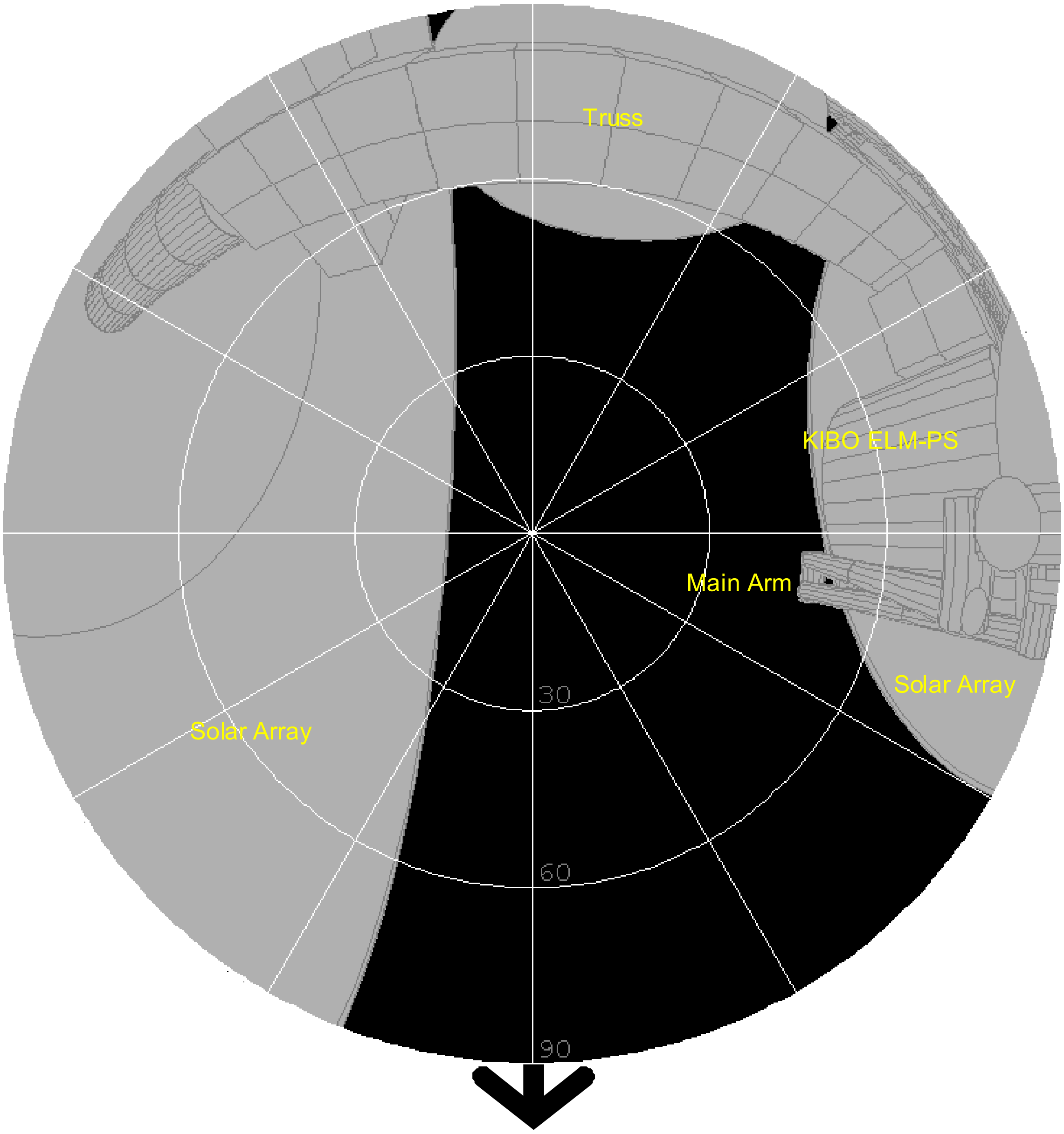


Viewing Point : Center of the front face of EFU#11 payload

Viewing Direction : Aft (-X direction in LVLH)

(Note 1) Refer Fig 1.1-1 for the location of EFU#.
(Note 2) ISS flies in LVLH attitude, and the altitude is 407 km.
(Note 3) Solar array is modeled as moving envelop.
(Note 4) KIBO Robot arm is in Stowed Position.
(Note 5) ICS antenna is modeled as moving envelop.

Fig 2.1.9-2(18/21) Viewing analysis from the EF payload

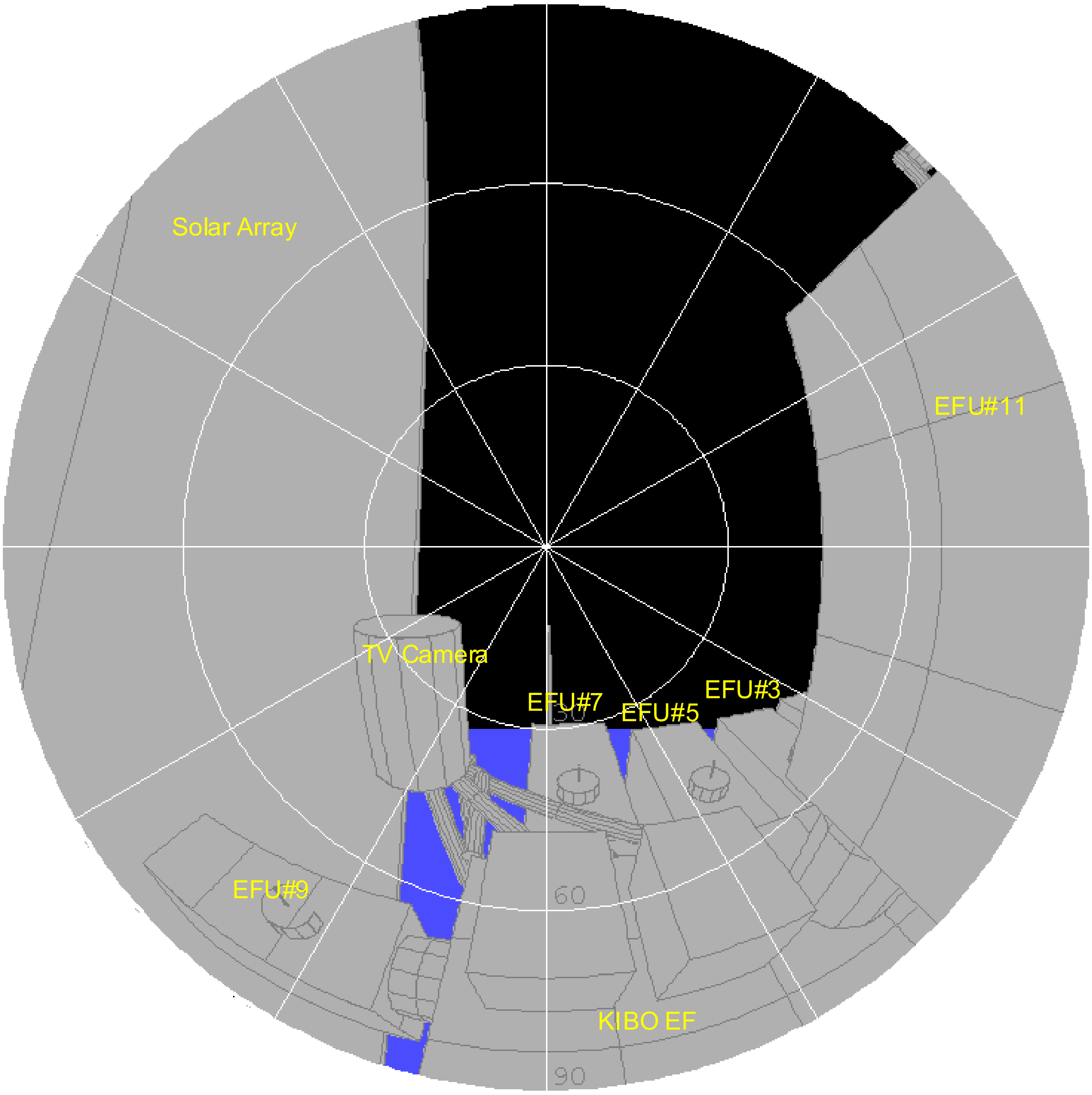


Viewing Point : Center of the top face of EFU#12 payload

Viewing Direction : Zenith

(Note 1) Refer Fig 1.1-1 for the location of EFU#.
(Note 2) ISS flies in LVLH attitude, and the altitude is 407 km.
(Note 3) Solar array is modeled as moving envelop.
(Note 4) KIBO Robot arm is in Stowed Position.
(Note 5) ICS antenna is modeled as moving envelop.

Fig 2.1.9-2(19/21) Viewing analysis from the EF payload

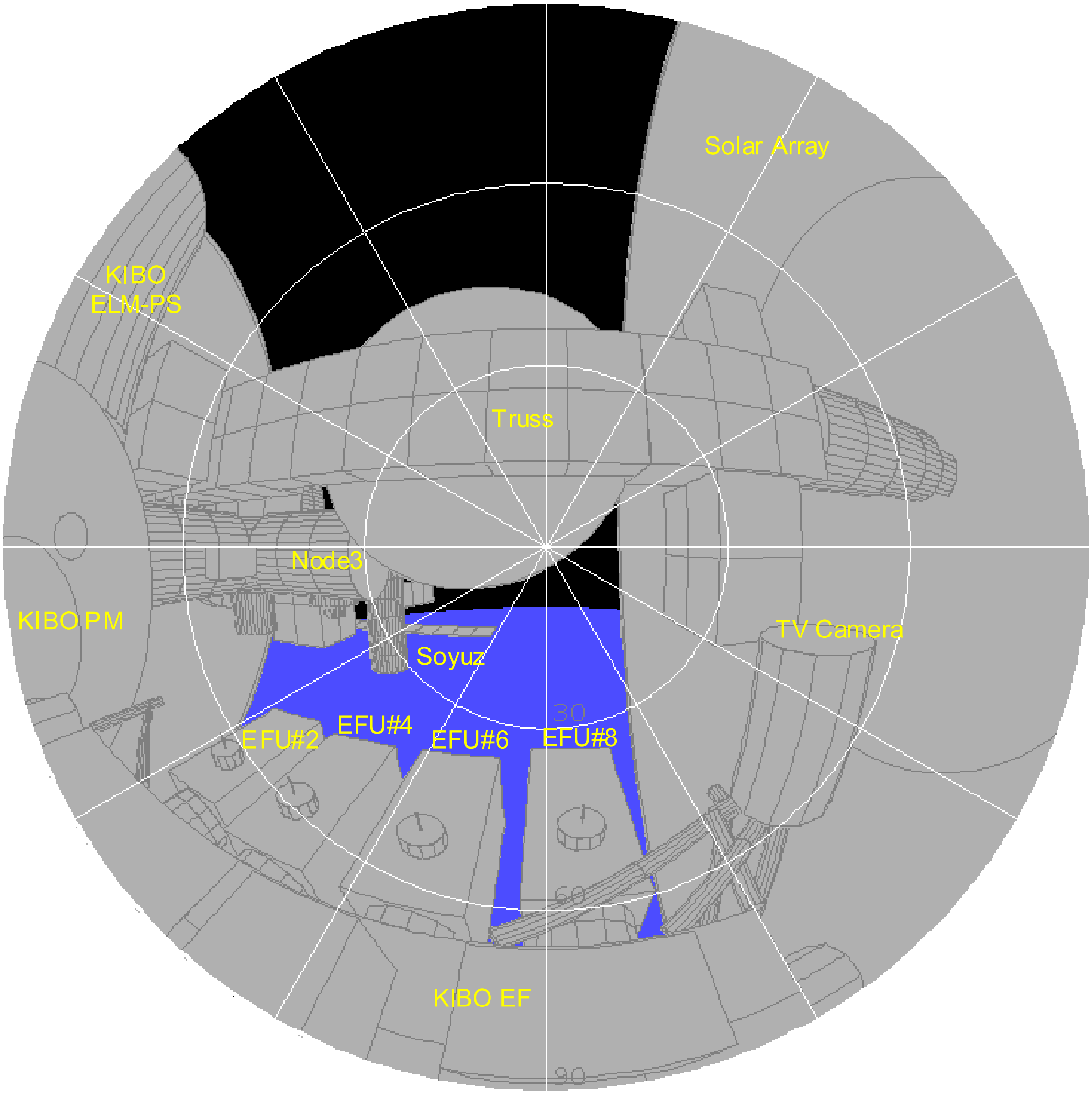


Viewing Point : Center of the front face of EFU#12 payload

Viewing Direction : Forward (+X direction in LVLH)

(Note 1) Refer Fig 1.1-1 for the location of EFU#.
(Note 2) ISS flies in LVLH attitude, and the altitude is 407 km.
(Note 3) Solar array is modeled as moving envelop.
(Note 4) KIBO Robot arm is in Stowed Position.
(Note 5) ICS antenna is modeled as moving envelop.

Fig 2.1.9-2(20/21) Viewing analysis from the EF payload



Viewing Point : Center of the front face of EFU#12 payload

Viewing Direction : Aft (-X direction in LVLH)

(Note 1) Refer Fig 1.1-1 for the location of EFU#.
(Note 2) ISS flies in LVLH attitude, and the altitude is 407 km.
(Note 3) Solar array is modeled as moving envelop.
(Note 4) KIBO Robot arm is in Stowed Position.
(Note 5) ICS antenna is modeled as moving envelop.

Fig 2.1.9-2(21/21) Viewing analysis from the EF payload

2.2 Available Services on the KIBO Exposed Facility

This section describes followings,

- Physical payloads attach points
- On board Services from EF

2.2.1 Physical Payload Attach Point (Port)

There are 12 payloads attach points (Port) on the EF as shown in the Fig 2.2.1-1. The EF can provide power, heat rejection, and communication services at each attach point to support the payload operations.

The following 2 of 12 attach points are for systems equipments, 10 of 12 are available for payloads use.

#7 : ICS Antenna

#10 : HTV Exposed Pallet

Also #12 is mainly designed for the temporal stow position for payload exchange, so the constant use may not be guaranteed.

Table 2.2.1-1 shows the summary specification of EF and Table 2.2.1-2 shows the detail service matrix at the each attach point.

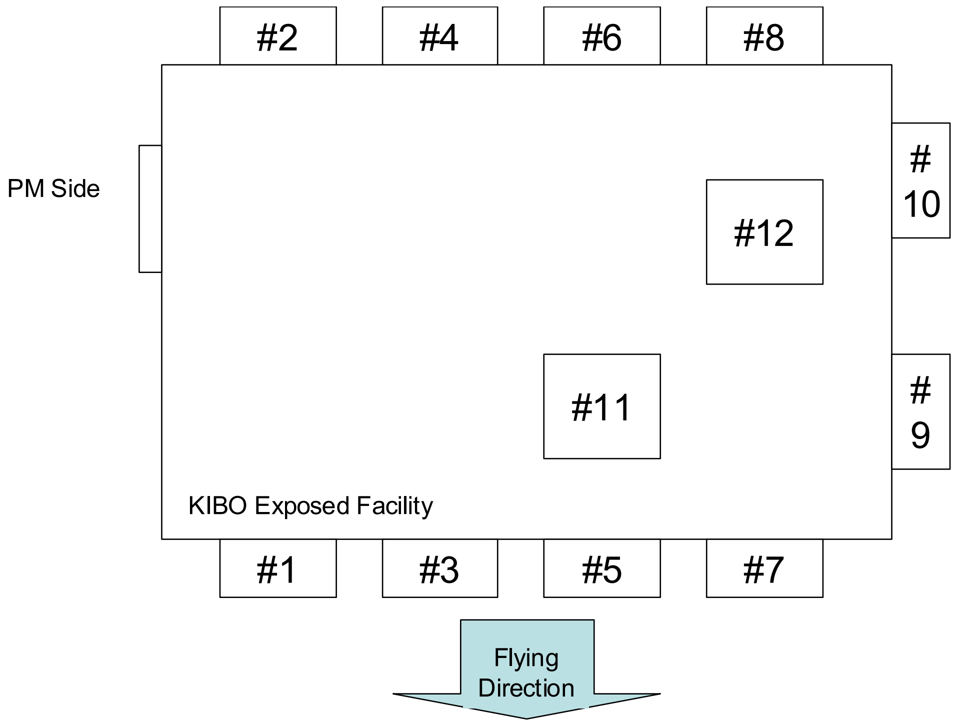


Fig 2.2.1-1 Physical Payloads Attach Points on the EF
(viewed from directly above)

As of August 2010, the following attach points are in use,

#1 : MAXI

#3 : SMILES

#6 : HREP

#7 : ICS

#9 : SEDA-AP

Section 3.3 describes the operations summary of those payloads.

#	Power		Communication								Thermal	Note
	3KW *1	100 W *2	Payload Bus *3	NASA Payload Bus *4	Video *5	High Rate	Ethernet	HK Data *6	ICS I/F	System Bus *7	Cooling (3KW)	
1	2	1	1R *10	1R	1	1	1	2R	-	-	1(6KW)	Currently in use by MAXI
2 *11	2 *8	1	1R	1R	1	1	1	2R	-	-	1(6KW)	
3	1	1	1R	1R	1	1	1	2R	-	-	1	Currently in use by SMILES
4	1	1	1R	1R	1	1	-	2R	-	-	1	
5	1	1	1R	1R	1	1	-	2R	1R	-	1	for ICS Back up
6	1	1	1R	1R	1	1	1	2R	-	-	1	Currently in use by HREP
7	- *9	1	1R	-	-	-	-	2R	1R	-	-	Currently in use by ICS
8	1	1	1R	1R	1	1	-	2R	-	-	1	
9 *11	1	1	1R	1R	1	1	1	2R	-	1R	1	Currently in use by SEDA-AP
10	1	1	1R	1R	-	-	-	2R	-	1R	1	for HTV Exposed Pallet
11	1	1	1R	1R	-	-	1	2R	-	-	1	
12	1 *8	1	1R	1R	-	-	1	2R	-	-	1	Temporal location for payload exchang

Unit : number of channels
Gray mask : Currently in use as of Aug, 2010

*1 : number of power channnels
*2 : number of survival power channels
*3 : number of 1553B bus channels for low rate data
*4 : same as above but dedicated for NASA payloads
*5 : 1ch from #1/4/5/8 and 1ch from #2/3/6/9
*6 : EF housekeeping data interface for KIBO system
*7 : 1553B Bus interface for system control
*8 : Power bus channel B of #2 and power bus of #12 can not be used simultaneously
*9 : Power feed is 0.6 KW
*10 : R shows Redundancy
*11 : Available for the large payloads up to 2.5 t

(Source) JEM Payload Accommodation Handbook Vol.3, EF/Payload Standard ICD (NASDA-ESPC-2563) Dec, 2000

Table 2.2.1-2 Available Service and Resource Matrix for Each Attach Point

2.2.2 Power - up to 3 KW for Operations, 0.6 KW for survival

EF can supply 3 KW power feed at the all attach points. There are 2 power bus channels on #1 and 2 so payload can use Max 6 KW.

100 W survival power feed is available at the all attach points for the heater power supply to avoid payloads freezing in case of failure or non-operational condition.

The power bus channel B of #2 and power bus of #12 can not be used simultaneously. Also, the total maximum number of power feed for the EF payloads is 10 kW.

2.2.3 Heat Rejection - up to 3KW

There is a cooling service at the all attach points but except #7. The EF cooling system is to reject the heat from payloads by rotating the Fluorinert refrigerant. There are 2 cooling channels at attach point #1 and 2 and they have Max 6 KW heat rejection capability. The temperature of the Fluorinert is from 16 to 24 degree C and the flow rate is adjusted against the amount of the heat rejection.

Payloads can release their heat passively in the deep space.

2.2.4 Communication - Low/Medium/High/Video

The EF communication systems can handle the command from the Crew or the ground, the telemetry from the payloads, and experiment data from payloads. The communication services are as follows;

Payload Bus — Low rate communication bus with MIL-STD-1553B. Commands and H&S(Health and Status) telemetries use this line. See NASDA-ESPC-2567 JEM Payload Accommodation Handbook Vol.7 for detail for the MIL-STD-1553B.

Ethernet — Max 8 Mbps
The Ethernet interface which is called Medium rate data link is available on the EF but not for the all attach point. The downlink routes are available thru JAXA ICS or NASA system. Two-way communication is also available between PLT(Payload Laptop Terminal) and the payload.

Next Generation Ethernet — Max 100 Mbps

LEHX (Layer 2 Ethernet Hub and Multiplexer) ,the next generation Ethernet hub is under development and will be launched in 2011 (currently planned to be launched on HTV 2, Feb 2011).
This LEHX will be exchanged with the PEHG-J and improve the following Ethernet capabilities;
- Maximum 100 Mbps in speculation
- Multiplex Medium rate data

High Rate	Max 42 Mbps The high rate data link via light fiber is also available on the EF but not for the all attach point. The downlink routes are available thru JAXA ICS or NASA system.
Video	Max 2 channels simultaneously The EF video system can handle 2 channels NTSC video simultaneously, 1 channel from #1/4/5/8 and 1 channel from #2/3/6/9. The downlink routes are available thru JAXA ICS or NASA system. The video can be recorded at the IPU (image Processing Unit) in the JEM Pressurized Module.

2.2.5 ICS (Interorbit Communication System) - 2-3 times a day, about 20 min/1 time

The ICS is the Japanese communication system which is independent from any US communication system and the ICS is available for data downlink, command and file uplink, and voice communication.

NASA use 15 GHz frequency, a.k.a. Ku Band, for the experiment and image data downlink but the ICS use 23/26 GHz frequency, a.k.a. Ka band. User can use this ICS if the Ku Band is busy or no vacant channels.

The communication between the ICS and the ground is via DRTS (Data Relay Test Satellite) and the other Japanese satellite also use this DRTS so the average ICS available time for the ISS is approximately twice or three times a day, and 20 minutes per 1 time (average from June – August, 2010). The ICS data processing unit in the KIBO PM can record the data. Refer 2.3.7 for detail.

		Specification
Size		1.1 x 0.8 x 2.0m (Antenna Stow) 2.2 x 0.8 x 2.0m (Antenna Deploy)
Weight		310kg
Data rate /frequency /modulation method	ICS to GRD	50Mbps/26GHz/QPSK
	GRD to ICS	3Mbps/23GHz/BPSK
DRTS Communication Window		Up to 40 min/1 pass

QPSK : Quadrature Phase Shift Keying

BPSK : Binary Phase Shift Keying

Table 2.2.5-1 ICS Specification

Fig 2.2.5-1 ICS First Communication Test
Aug 21, 2009

Besides the current on-board services mentioned above, the following new service is under study for the EF payloads.

- Wifi for EF payloads

2.3 Other On-orbit Services

This section describes the services which the EF payloads can get from other than EF.

2.3.1 KIBO Robot Arm - Transfer and Install the Payload

There are two parts of KIBO robot arm, the Main Arm (MA) and the Small Fine Arm (SFA).

The MA is operated by the Crew from the Robotics workstation in the PM. The MA grapples the ISS standard fixture which is called Grapple Fixture (GF) and berth the exposed payload to the EF. Crew and the ground can monitor the arm motion via TV camera on the MA.

There are two types of GFs, one is PDGF (Power and Data Grapple Fixture) and the other is FRGF (Flight Releasable Grapple Fixture), the MA can grapple both GF type.

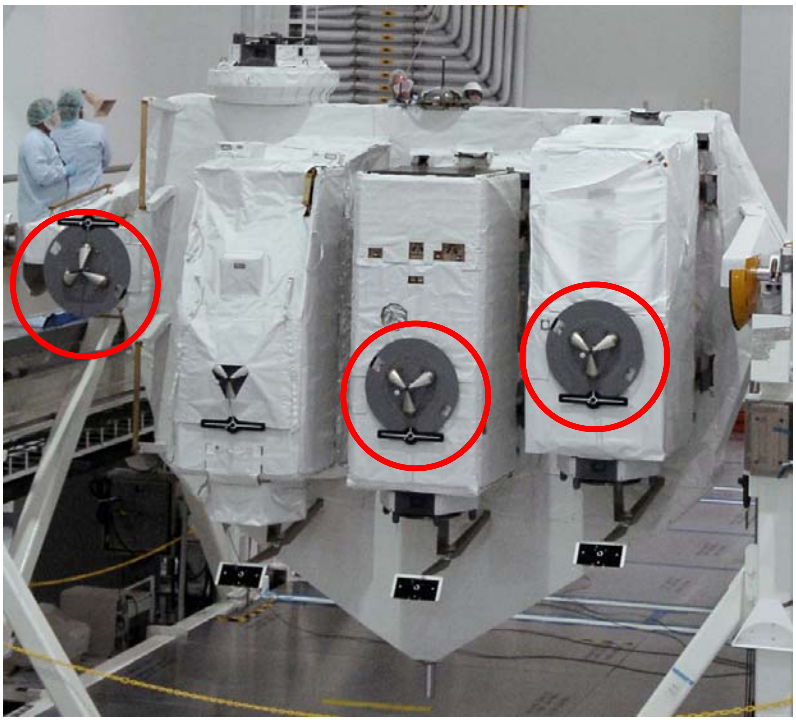


Fig 2.3.1-1 Grapple Fixture

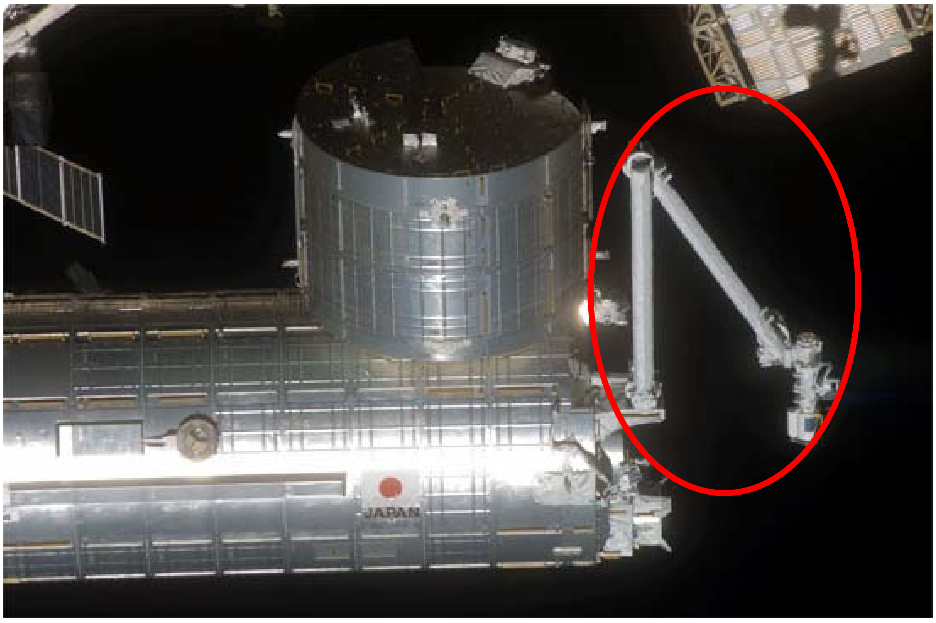


Fig 2.3.1-2 Main Arm
June 11, 2008

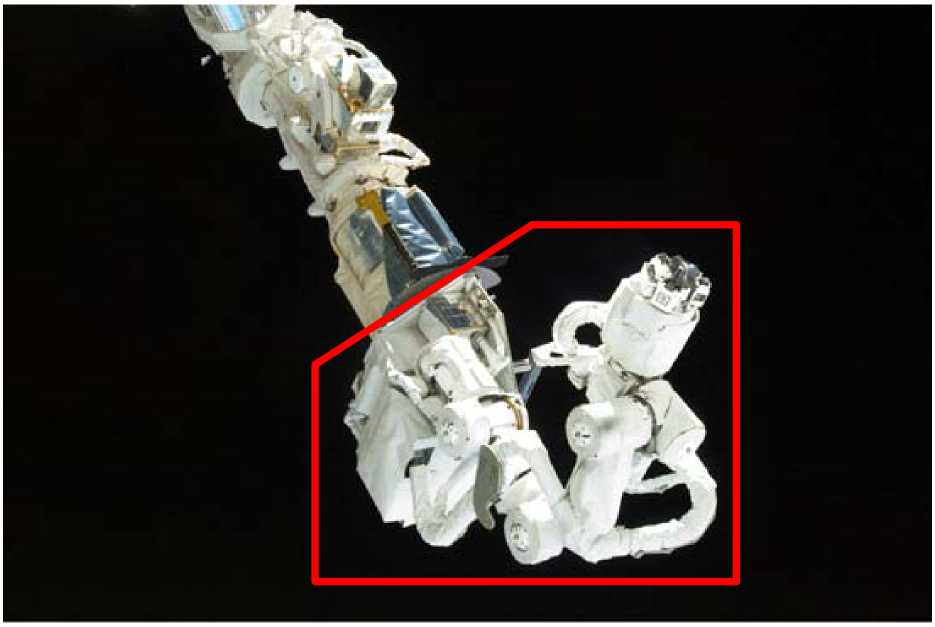


Fig 2.3.1-3 Small Fine Arm
March 10, 2010

SFA is normally stowed in the SSE (SFA Stowage Equipment) on the EF and MA grapples SFA when operational.

The SFA is not used yet as of August 2010 but is to be used for exchanging the EF ORU (Orbital Replaceable Unit).

	Specification	
	MA	SFA
Type	Main Arm with attached Small Fine Arm. Both arms have 6 joints	
DOF	6	6
Length	10m	2.2m
Weight	780kg	190kg
Handling Capacity	Max 7000kg	Max 300kg
Positioning Accuracy	Translation ± 50mm	Translation ± 10mm
	Rotation ± 1 degree	Rotation ± 1 degree
Tip Speed	60mm/s(Target : 600 to 3000kg)	50mm/s(Target : 80kg or less)
	30mm/s(Target : 3000kg or less)	25mm/s(Target : 80 to 300kg)
	20mm/s(Target : 3000 to 7000kg)	-
Maximum Tip Force	Over 30N	
Lifetime	Over 10 years	

Table 2.3.1-1 KIBO Robot Arm Specification

2.3.2 KIBO Airlock

The KIBO airlock is used to transfer equipments from pressurized section to the outer space, however it is not available for the EVA Crew use such as US Quest and Russian MRM-2 airlock.

The SFA described in the section 2.3.1 was assembled in the PM and transferred on the EF thru this KIBO airlock.

The airlock specification is shown in the Table 2.3.2-1, and the equipment envelope is shown in the Fig 2.3.2-3

Section 3.2.4 describes the current study summary of future airlock usage for transferring the small payloads or small satellites thru KIBO airlock.

Fig 2.3.2-1 KIBO Airlock January 6, 2010
(SAF is attached on the slide table. Photo from overhead side)

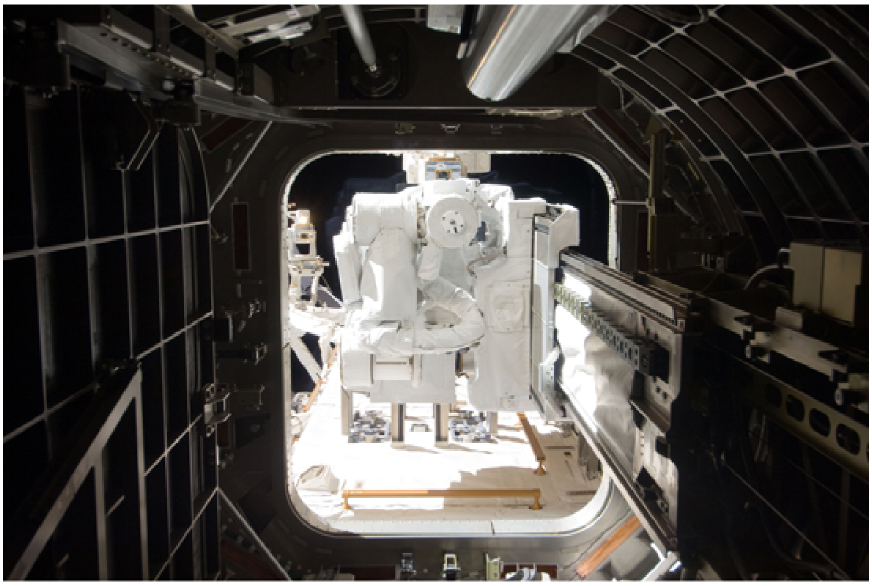


Fig 2.3.2-2 KIBO Airlock March 11, 2010
(Extending the slide table to the outer space)

	Specification
Diameter	1.7m (EF side)
	1.4m (PM side)
Length	2.0 m
Pressure Capacity	1047 hPa
Maximum Payload Envelope	0.64 x 0.83 x 0.80m
Maximum Payload Weight	300 kg
Power Consumption	Max 600W

Table 2.3.2-1 KIBO Airlock Specification

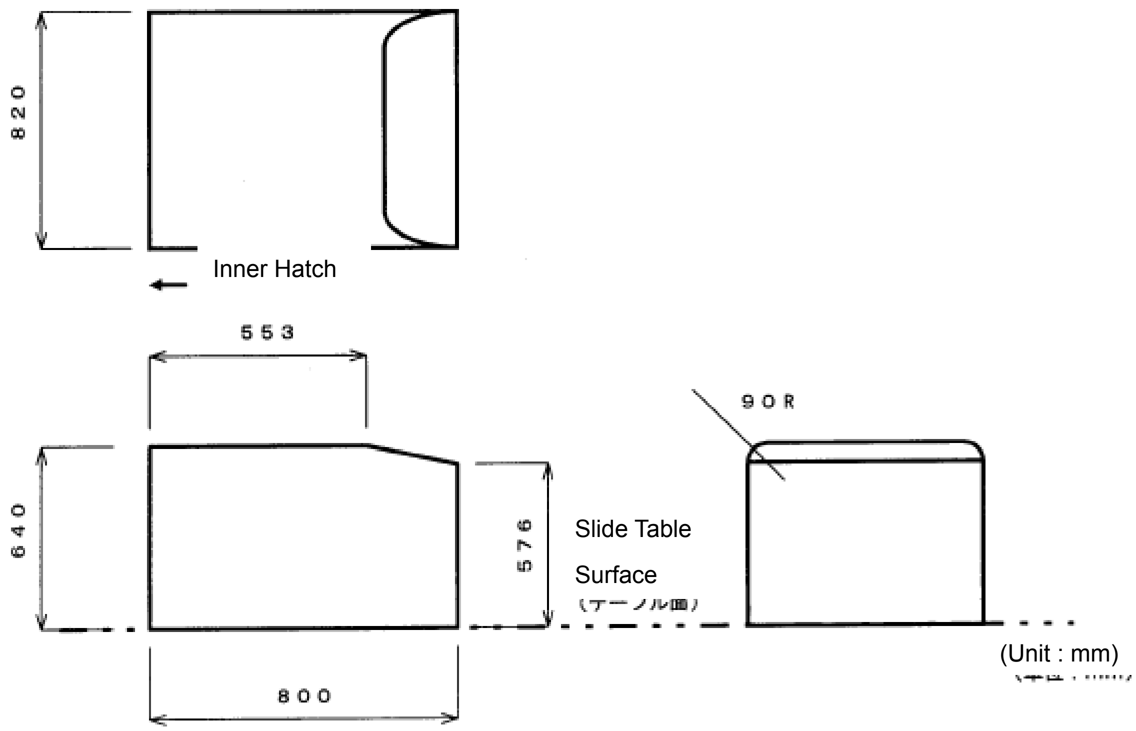


Fig 2.3.2-3 Equipment Envelope

2.3.3 Crew Time - 3 - 4 hours a week

There are up to 6 Crew members on board and they work 5 day a week and 8 hours a day. Since 3 of 6 Crew are responsible for the Russian module, basically they don't work for US module including KIBO.

The Crew work time is planed to use for the ISS system maintenance first and the rest of Crew time is shared by JAXA, NASA, ESA, and CSA for their utilization.

The Crew time for the JAXA utilization is approximately 3 - 4 hours per week on average since the KIBO launch on May 2008, but the number is negotiable in the planning and could plan more Crew hours for an activation phase or critical operations phase.

2.3.4 Voice - Operations Instructions

Voice communication system does not have direct interface with the EF payloads but the ground can inform any instruction for the payload operations to the Crew via voice communication system.

2.3.5 KIBO TV Camera

KIBO has the following TV camera systems,

- 4 cameras on the PM (2 are inside and 2 are outside)
- 2 cameras on the EF
- 2 cameras on the Robot arm

User can monitor the payload exterior or deploy/extension status via those TV cameras. Fig 2.3.5-1 shows the TV camera physical location.

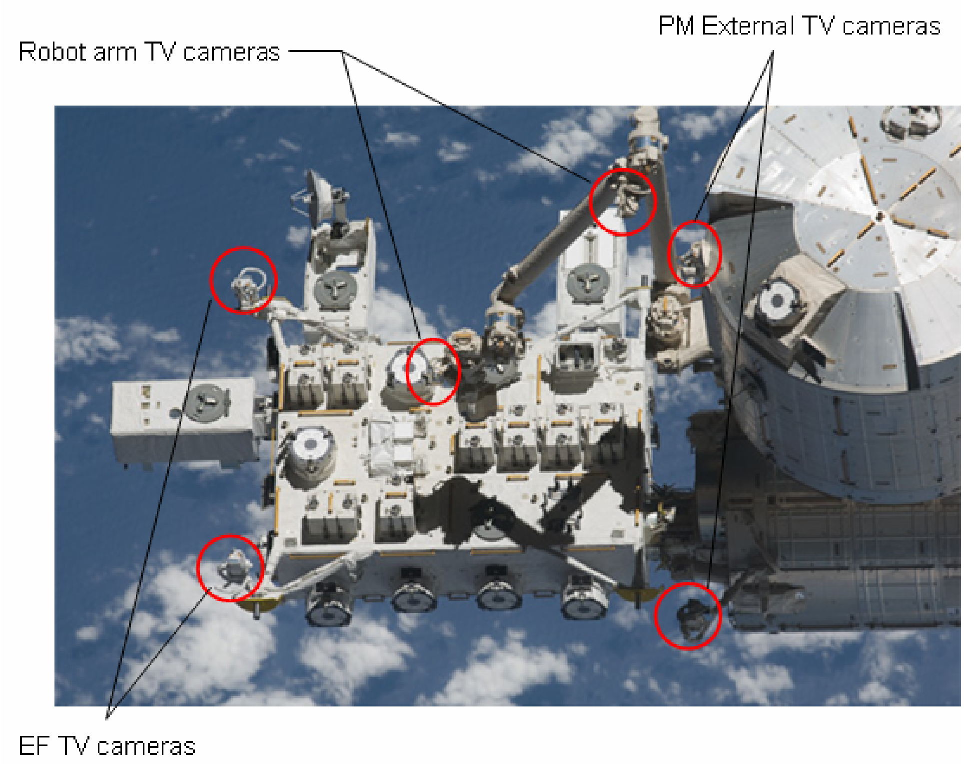


Fig 2.3.5-1 TV Camera Location

2.3.6 On Board Laptop Computer

Crew can monitor the experiment and payload status via PLT from PM. However, the payload operations monitoring are basically performed by the ground and the Crew just support the ground operations. If Crew time is required, it should be coordinated and scheduled in the planning process.

2.3.7 Data Recording

User can ask to record their experiment data on board temporarily at NASA COR (Communication Outage Recorder) or ICS HRDR (High Rate Data Recorder).

The COR can record the high rate data only but the ICS HRDR can record high rate data and medium rate data. Also, KIBO has IPU in the PM and it can record the NTSC video. KIBO Medium Rate Date through the Ethernet is integrated into High Rate Data System in the US module so the COR can record KIBO Medium Rate Data also.

The ICS HRDR can record the data during the loss of signal (LOS) period up to 24 Gbit and start downlink during the acquisition of signal (AOS) period.

[Note]

24 Gbit : can record approximately 13.3 hours for 500 Kbps rate data

The IPU can receive up to 6 channels analogue video data simultaneously from PM/EF payloads including US payloads on PM/EF. These data are recorded in the Video Record Unit (VRU) as digitized data and encode to MPEG2 format and downlink to the ground via the high rate data link. There are 6 replaceable 120 GB VRUs in the IPU and accessing to the VRU is easy from the IPU front panel.

1 Ethernet HUB can be installed in the IPU instead of 1 VRU and users can downlink the recorded video in the Motion JPEG format as a data file thru this HUB. The IPU is a kind of communication platform in KIBO to handle and support a variety of data.

IPU can also downlink experiment data received from the Ethernet interface.

The summary of the IPU functions is as follows;

- Receive and record analogue video data
- Display receiving or recorded video on the IPU monitor
- Decode and downlink receiving or recorded video
- Downlink the experiment data from Ethernet

	Specification	
Interface	High Rata Data Link (HRDL)	Input 1ch Output 1ch
	Medium Rate Data Link (Ethernet)	Input/Output 1ch
	Low Rate Data link (1553B)	Input/Output 1ch
	RS422	Input/Output 1ch
	User Vide Input/SYNC output	Input 6ch Output 6ch
Video Decoding/ Downlink	MPEG2	5ch multiplex, 1ch Decoding
	Variable Time Resolution	GOP Sequence Selection
	Downlink Rate	1.5 - 15Mbps/channel Up to 43 Mbps/Total
	Video Clip File Downlink	Up to 12Mbps Up to 2 GB/1 video clip
Data Storage	Recording Method	Motion JPEG (Harris DVR-3901)
	Number of VRUs	6 (but 5 if 1 HUB）
	Density	17 - 42Mbps

	Recording Time (120GB HDD)	Approx. 12h 30m@17Mbps Approx. 8h 40m@25Mbps Approx. 5h 20m@42Mbps
Crew Interface	LCD Monitor	12.1 Inch, Touch panel
On Board Monitor	LCD Monitor	1/2/4 split screen
HDD	Removable HDD	120 GB

Table 2.3.7-1 IPU Specification

2.4 Ground Services

This section describes the available services from the ground for the EF payloads.

2.4.1 Payload Planning

There are approximately 40 payload locations in the entire ISS pressurized module and 20 attach points on the unpressurized module. Since All agencies and all users need to share the limited on board resources for those payloads operations, payload planning and scheduling need to be coordinated thru multilateral planning community.

The ISS planning is categorized as Strategic, Tactical, and Execution level and each planning community develop and breakdown the plans from yearly basis to minutely basis. In the Strategic level, 5 year-long utilization plan is developed within the allocated resources to each agency.

In the Tactical level, each agency develop their Increment plan based on the payloads objectives, launch/return requirements, up/down mass, up/down volume, and resources for each launch vehicle within that Increment. A Tactical planning community integrates all increment plans from agencies and released as IDRD (Increment Definition and Requirements Documents). The Increment is duration from Crew rotation to Crew rotation and it is approximately 3 – 6 months. Users are expected to provide their requirements for payload operations such as Crew time, launch mass, etc, in this time frame.

In the Execution level, the International planning community develops a daily basis plan called OOS (On orbit Operations Summary) and is released 1 month prior to the Increment start.

The minutely basis plan is developed based on the OOS and uplinked to the ISS for Crew review.

2.4.2 User Operations Area

The overall ISS realtime operations are lead by Johnson Space Center (JSC) and the ISS payload operations are lead by Payload Operations and Integration Center (POIC) of Marshall Space Flight Center (MSFC). KIBO is controlled by Space Station Integration and Promotion Center (SSIPC) of Tsukuba Space Center.

EF payloads users can operate their payloads from the User Operations Area (UOA) of SSIPC and the users located off site can also monitor their experiment data.

Users can use the following facilities and equipments in the UOA;

(1) Equipments at the UOA

The UOA provides the experiment support client computers, voice terminal, video monitors, and time displays as shown in the Fig 2.4.2-1.

User can monitor the experiment data and ancillary data, and issue the command via the experiment support client computers. User Built-In Software (U-BIS) is also installed in these client computers and this UBIS provides graphical output, ISS position in orbit, attitude and altitude, and command pre-set to support users.

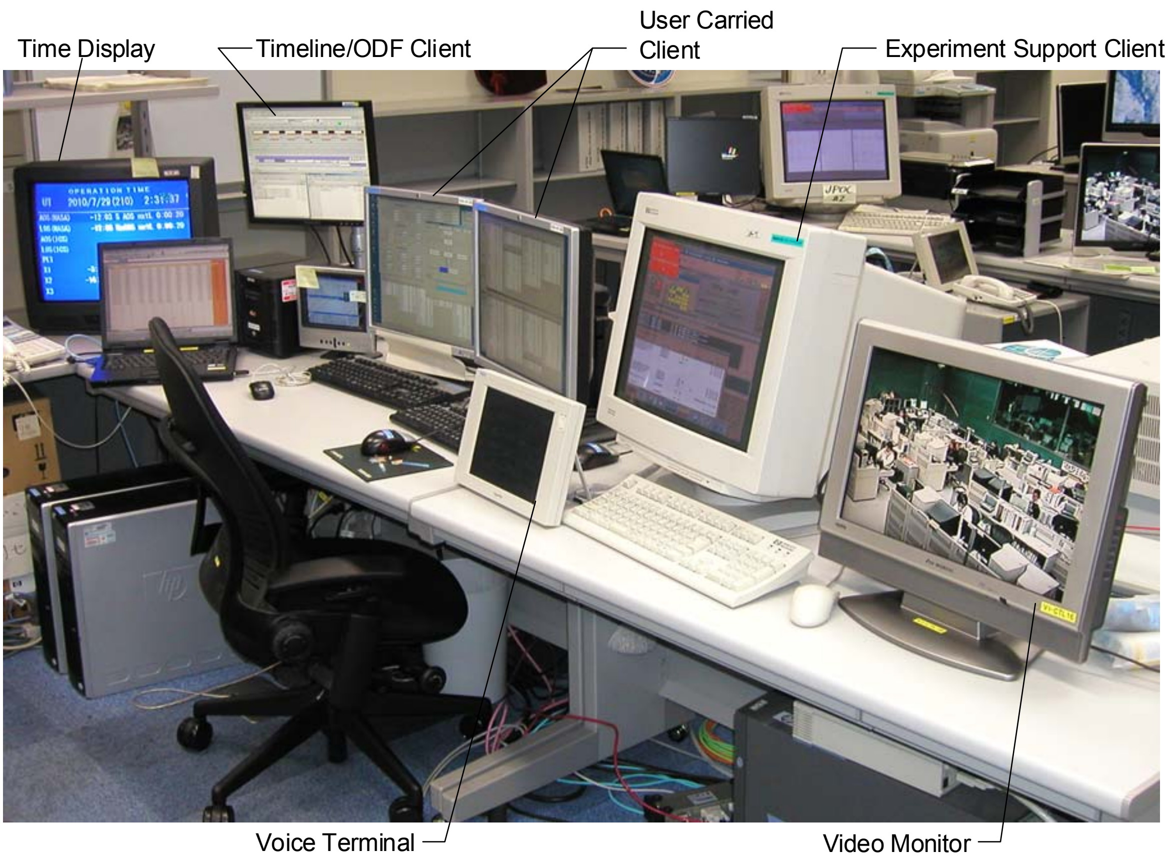


Fig 2.4.2-1 Equipments at the UOA (sample)

Fig2.4.2-2 UOA

(2) Interface with the equipments in the UOA

The experiment support client computers provide interfaces with user-carried computers and the users can directly monitor and process the downlinked experiment data by the programs on their computers (User-carried computers and media need to be cleared by JAXA regulation).

Also, users can get the engineering data at their own site which is converted from the downlinked raw data at the UOA.

2.4.3 Realtime Operations

The realtime operations from the UOA can be conducted for monitoring the experiment data and monitoring and controlling the payloads as follows;

(1) Monitoring the payloads

User can monitor the payloads and experiment data via any low, medium, and high rate data at the experiment support client at the UOA.

a. Telemetry

The telemetry is downlink data of payload status such as activated or deactivated and experiment data. The telemetry also includes the header information such as payload ID and GPS time information added by the payload.

b. Video

The NTSC analog video data is converted to the digital and downlink to the ground.

Fig2.4.3-1 Downlink Video Sample at UOA
(4 in 1 view for SEDA-AP mast extension)

c. Voice communication

User can monitor the realtime communication between Crew and flight control team and among the flight control team. Also user can directly communicate with Crew in case of necessary.

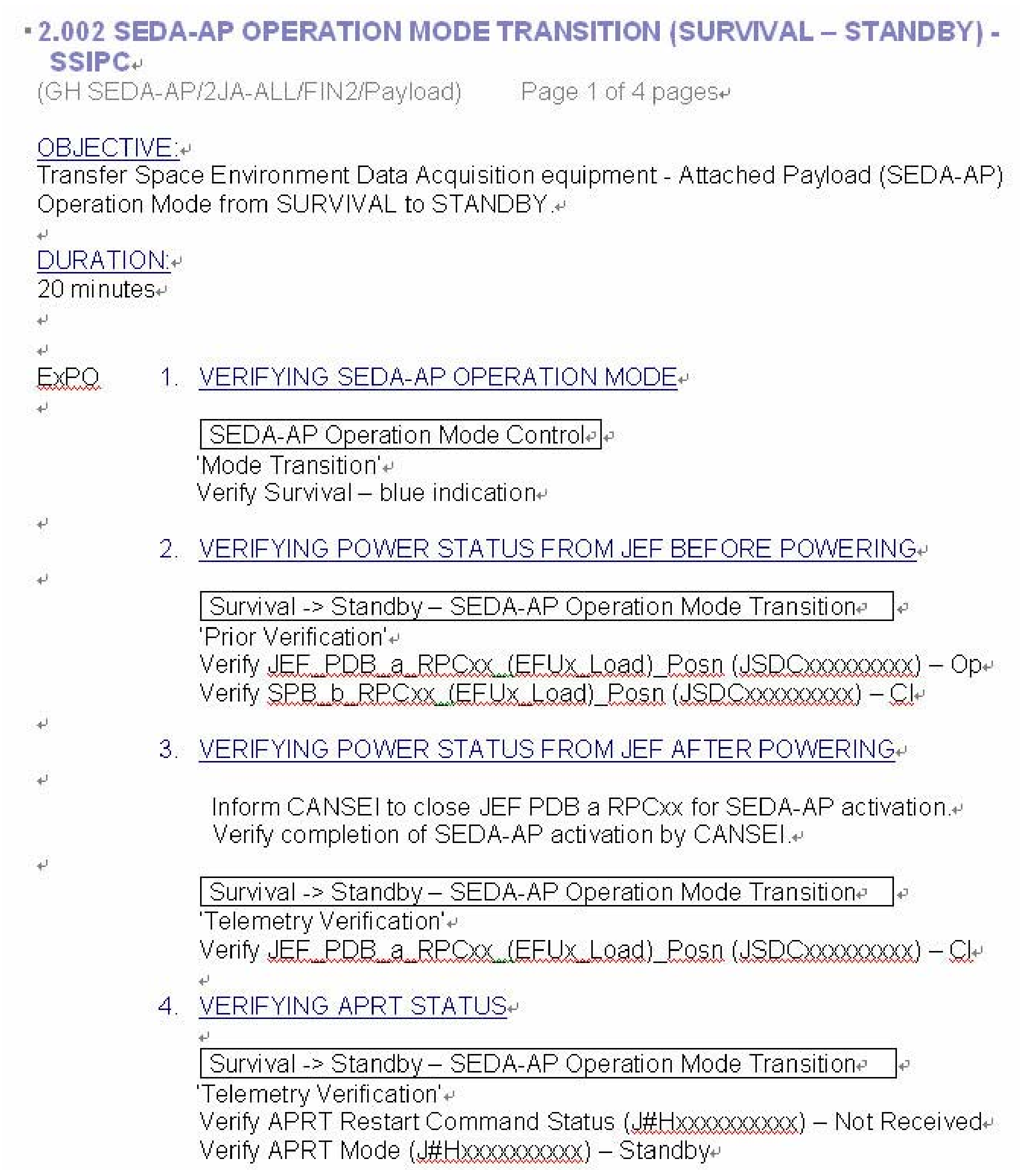
(2) Controlling the payloads

a. Operations Preparation

Prior to the payloads activation, the procedures for Crew and flight control team need to be prepared as ODF (On board Data Files. See below for Sample) and uplinked to the ISS.

The ODF must be written in an internationally unified format so that Crew can use the ODF easily if they are from different International Partners. Therefore users ask or consult with their Agency's counterpart to prepare the ODF.

The ODF need to be verified on the ground before uplink to ensure its healthy and safety. If the ODF is for the flight control team, it is ready to use once JAXA approve it, but if it is for Crew, the ODF need to be approved by NASA also before uplink. The Crew ODF should be uplinked on board at least 3 days prior to the execution for Crew's review.


2.002 SEDA-AP OPERATION MODE TRANSITION (SURVIVAL – STANDBY) - SSIPC
(GH SEDA-AP/2JA-ALL/FIN2/Payload) Page 1 of 4 pages

OBJECTIVE:
Transfer Space Environment Data Acquisition equipment - Attached Payload (SEDA-AP) Operation Mode from SURVIVAL to STANDBY.

DURATION:
20 minutes

ExPO

1. VERIFYING SEDA-AP OPERATION MODE

SEDA-AP Operation Mode Control
'Mode Transition'
Verify Survival – blue indication

2. VERIFYING POWER STATUS FROM JEF BEFORE POWERING

Survival -> Standby – SEDA-AP Operation Mode Transition
'Prior Verification'
Verify JEF_PDB_a_RPCxx_(EFUx_Load)_Posn (JSDCxxxxxxxxx) – Op
Verify SPB_b_RPCxx_(EFUx_Load)_Posn (JSDCxxxxxxxxx) – Cl

3. VERIFYING POWER STATUS FROM JEF AFTER POWERING

Inform CANSEI to close JEF PDB a RPCxx for SEDA-AP activation.
Verify completion of SEDA-AP activation by CANSEI.

Survival -> Standby – SEDA-AP Operation Mode Transition
'Telemetry Verification'
Verify JEF_PDB_a_RPCxx_(EFUx_Load)_Posn (JSDCxxxxxxxxx) – Cl

4. VERIFYING APRT STATUS

Survival -> Standby – SEDA-AP Operation Mode Transition
'Telemetry Verification'
Verify APRT Restart Command Status (J#Hxxxxxxxxxx) – Not Received
Verify APRT Mode (J#Hxxxxxxxxxx) – Standby

Fig2.4.3-2 ODF Sample

b. Automated Operations

The Automated operations are automatically initiated operations on board by some trigger. User can uplink and register some files including time-tagged commands for some payload actions such as taking pictures and the files automatically executed at planned time.

These automated operations can save time from flight control team to issue command one by one but difficult to issue the appropriate command accordingly based on the realtime payload and experiment status.

c. Realtime Operations

User can issue the command and control the payloads at the scheduled time in the timeline based on the uplinked ODF.

d. File Uplink

User can uplink the changes or updates of ODF and the payload control software.

3. DEVELOPMENT AND OPERATIONS

This section describes,

- Considerations for payload design and development
- Payload launch, install, and return
- Summary of current EF payloads
- Summary of future EF payloads

3.1 EF Payload Development

This section describes design and safety requirements for the EF payloads development.

3.1.1 Design Requirements

The standard KIBO EF payload box is,

Size : Width 0.8m x Height 1.0m x Length1.85m

Weight : 500kg or less

The experiment equipments need to be designed and developed within this envelope and installed in this box then attached to the EF.

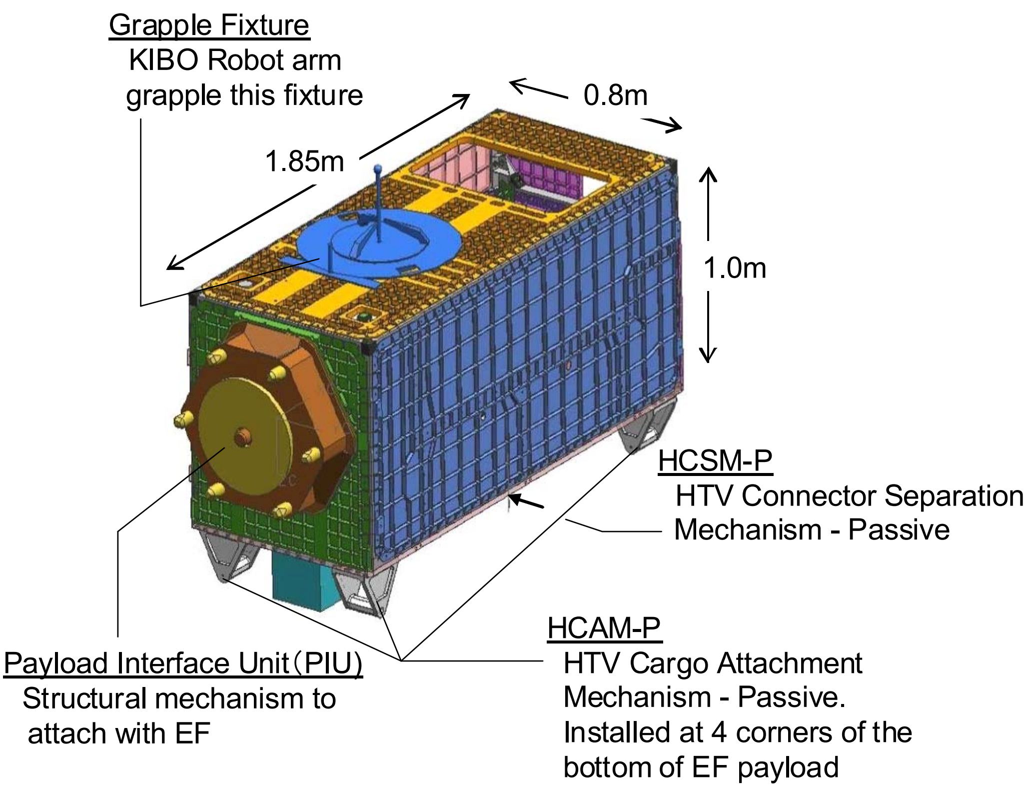


Fig 3.1.1-1 Standard EF Payload

The larger size payload is available at EF attach point #2 and #9 only. Users need to aware that there might be potential interference the payload and KIBO robot arm envelop, EVA Crew envelop, other payload operations, and TV camera view. Any users who want to launch the larger size payload need to have technical coordination respectively with JAXA.

The standard EF payload box has HTV Cargo Attachment Mechanism – Passive (HCAM-P), HTV Connector Separation Mechanism - Passive (HCSM-P) shown in the Fig 3.1.1-1 and 3, and Payload Interface Unit (PIU) shown in the Fig 3.1.1-1 and 2. HCAM-P is captured by HCAM and fixed on the EP for the launch, HCSM-P and HCSM are the mechanism to separate the launch to activation heater cable, and PIU is an attachment mechanism to berth with EF.

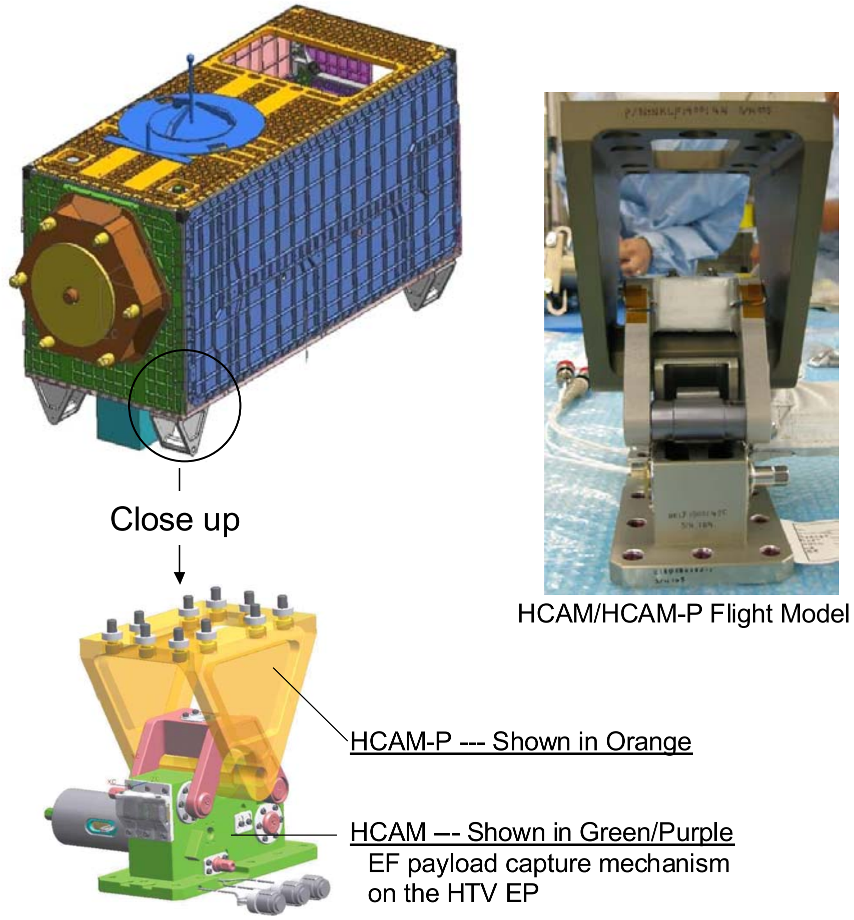


Fig 3.1.1-2 HCAM and HCAM-P

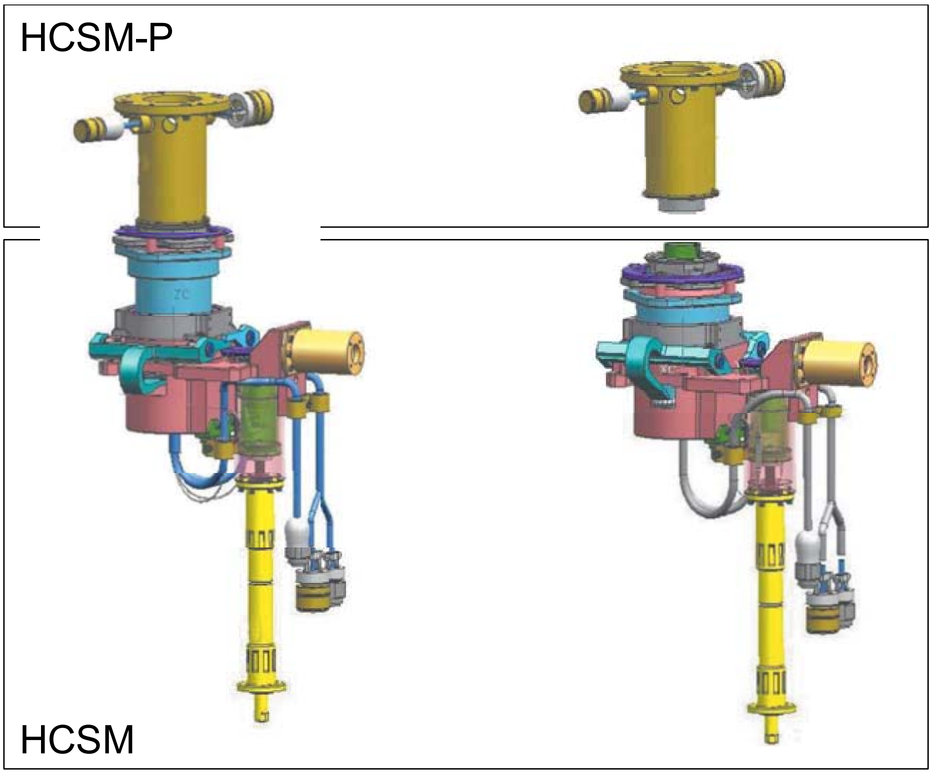


Fig 3.1.1-3 HCSM and HCSM-P
(Left : Before Separation, Right : After Separation)

The PIU of the EF payload side is physically attached to the Exposed Facility Unit (EFU) on the EF side, and the resources such as power, communication, and thermal are provided to the EF payload. The pair of PIU and EFU are called Equipment Exchange Unit (EEU).

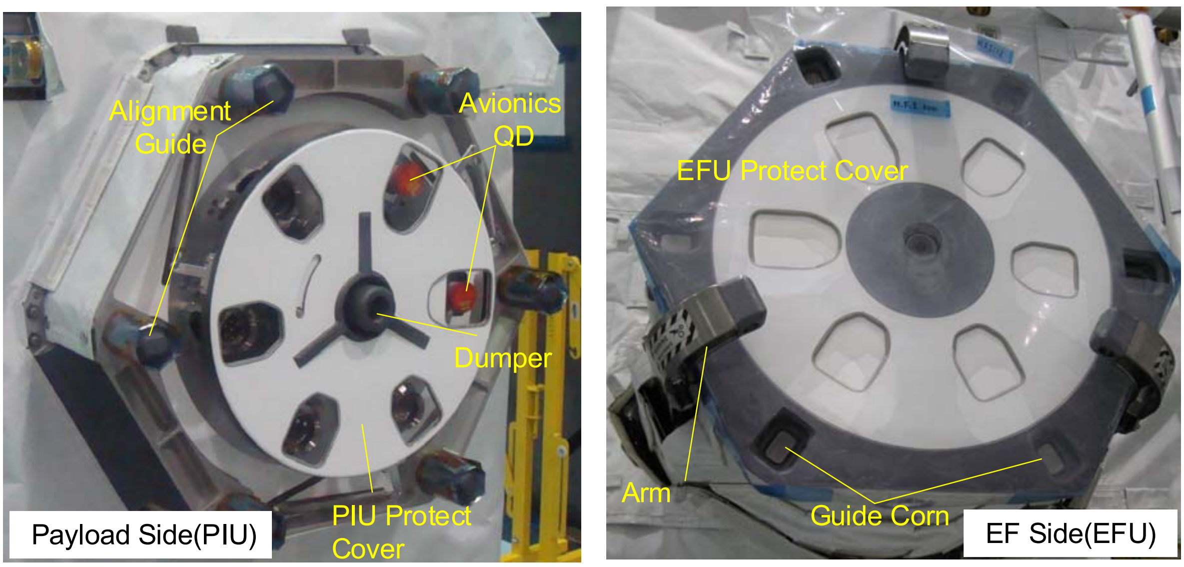


Fig 3.1.1-3 EEU Pictures

Refer the “JEM Accommodation Handbook Vol.3 EF/Payload Standard ICD” for EEU interface detail.

The EF payload developer is responsible for ensuring the payload safety to avoid any hazard to the ISS, KIBO, and the Crew.

Any hazardous items must be completely resolved or under control. Users need to be awared that the hazard is to be happened not only by their payload failure but also caused by the KIBO systems failure. Therefore any payloads need to have safety analysis and clear the safety review by JAXA and NASA to ensure the launch and on board operations safety. The followings are the documents which need to be aplied for their payload development and operations.

Vehicle/Module	Safety Requirements Documents
HTV	JMR-002B:Rocket and Payload Safety Standard or NSTS 1700.7B ISS ADDENDUM : Safety Policy and Requirements For Payloads Using the International Space Station
Progree and Soyuz	P32928-103 : Requirements for International Partner Cargoes Transported on Russian Progress and Soyuz Vehicles
ISS (Non Russian Module)	NSTS 1700.7B ISS ADDENDUM : Safety Policy and Requirements For Payloads Using the International Space Station
ISS Russian Module	P32958-106 : Technical Requirements for Hardware to be Stored or Operated on the ISS Russian Segment

Table 3.1.1-1 Safety Requirements Documents

After the Space Shuttle retirement, NSTS 1700.7B ISS ADDENDUM : Safety Policy and Requirements For Payloads Using the International Space Station will be integrated into the SSP-51700 Payload Safety Policy and Requirements for the International Space Station.

There should be other safety requirements at the launch site.

Here are prime topics at the safety review which the payloads get cleared before they come on board.

The design requirements need to identify any hazard items and show the appropriate control and its verification method.

Users need to implement the fault tolerant design for their payload if the hazard may cause the loss of function or unexpected movement. Also, users need to implement the risk minimize design to control the hazard such as structure, pressure vessels, pressure piping and its joint, mechanical firing equipments, any mechanizm for the critical parts, and material compliance and flammability.

The following hazard items need to be considered for designing and developing the payloads.

(4) Structural Damage

Users need to design their payloads to avoid any damages to ISS or KIBO in case of their payloads get any structural damages. The structures need to be controlled by using the appropriate materials and parts with defined safety factor for the load of launch, emergency landing, and EVA Crew.

[Reference Documents]

SSP52005 ISS Payload Flight Equipment Requirements and Guidelines for Safety Critical Structures

(5) Moving Parts

To ensure the Crew safety, any equipments which include rotating parts such as motor or shaft need to be desinged to avoid unexpected direct contact from Crew. The payload also need to be designed to avoid any damages to the ISS or KIBO from the damages of rotating parts themselves.

The fault torelant design need to be implemented for the hazard of unexpected motion of extending parts. 2 fault torelant design (need 3 independent controls implementation for happening 2 fail or misoperations at the same time) must be required for the catastrophic hazard which may cause loss of vehicle or Crew, and 2 of 3 control need to be monitorable.

(6) Touch Temperature

The touch temeperature for the EVA Crew is regulated to avoid the damages to the space suits and Crew from unexpected contact or contact point to perform EVA activities.

[Reference Documents]

NASDA-ESPC-840 JEM System Specification

NSTS 07700 Volume XIX Appendix 7

(7) Sharp edges

Users must ensure the EVA Crew safety from any catastrophic damages caused by the sharp edges. The corner or sharp edges must be chamfered
[Reference Documents]
SSP50005 ISS Flight Crew Integration Standard
NSTS 07700 Volume XIX Appendix 7

(8) Pinching

Users must ensure the EVA Crew safety from unexpected pinching at the gap of flexible area by covering or having more space than the regulations.

(9) External Contamination

The payload must be designed not to offgass any dangerous materials in the launch vehicle or the ISS. Also, users need to evaluate and estimate the annual average amount of offgass from their payload material.

(10) Flammability

The EF payloads are installed at the outer space but they need to use the regulated materials or to get the concurrence if using the non-regulated materials to avoid fire at the launch site.
[Reference Documents]
NHB 8060.1C Flammability, Odor, Offgassing, and Compatibility Requirements and Test Procedures for Materials in Environments that Support Combustion
NSTS 22648 Flammability Configuration Analysis for Spacecraft Systems

(11) Glass Parts

Any glass parts must be covered to avoid any damages to the EVA Crew in case of broken.

(12) Pressure vessels, Sealed vessels

The pressure vessels are as follows;
contain 2×10^4 J or more energy,
may have 7×10^5 Pa or more design limit pressure,
contain 1×10^5 Pa or more fluid which may cause of hazard in case of leak,
Other vessels are categorized as Sealed vessels.
Users need to prove their safe by proof test or fatigue analysis against the

regulated pressure.

[Reference Documents]

ANSI/AIAA S-080-1998 Space Systems – Metallic Pressure Vessels, Pressurized Structures, and Pressure Components

ANSI/AIAA S-081-2000 Space Systems – Composite Overwrapped Pressure Vessels (COPVs)

(13) Electrical shock

The payload need to be designed for grounding and bonding to avoid any electrical shock from Crew and avoid Crew contact from high voltage equipments.

[Reference Documents]

SSP30240 Space Station Grounding Requirements

SSP30245 Space Station Electrical Bonding Requirements

(14) Electrical circuits

The electrical circuits need to be designed to have protection circuits such as current limitter or fuse to avoid having imapcts on the upper stream in case of the lower stream inrush current or short circuit.

Also, they should be designed to avoid 2 or more hazard control functions go invalid at the same time from short circuit in the connecter caused by the bend pin.

(15) Electromagnetic Compatibility (EMC)

The payload should be designed to avoid any unsafe malfunctions to itself or other equipments caused by the electromagnetic interference.

[Reference Documents]

SSP30237 Space Station Electromagnetic Emission and Susceptibility Requirements for Electromagnetic Compatibility

(16) Optical instruments

The optical instruments which has harmful light intensities and wavelength shall be designed to prevent from being unexpected viewed by Crew.

[Reference Documents]

ANSI-Z-136.1 American National Standard for Safe Use of Lasers

(17) Exhaust gas

The exhaust gas from both PM and EF payloads shall be inbited during EVA to keep Crew from contamination and ensure safety.

(18) Battery Cell

The battery cells for the payload need to be designed and verified not to exhaust flammability, corrosivity, and toxic gas, not to exhaust any materials produced by chemical reaction, not to exhaust electrolytic solution, and avoid unexpected damage cause by any failure mode such as abnormal thermal, short circuit, reverse current, reverse connection, leak, and excess voltage. Small general-purpose cells need to clear the voltage test, appearance test, and depressurization test. Vibration and discharge and charge test need to be added and cleared for the rechargeable battery.

3.1.2 Safety Review

The following Safety Reviews for the EF payloads are held as in-house review of the EF payloads developer.

Preliminary Safety Review (Phase 0),

Phase I Safety Review at Preliminary Design Phase,

Phase II Safety Review at Critical Design Phase,

Phase III Safety Review at Verification Test Phase,

After those in-house safety review, JAXA hold a JEM Payload Safety Review Panel (JPSRP) based on the developer’s review results and then NASA hold a Payload Safety Review Panel (PSRP).

The Safety Assurance Report (SAR) is the target document at each safety review. The description level of the SAR is focused on the each safety review decribed below and the SAR needs to be updated with the design status.

- JSX-2008041A:HTV cargo review process
- NSTS/ISS 13830C:Payload Safety Review and Data Submittal Requirements For Payloads Using the:- International Space Station
- SSP-30599E:Safety Review Process (for the Russian Vehicle and module)

(1) Phase 0

The purpose of this Phase 0 Safety Review is,

To identify any hazards,

To clarify the safety requirements,

To evaluate the safeness,
To verify if these things are incorporated in the preliminary design at the middle phase 0.

(2) Phase I

The purpose of this Phase I Safety Review is,
To confirm if the all of preliminary design meets the safety requirements,
To verify if the hazard control and its verification methods are appropriate,
To incorporate the all results of Phase I Safety Review into the critical design.

(3) Phase II

The purpose of this Phase II Safety Review is,
To confirm if the all of critical design meets the safety requirements,
To verify the implementation of hazards controls and their verification methods in the design,
To verify if these things are incorporated in the critical design.

(4) Phase III

The purpose of this Phase III Safety Review is,
To confirm if the safety verification of all review target are completed,
To confirm all of the action items are closed,
To approve the final version of SAR and evaluate the safeness finally.

3.1.3 Launch Site Operations

(1) Launch Site Operations

After the development and test completion, the EF payloads are loaded into the container for the HTV and shipped to Tanegashima Space Center (TNSC) from Tsukuba Space Center (TKSC). Then the payloads are off loaded, moved to the clean room, and have visual inspection and telemtry/command check.

In case of launching on the Dragon or Cygnus, they are shipping to the Kennedy Space Center (KSC) or Cape Canaveral Air Force Station and will have the same check before the launch. The same launch site operations will be performed at Guiana Space Center at Kourou for the ATV launch, and at Baikonur Cosmodrome at Kazakhstan for the Progress launch.

(2) System Operations

After completion of the launch site operations, the payloads are handed over to the launch vehicle team and are processed to load into the Exposed Pallet, to install into the HTV, and to perform other pre launch operations.

If the payloads are launched on the Dragon, Cygnus, ATV, or Progress, they will have the same pre launch process.

3.2 Transportation to/from the EF

This section describes the way to launch, install, and return the payloads to/from the EF.

3.2.1 Launch

Since the Space Shuttle is retiring in 2011, the launch vehicles to the ISS are Progress and Soyuz of Russia, ATV of ESA (ESA : European Space Agency), and HTV of JAXA. In the United States, Dragon (Space Exploration Technologies Corp.) and Cygnus (Orbital Sciences Corp.) are under development.

Table 3.2.1-1 shows the summary of each launch vehicle specification.

Vehicle	HTV (JAXA)	ATV (ESA)	Progress (Russia)	NASA			
				Cygnus		Dragon	
							
First launch	2009–	2008–	1978–	Planned 2011		Planned 2011	
Flight history	1	1	128	Not yet		Not yet	
Transfer capability	6t	7.5t	2t	Launch	2t	Launch	3t
				Return	1.2t	Return	2.5t
Weight	16.5t	20.5t	7.2t	5.3t		8.7t	
Note	–Transfer pressurized payloads thru 1.3m×1.3m hatch –Transfer EF payloads –Berthing via ISS robot arm	–Use Progress docking technique –Small hatch (Dia.0.8m) –ISS maneuver –No EF payloads transfer but available for smaller external payloads	–High reliability unmanned transfer vehicle –ISS maneuver –No EF payloads transfer but available for smaller external payloads	–Developer : Orbital Sciences –Medium hatch (0.9m×0.9m) –Berthing via ISS robot arm –Install HTV PROX docking system –No EF payloads transfer but available for smaller external payloads –Return 1200kg		–Developer : Space X –Nominal hatch (1.3m×1.3m) –Difficult to transfer pressurized payload due to small volume –No EF payloads transfer but available for smaller external payloads –Berthing via ISS robot arm –Original docking system –Return 2500kg	

HTV: H–II Transfer Vehicle, ATV: Automated Transfer Vehicle

Table 3.2.1-1 Launch Vehicle Summary for ISS(as of August 2010)

(1) Progress

The Progress is the Russian unmanned launch vehicle. It carries Crew commodities, foods, oxygen, and propulsion. The Progress is not capable of re-entry, it burns up in the atmosphere with the trashes from the ISS. Therefore EF payloads and samples cannot be loaded for return. The Progress docks at Russian module, so the EF payloads cannot be launched because there is no way to transfer and install them on the EF.

Fig 3.2.1-1 Progress approaching the ISS (37P)
May 2, 2010

(2) Soyuz

As of August 2010, only the Space Shuttle and the Soyuz are the manned launch vehicle to/from the ISS, but the Soyuz is too small to carry the EF payloads.

Fig 3.2.1-2 Soyuz approaching the ISS (21S)
December 23, 2009

(3) Dragon

The Dragon spacecraft is a new space vehicle to/from the ISS launched by Falcon 9 of Space Exploration Technologies Corp. It is under development but will have manned and unmanned configuration.

June 5, 2010, the Dragon qualification unit is launched and inserted into the 250 km circular orbit. They will have ISS docking test and have the first official flight to the ISS on June 2011.

The Dragon spacecraft has the same size hatch but cannot launch the EF payloads due to the small volume of cargo area. It can launch the smaller size payloads.

Fig 3.2.1-3 Dragon Spacecraft : Cargo Configuration
(from Space X HP)

(4) Cygnus

The Cygnus spacecraft is also a new space vehicle to/from the ISS launched by Taurus II of Orbital Sciences Corp. It is unmanned vehicle but can carry and return cargo to/from the ISS.

The Cygnus is consisted from the Service Module (SM) and the cargo module, and the cargo module has 3 types, Pressurized cargo module, Unpressurized cargo module, and Return module. However the Cygnus cannot launch neither the EF payloads nor smaller exposed payloads.

It is under development and will launch in 2011.

(5) ATV

The ATV is the unmanned vehicle of ESA. It can transfer cargo to the ISS but cannot return to the earth. ATV docks at the Russian module like Progress, so the EF payloads cannot be launched because there is no way to transfer and install them on the EF.

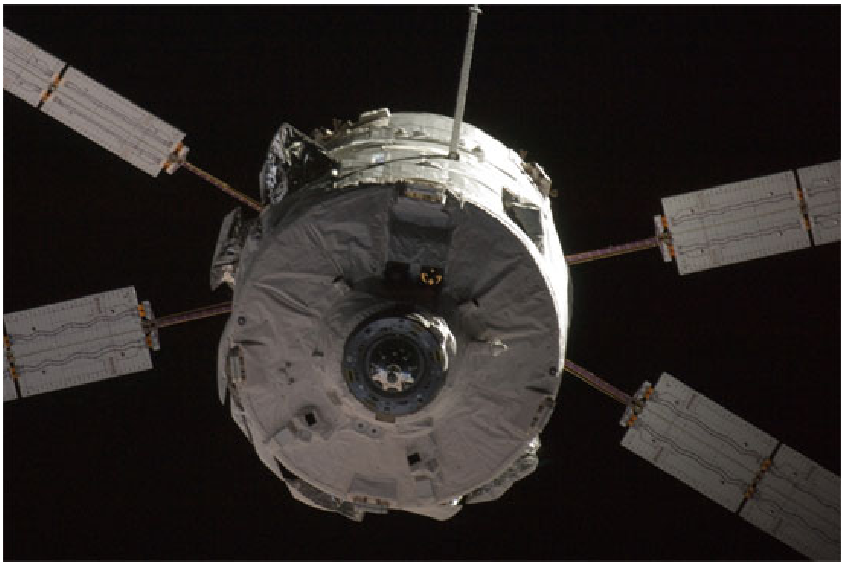


Fig 3.2.1-4 ATV approaching ISS (ATV1)
April 1, 2008

(6) HTV

The HTV is the Japanese unmanned transfer vehicle and had first flight to the ISS on September 2009. The HTV is not capable to return the earth but has pressurized and unpressurized cargo at one time and can carry both PM and EF payloads.

Fig 3.2.1-5 HTV grappled by the ISS Robot Arm (HTV-1)
September 18, 2009

Fig 3.2.1-6 shows the HTV overall summary and Table 3.2.1-1 shows the HTV specification.

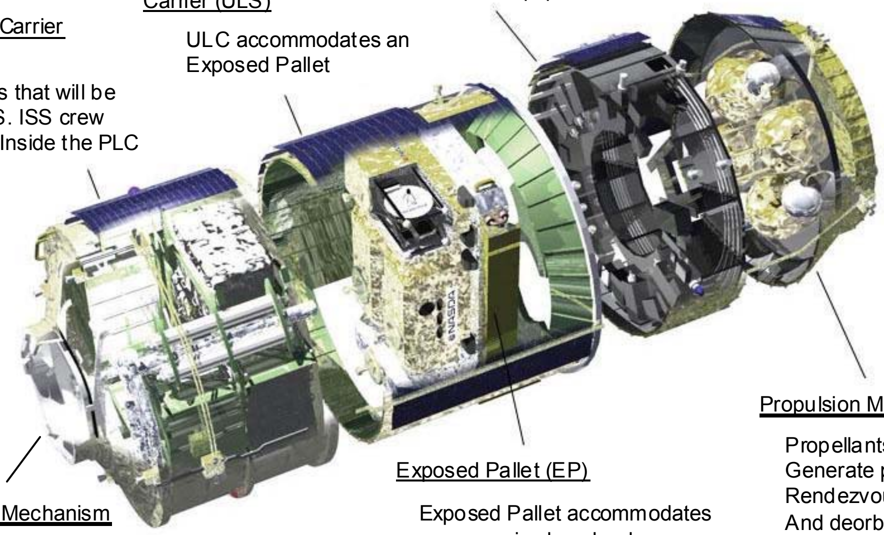


Fig 3.2.1-6 HTV Overall Summary

	Specification
Length	10m (including the length of the thruster)
Diameter	4.4m
Weight	10.5t (excluding cargo mass)
Supply Capability	6t Pressurized Carrier : 4.5t Unpressurized Carrier : 1.5t
Trash Capability	6t
Target Orbit	350km - 460km Inclination 51.6 degrees
Mission Duration	Solo Flight : 100hours Stand-by (on-orbit) : more than 1 week Berthed operations : more than 30 days

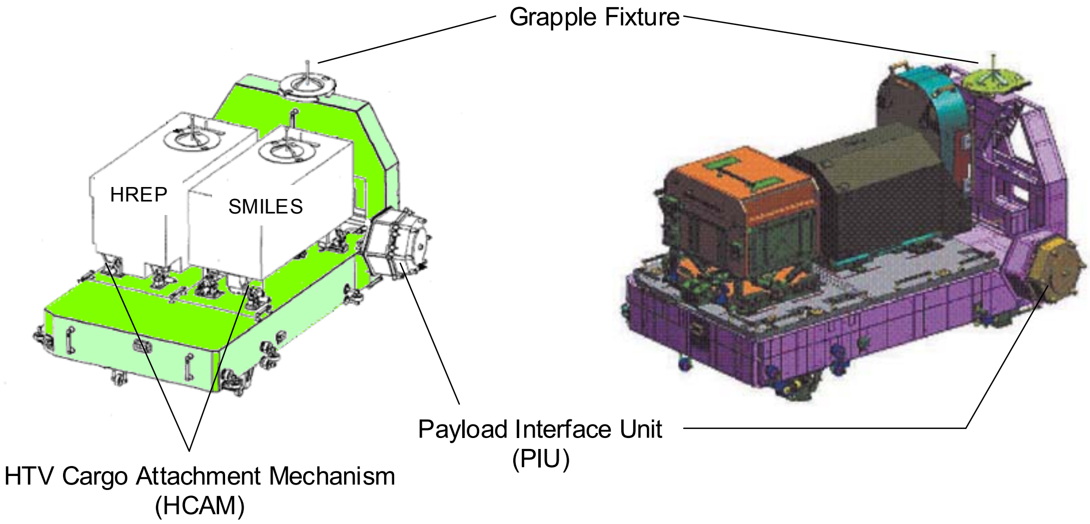
Table 3.2.1-1 HTV Specification

EF payloads are launched with installing on the Exposed Pallet (EP). There are currently two type of EPs, Type I and Type MP.

Type 1 : Carries 2 or 3 KIBO EF unpressurized payloads.

Type MP : Carries ISS common external equipments such as batteries. Type MP can carry max. 6 batteries and is attached at Mobile Base System (MBS).

Fig 3.2.1-7 shows the Exposed Pallet configuration.



HTV 1 EP Configuration

HTV 2 EP Configuration

Fig 3.2.1-7 Exposed Pallet Configuration

Currently, the HTV Return (HTV-R) which can be re-entry the atmosphere is under study. This will return cargos on the ground.

3.2.2 Install

The EP is grappled by the SSRMS and off loaded from the HTV. Then the EP is handed over to the KIBO robot arm and installed at #10 of EF. The unpressurized payload on the EF is grappled and installed by the KIBO robot arm.

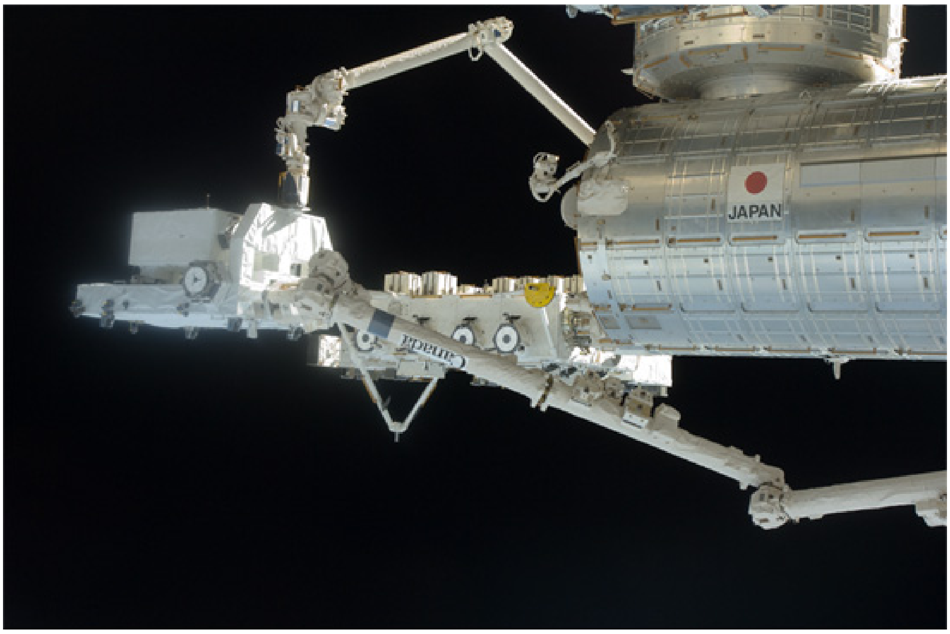


Fig 3.2.2-1 Type 1 EP is handed over from SSRMS to KIBO robot arm
September 23, 2009

3.2.3 Return

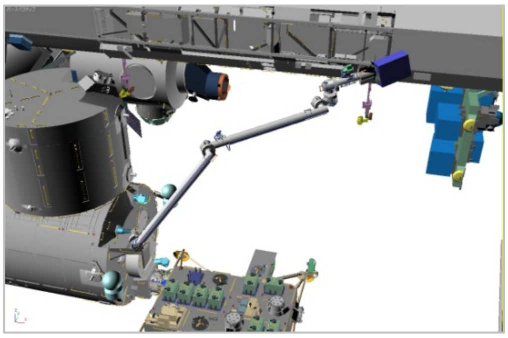
There will be no way to return the EF payloads to the ground after Space Shuttle retiring in 2011. The EF payloads which completed its mission or are failed will be loaded into the HTV and burned in the atmosphere.

3.2.4 Smaller Payloads Transportation and Operations

Addition to the payload launch by the HTV, JAXA is currently studying the smaller payload launch by other launch vehicles and operations via KIBO airlock to promote the KIBO utilization. Here are 3 ideas for the smaller payload operations.

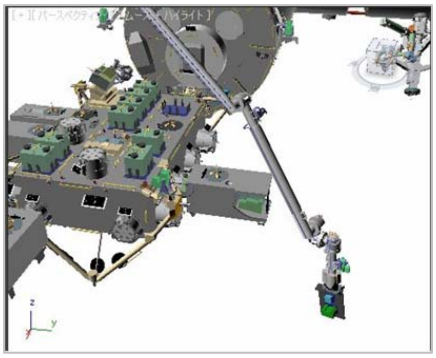
(1) Main Arm Grappling Payload

The payload is transferred to the outer space via the airlock and grappled by the KIBO main arm. The arm and payload moves to the target position and stay for some duration for the mission such as observation.



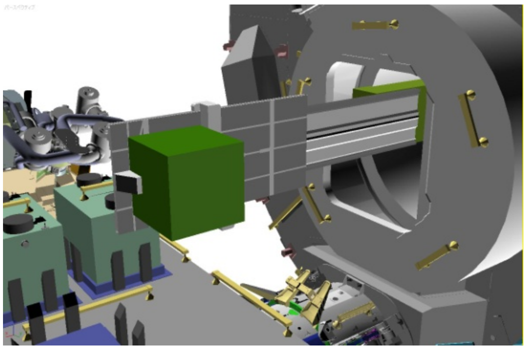
(2) Main Arm Releasing Payload

The payload is transferred to the outer space via the airlock and grappled by the KIBO main arm. Then the payload is released by the arm and start missions as a small satellite.



(3) Airlock Installing Payload

The payload is transferred to the outer space via the airlock and stays as is for the mission such as observation.



The payloads mentioned above are all installed or released through the KIBO airlock. Therefore these payloads are smaller than the EF standard size payload but have some advantages as follows.

1) Easy transportation

    The payload can be launched with foams and bags and no need to implement the direct interface with the launch vehicle.

2) Prepare/Checkout in the PM

    The payload can be checked out with JEM system in the KIBO Pressurized Module (PM) before transferring to the outer space. Troubleshoot can be performed in the PM if found any anomalies.

3) Return to the ground

    The payload can be re-transferred into the PM through the airlock and return to the ground.

4) Lots of flight opportunities

    The payload is launched as a pressurized cargo so not only HTV but also Progress, ATV, Dragon, and Cygnus can carry it. There will be about 10 times launch opportunities.

These options are still under study and will be added detail information later.

3.3 KIBO Exposed Facility Payload Sample

This section summarizes the EF payloads operations which are currently operating on the EF. There 4 payloads on the EF as of Aug 1020, 1 is from US and 3 are from JAXA. They were launched by the Space Shuttle or HTV but will be loaded into the HTV and burned.

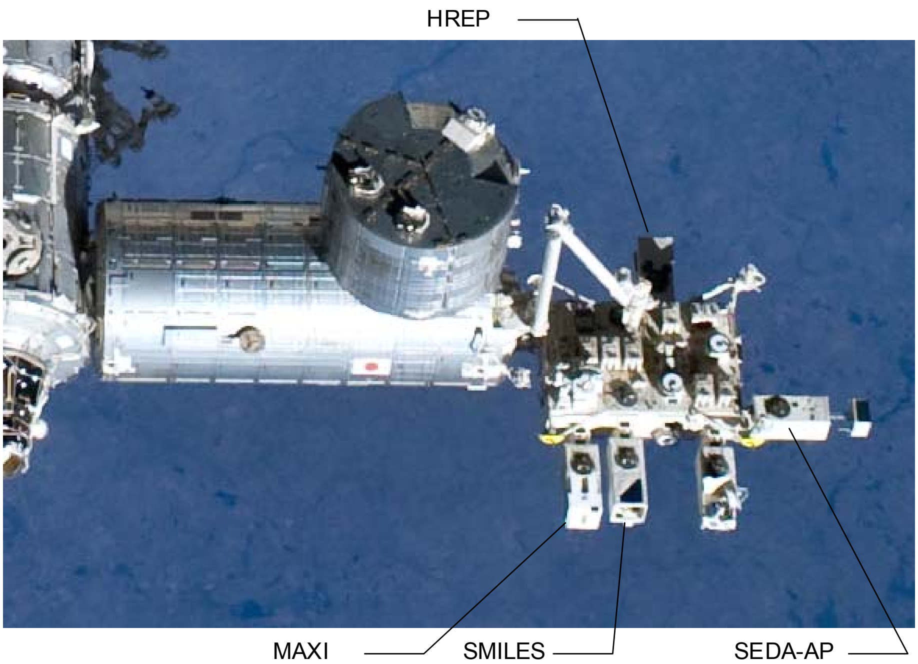


Fig 3.3-1 Payloads on the EF
April 3, 2010

3.3.1 Monitor of All-sky X-ray Image (MAXI)

MAXI (Monitor of All-sky X-ray Image) has 2 X-ray cameras to identify the difference energy zone and keeps monitoring continuously the intensity of X-ray from astronomical X-ray objects for more than 1,000 X-ray sources covering the entire sky on time scales from a day to a few months.

The MAXI ground system at JAXA Tsukuba Space Center monitors MAXI down-linked data 15 to 17* hours/day while real-time connection with the ISS is established.

When a transient or significant phenomenon such as an X-ray nova is observed, the MAXI ground system will transmit alert information to observers of all over the world within 30sec after the incident.

Launch : July 2009, STS-127/ISS Flight 2J/A
Location : EFU #1
Mission Duration : 2 yrs

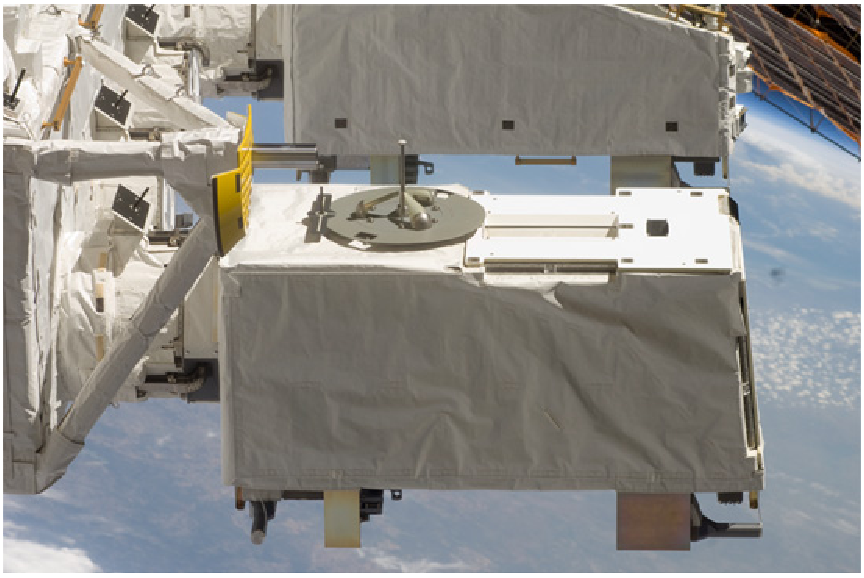


Fig 3.3.1-1 MAXI at the EFU#1
July 28, 2009

Fig 3.3.1-2 Pictures downlinked from MAXI

3.3.2 Superconducting Submillimeter-Wave Limb-Emission Sounder (SMILES)

SMILES (Superconducting Submillimeter-Wave Limb-Emission Sounder) is observing submiliwaves emitted from the trace gases with its highly sensitive submillimeter-wave sounder at the stratospheric ozone and trying to clear the depletion mechanism of the ozone layer.

The submillimeter-wave equipment failed in April 2010 and the SMILES has stopped observation and has been in Stand by mode.

Launch : September 2009, HTV1
Location : EFU #3
Mission Duration : 1 yr

Fig 3.3.2-1 SMILES on the HTV Exposed Palette

3.3.3 Space Environment Data Acquisition equipment – Attached Payload (SEDA-AP)

SEDA-AP (Space Environment Data Acquisition equipment – Attached Payload) is measuring space environment (neutrons, plasma, heavy ions, high-energy light particles, atomic oxygen, and cosmic dust) in ISS orbit and environmental effects on materials and electronic devices to investigate the interaction with and from the space environment at the KIBO EF.

Fig 3.3-1 shows the SEDA-AP nominal configuration with extended mast.

Launch : July 2009, STS-127/ISS Flight 2J/A
Location : EFU #9
Mission Duration : more than 3 yrs

3.3.4 Hyperspectral Imager for the Coastal Ocean (HICO) & Remote Atmospheric &

Ionospheric Detection System(RAIDS) Experimental Payload (HREP)

HREP (Hyperspectral Imager for the Coastal Ocean (HICO) & Remote Atmospheric & Ionospheric Detection System(RAIDS) Experimental Payload) is the NASA payload on the EF.

HICO demonstrates space-based Maritime Hyper-Spectral Imagery (MHSI) for characterization of littoral regions (the coast of an ocean or sea) on Earth. RAIDS is an ultraviolet (UV) and visible remote sensing instrument that measures limb profiles of electron density and neutral density to improve ionospheric (the upper part of the atmosphere) and satellite drag models.

Launch	: September 2009, HTV1
Location	: EFU #6
Mission Duration	: TBD

Fig 3.3.4-1 HREP at the EFU#6
September 25, 2009

3.4 Future KIBO Exposed Facility Payload

This section summarizes the future EF payloads missions which have been selected as the KIBO second phase utilization.
These payloads will also be loaded into the HTV and burned after mission completion.

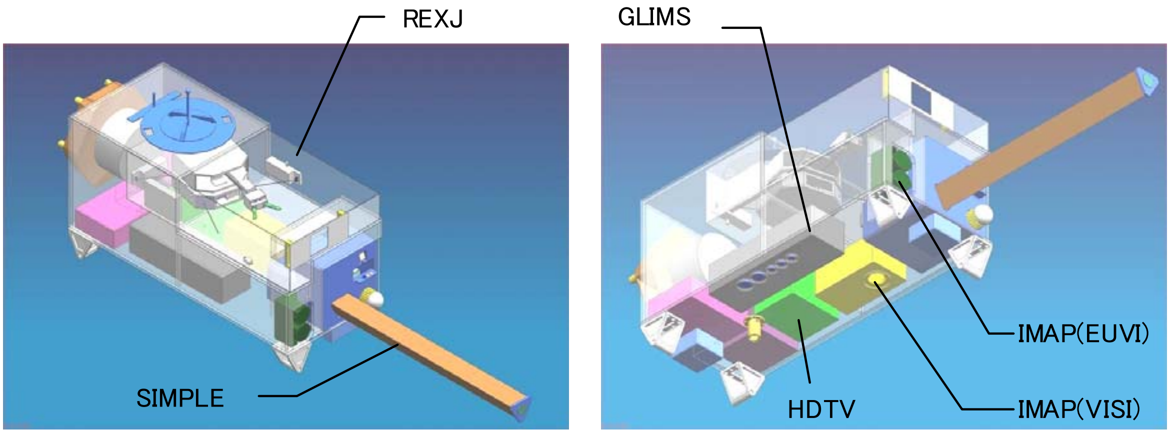
3.4.1 Multi-Mission Consolidated Equipment (MCE)

MCE has several observation equipments in one EF standard size box. The equipments and their functions are as follows.

Launch : HTV3, 2011
Location : EFU#8
Mission Duration : 2 yrs

Equipment	Payload	Mission
Ionosphere, Mesosphere, upper Atomosphere, and Plasmasphere mapping	IMAP	Observe plasma and air disturbance by shooting the invisible lights occurring in between the border of the atmosphere and the space by ultrasensitive camera
Global Lightning and Sprite Measurement Mission	GLIMS	Observe the lightning discharge and luminous phenomenon such as sprites, blue jets, and Elves above the thunder cloud.
Space Inflatable Membranes Pioneering Long-term Experiments	SIMPLE	Operate the inflatable structure for a long period and verify its practicality under the space environment. And collect the basic data for the future structures in space.
Robot Experiment on JEM	REXJ	Learn the special migration technique for the EVA Support Robot to support EVA Crew
COTS HDTV Verification	HDTV	To verify the COTS HDTV function under the space environment

Table 3.4.1-1 MCE Equipments Summaries



Payload Upper Side   Payload Lower Side

Fig3.4.1-1 MCE Payload

3.4.2 TANPOPO

This is the science mission to find the possibility of microbe and organic materials migration in the space. The payload will be launched in 2011 and deployed the special tray on the EF for more than 2 years for the purpose of the followings.

(1) Exposing the microbe in the space
(2) Collecting the micro-meteoroid
(3) Collecting the organic materials in the space

The payload for this mission is under the feasibility study to verify if it is launched under the pressurized environment and transferred to the EF via the KIBO airlock and Main arm.

Launch : TBD
Location : TBD
Mission Duration : more than 3 yrs

3.4.3 CALorimetric Electron Telescope (CALET)

CALET will observe high energy electron, gamma ray, and nucleus in the deep space, and also monitor the cosmic ray from solar activities to understand impacts on the earth environment. CALET will try to figure out the overall high energy space phenomenon from the interplanetary space to the extragalactic space. CALET is slated to be launched on the HTV5.

Launch : HTV5

Location : EFU#9

Mission Duration : 2 yrs

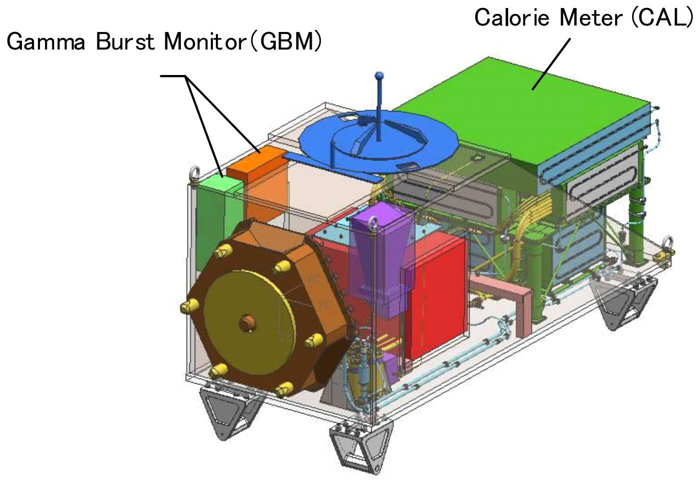


Fig 3.4.3-1 CALET Payload

4. Appendix

Abbreviation and Documents.

4.1 Abbreviation

	Abbrebiation
AC	Assembly Complete
APS	Automated Payload Switcher
ASCR	Assured Safe Crew Return
ATCS	Active Thermal Control System
CCSDS	Consultative Committee for Space Data System
CDR	Critical Design Review
CMG	Control Moment Gyro
Col-CC	Columbus Control Center
COR	Communications Outage Recorder
COUP	Consolidated Operations and Utilization Plan
CTV	Crew Transfer Vehicle
CVCM	Collected Vacuum-Condensable Materials
DRTS	Data Relay Test Satellite
DRTSS	Data Relay Test Satellite System
EEU	Equipment Exchange Unit
EF	Exposed Facility
EFU	Exposed Facility Unit
ELM-PS	Experiment(al) Logistics Module-Pressurized Section
EMC	ElectroMagnetic Compatibility
EMGF	Electrical Mechanical Grapple Fixture
ESA	European Space Agency
EVA	Extravehicular Activity
FGB	Functional Cargo Block
FM	Flight Model
FRGF	Flight Releasable Grapple Fixture
GF	Grapple Fixture
GPS	Global Positioning System
GSE	Ground Support Equipment
H&S	Health and Status
HCAM	HTV Exposed Pallet, Cargo Attachment Mechanism
HCAM-P	HTV Exposed Pallet, Cargo Attachment Mechanism - Passive

HCSM	HTV Exposed Pallet, Connector Separation Mechanism
HCSM-P	HTV Exposed Pallet, Connector Separation Mechanism - Passive
HK	House Keeping
HRDR	High Rate Data Recorder
HRMS	High Rate data Multiplexer and Switcher
HTV	H-II Transfer Vehicle
HTV EP	HTV Exposed Palet
ICS	Inter-orbit Communication System
IDRD	Increment Definition Requirements Document
IPU	Image Processing Unit
ISDN	Integrated Services Digital Network
ISS	International Space Station
ITU	Internatinal Telecommunication Union
IVA	Intravehicular Activity
JAXA	Japan Aerospace Exploration Agency
JCP	JEM Control Processor
JEM	Japanese Experiment Module
JEMRMS	JEM Remote Manipulator System
JPAH	JEM Payload Accommodation Handbook
JPSRP	JEM Payload Safety Review Panel
JSC	Johnson Space Center
KSC	Kennedy Space Center
LVLH	Local Vertical / Local Horizontal
MA	Main Arm
MCC-M	Mission Control Center - Moscow
MCD	Molecular Column Density
MD	Molecular Deposition
MLI	Multi Layer Insulation
MOU	Memorandum of Understanding
MSFC	Marshall Space Flight Center
NASA	National Aeronautics and Space Administration
NTSC	National Television Standards Committee
OCS	Operations and Control System
OCS-CL	OCS Client
ODF	Operations Data File
OLR	Outgoing Long-wave Radiation

OOS	On-orbit Operations Summary
ORU	Orbital Replaceable Unit
OSR	Optical Solar Reflector
OSTP	On-board Short Term Plan
PAM	Payload Attach Mechanism
PAM-PU	Payload Attach Mechanism-Payload Unit
PB	Particulate Background
PDGF	Power and Data Grapple Fixture
PDH	Payload Data Handling unit
PDR	Preliminary Design Review
PEHG	Payload Ethernet Hub Gateway
PIU	Payload Interface Unit
PLT	Payload Laptop Terminal
PM	Pressurized Module
POIC	Payload Operations Integration Center
PQR	Post Qualification Review
PSR	Pre-Shipment Review
PSRP	Payload Safety Review Panel
PTCS	Passive Thermal Control System
RSA	Russian Space Agency
RSS	root-sum-square
S/N	Signal, Noise
SAA	South Atlantic Anomaly
SAR	Safety Assessment Report
SFA	Small Fine Arm
SLM	Structure Latch Mechanism
SSCC	Space Station Control Center
SSIPC	Space Station Integration and Promotion Center
STP	Short Term Plan
TBD	To Be Determined
TDRS	Tracking and Data Relay Satellite
TDRSS	Tracking and Data Relay Satellite System
TEA	Torque Equilibrium Attitude
TKSC	TsuKuba Space Center
U-BIS	User Built-In Software
UOA	User Operations Area

USB	unified S-band
USOS	US Orbital Segment
UT	Universal Time
VCU	Video Control Unit
VSW	Video Switcher
WSGT	White Sands Ground Terminal

4.2 Documents

Here is a list of referred homepage and documents.

4.2.1 Homepages

(1) KIBO
http://kibo.jaxa.jp/
(2) SEDA-AP Observation Data
http://seesproxy.tksc.jaxa.jp/fw/dfw/SEES/Japanese/Data/docs_ja/SEDAAP/SEDAAP_RealTimeGraph_world_map.htm
(3) MAXI Observation Data
http://maxi.riken.jp/news/jp/
(4) NASA Reference Guide to the International Space Station
http://www.nasa.gov/mission_pages/station/news/ISS_Reference_Guide.html
(5) NASA ISS Interactive Reference Guide
http://www.nasa.gov/externalflash/ISSRG/
(6) NASA webpage: Earth and Space Science using ISS as a platform
http://www1.nasa.gov/mission_pages/station/science/nlab/platform.html
(7) Overview of attached payload accommodations and environment on the international space station
http://www1.nasa.gov/pdf/190373main_TP-2007-214768.pdf
(8) ISS PIMS microgravity data webpage
http://pims.grc.nasa.gov/pims_iss_index.html
(9) ISS PIMS data examples of actual disturbances
http://pims.grc.nasa.gov/pimsdb/index.cfm?method=Handbook.pimslist
(10) NASA Window Observation Research Facility
http://www.nasa.gov/mission_pages/station/science/experiments/WORF.html

4.2.2 Applicable Documents

Here is a list of applicable documents for the EF payload development. Users need to apply these documents when starting payloads development.

Please verify the latest version when use.

[JAXA Documents]

(1) NASDA-ESPC-1681 JEM Payload Safety and Products Assurance Requirements

(2) NASDA-ESPC-2562 JEM Payload Accommodation Handbook (JPAH) Vol.2 JEM Pressurized Payload Standard ICD

(3) NASDA-ESPC-2563 JPAH Vol.3 JEM EF/Payload Standard CD

(4) NASDA-ESPC-2564 JPAH Vol.4 JEM Manipulator System/Payload Standard ICD

(5) NASDA-ESPC-2566 JPAH Vol.6 JEM Airlock/Payload Standard ICD

(6) NASDA-ESPC-2567 JPAH Vol.7JEM Communication Protocol and. C&DH Service Std. ICD

(7) NASDA-ESPC-2857 HTV Cargo Standard ICD

(8) JSX-2000046 HTV Cargo Safety Requirements

(9) NASDA-ESPC-2328 JEM Operations Control System/Payload Standard ICD

(10) NASDA-ESPC-1986 Command and Control Common Specifications Vol. I

(11) NASDA-ESPC-1987 Command and Control Common Specifications Vol. II

(12) NASDA-ESPC-1988 Command and Control Common Specifications Vol. III

[NASA Documents]

(1) NSTS-1700.7 Safety Policy and Requirements for payload using the ISS Addendum

(2) NSTS 07700 Space Shuttle System Payload Accommodations Volume XIV

(3) NHB 8060.1 Flammability, Odor and Offgassing Requirements and Test Procedures for Materials in Environments That Support Combustion

(4) NSTS 22648 Flammability Configuration Analysis for Spacecraft Systems

(5) SSP 30237 Space Station Electromagnetic Emission and Susceptibility Requirements for Electromagnetic Compatibility

(6) SSP 30238 Space Station Electromagnetic Techniques

(7) SSP 30240 Space Station Grounding Requirements

(8) SSP 30242 Space Station Cable/Wire Design and Control Requirements for Electromagnetic Compatibility

(9) SSP 30243 Space Station Requirements for Electromagnetic Compatibility

(10) SSP 30245 Space Station Electrical Bonding Requirements
(11) SSP 30425 Space Station Program Natural Environment Definition for Design
(12) SSP 30426 Space Station External Contamination Control Requirements
(13) SSP 30482 Electric Power Specifications and Standards Volume 1 : EPS Electrical Performance Specifications
(14) SSP 30512 Space Station Ionizing Radiation Design Environment
(15) SSP 41165 Segment Specification for the Japanese Experiment Module
(16) SSP 42004 Mobile Servicing System to User (Generic) Interface Control Document
(17) SSP 50005 International Space Station Flight Crew Integration Standard (NASA-STD-3000/T)
(18) SSP 50036 Microgravity Control Plan
(19) SSP 52005 Payload Flight Equipment Requirements and Guidelines for Safety-Critical Structures
(20) ANSI-Z-136.1 American National Standard for Safe Use of Lasers

4.2.3 Reference Documents

(1) NASDA-ESPC-840 JEM System Specification
(2) NASDA-ESPC-2560 JPAH Main Volume
(3) JCX-95068 JEM Environment Condition Regulations
(4) JSX-2000046 HTV Cargo Safety Requirements
(5) SSP 41000 System Specification for The International Space Station
(6) SSP 30233 Space Station Requirements for Materials and Processes
(7) MSFC-HDBK-527 Materials Selections List for Space Hardware Systems
(8) MIL-STD-1553B Military Standard Digital Time Division Command/Response Multiplex Data Bus NOTICE2
(9) MIL-STD-1522A Standard General Requirements for Design and Operation of Pressurized Missile and Space Systems
(10) MIL-STD-454 Standard General Requirements for Electronic Equipments