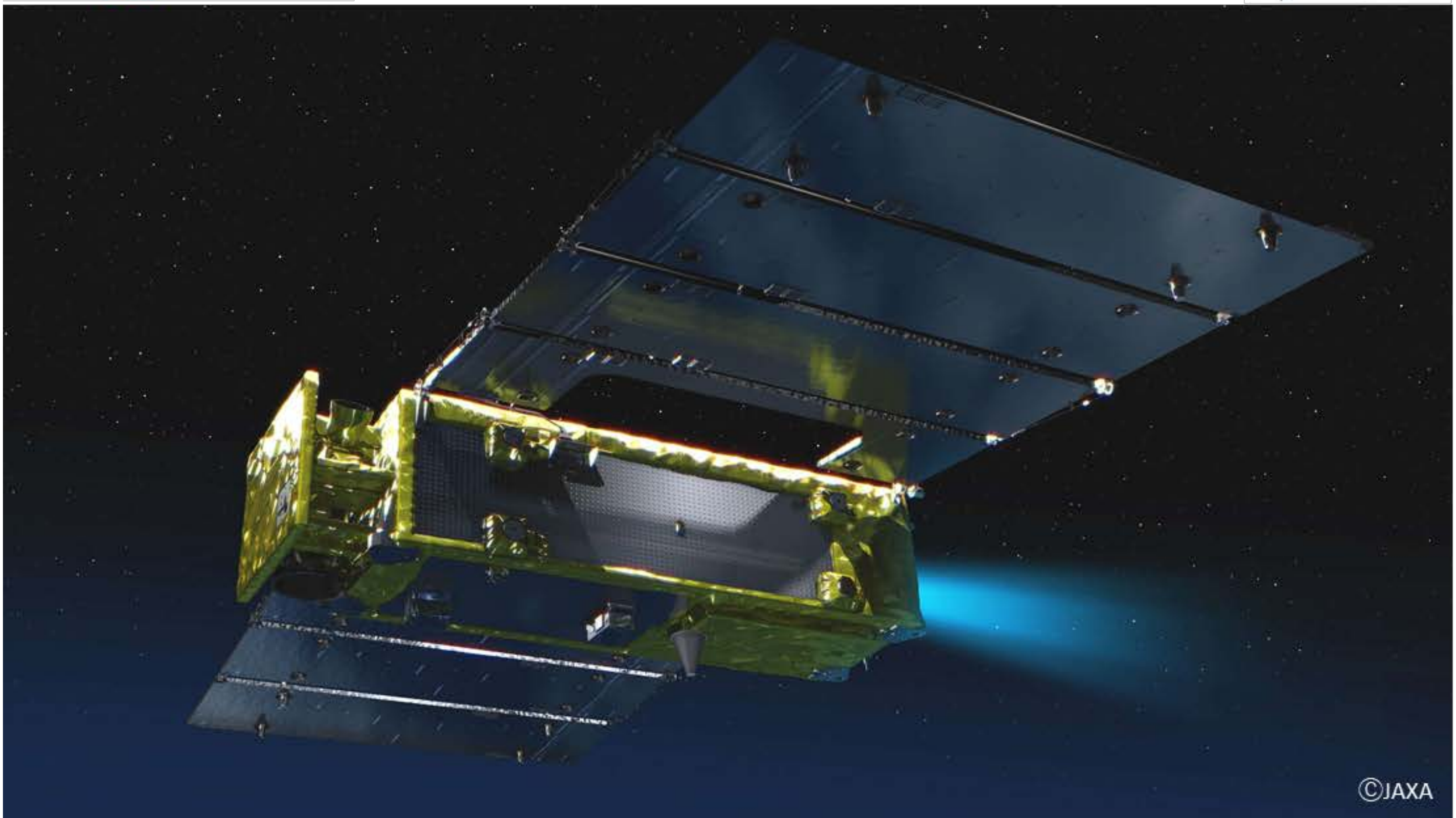
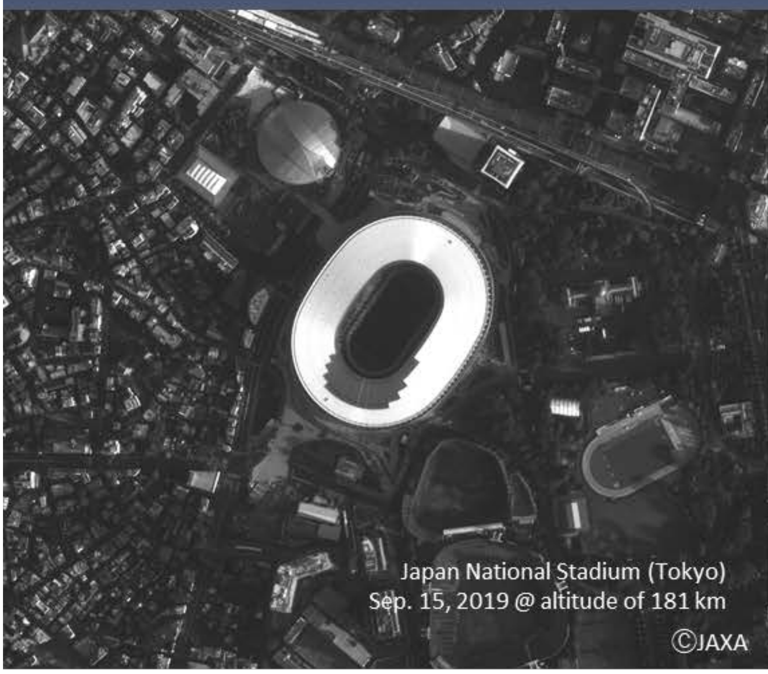


Super Low Altitude Test Satellite (SLATS)
Small and High Resolution Optical Sensor (SHIROP)
Description for data format

March, 2020


Japan National Stadium (Tokyo)
Sep. 15, 2019 @ altitude of 181 km


Around Hamamatsu Station (Shizuoka)
Sep. 27, 2019 @ altitude of 167 km

Specification for SHIROP data format

1. Super Low Altitude Test Satellite (SLATS), Tsubame

JAXA proceeds technical studies for a satellite continually orbiting lower than 300 km, so called very low Earth orbit (VLEO), which has not demonstrated in the past. One of the benefits of the very low altitude satellite is that the high-resolution imaging and the small-aperture optical system are available simultaneously. In the VLEO, on the other hand, atmospheric drag and the density of atomic oxygen, which causes material deterioration, are about 1000 times larger than those in the typical orbit for the earth observation satellites. Because most of earth observation satellites require a very accurate attitude control as well as the long-period operation, there had been significant technical difficulties to operate those in VLEO.

The goal of Super Low Altitude Test Satellite (SLATS), Tsubame, is to demonstrate a possibility for the satellite operation in VLEO. SLATS was launched by H-IIA vehicle alongside GCOM-C on December 23rd, 2017 from Tanegashima space center. After launch, it had lowered the altitude mainly by aerobraking, and it started the operation to keep a certain altitude lower than 300km using an ion engine from April 2nd, 2019. SLATS had successfully demonstrated the 6-stage operations at the altitude range of 271.1 to 181.1 km. At the same time, the high-resolution satellite images were taken, and those qualities have been proved. In addition, SLATS had made the long-term measurements for the first time for atmospheric drag and the AO deterioration of exposed material.

The all planned missions were fully achieved, and SLATS completed its operation in October 1st, 2019.

For more details: https://global.jaxa.jp/projects/sat/slats/

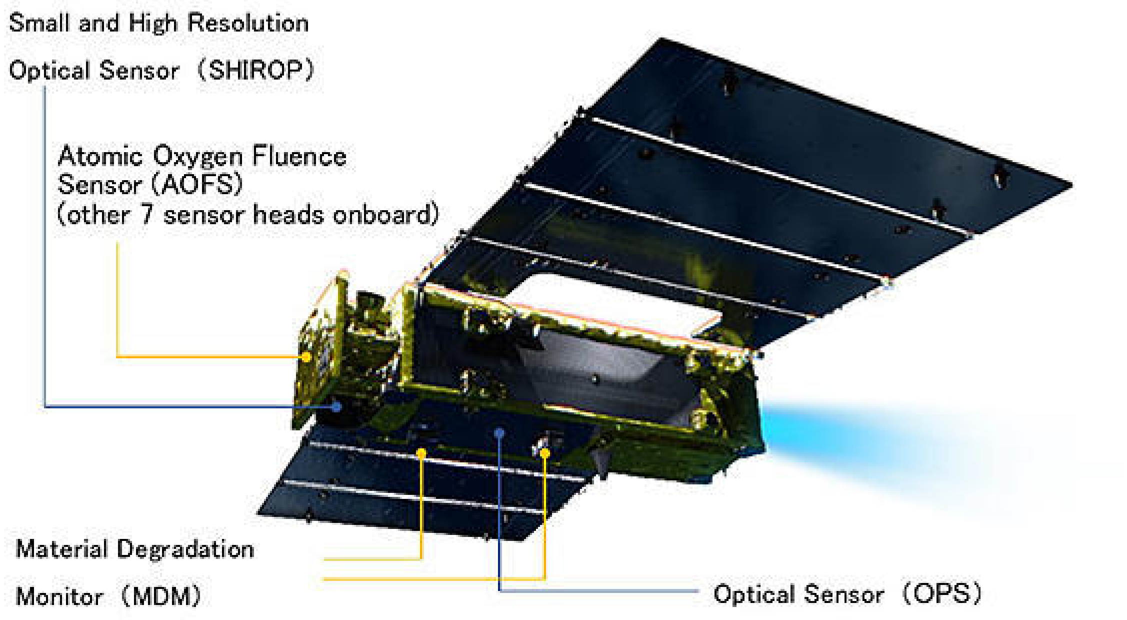


Fig. 1. SLATS Overview

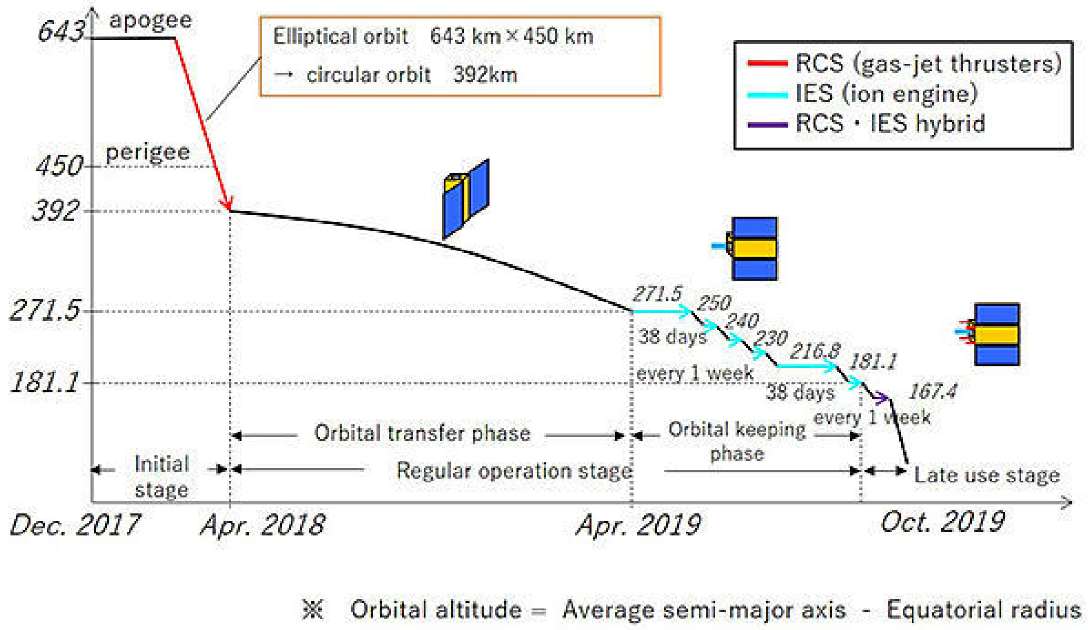


Fig. 2 Altitude profiles for SLATS operation

2. Small and High Resolution Optical Sensor: SHIROP

Small and high-resolution optical sensor (SHIROP) onboard SLATS is the sensor aiming to test the improvement of ground sampling distance by the VLEO operation. The specifications of SHIROP are summarized in Table 1, and the picture of SHIROP are shown in Figure 3

Table 1 Specification for SHIROP

Item	**Specification**
Optical design	Cassegrain telescope with correcting lens system
Clear aperture	>20 cm
Detector	Area CCD
Imaging	Single-shot, TDI imaging (max 64 stage)
Wavelength	Panchromatic (visible）
IFOV	2.7 μrad (CT/AT)
FOV	17.7 mrad (CT)×11.8 mrad (AT)
Altitude range	500km ～ 160km
Imaging period	Variable in above altitude range
Quantization bit rate	12bit（extend to15bit on ground）
Total MTF	> 0.08
Timing control for imaging	Realtime, reserve by time, autonomous by latitude, sequential imaging
Weight	19.4kg（Optics 16.9kg, Electronics 1.9kg）
Size	Optics 270×540×270 mm, Electronics 125×225×95 mm
Pwer consumption	<33W including heaters

Figure 1 Picture of the SHIROP optics

2.1. Wavelength range

0.48 〜 0.70 µm Panchromatic

2.2. GSD (IFOV)

IFOV : 2.7 µrad

GSD 73 cm at altitude of 271 km at nadir

GSD 59 cm at altitude of 217 km at nadir

GSD 49 cm at altitude of 181 km at nadir

Over the entire operation period, SLATS has gradually lowered its orbit. The GSD gets improved as the altitude becomes lower. The relation of the altitude and the GSD at nadir is shown in Figure 4.

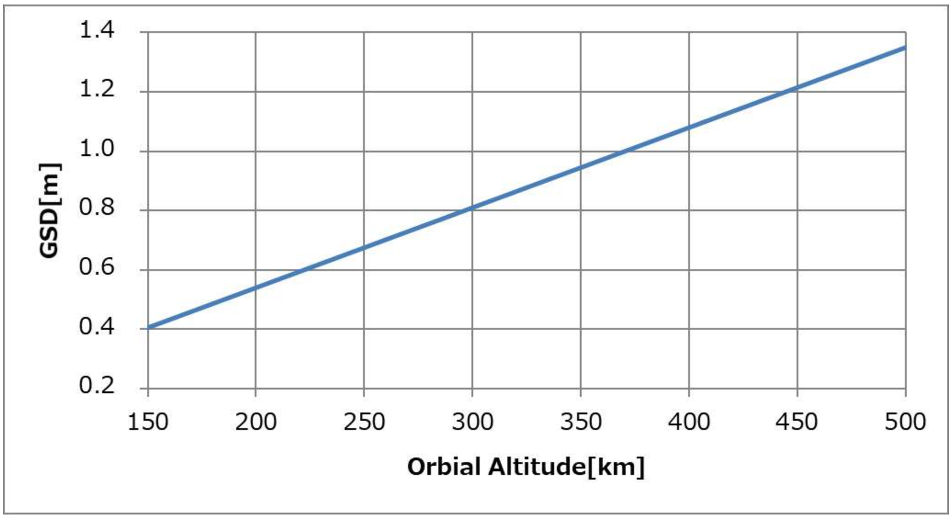


Figure 2 GSD as a function of altitude

2.3. Pointing

SHIROP can take an image at the range of +/-45 deg along the cross track with the center of the nadir. The GSD gets worse as the pointing angle gets large. It can be roughly estimated as (GSD for pointing) = (GSD of the nadir) / (angle of pointing)

Position accuracy (Just for reference)The position accuracy is not guaranteed since SLATS is categorized as a technological test mission, but some kinds of evaluation has been performed.* Note that this is just for reference, the evaluation results are below:

In a north-south direction： about 30 m

In a west-east direction： about 52 m

* Based on the geometrical evaluation using the 35 SHIROP images including the GCP points constructed for the ALSOS mission.

2.4. Quantization bit rate

The quantization bit rate for the SHIROP image data and the image product are 15- and 16-bit, respectively.

3. Specification for image products

3.1. File format

Geotiff format (16-bit)

3.2. Size of scene

The size of a scene is 6576 x 4384 pixels, where the pixel size is corresponding to the GSD of the picture.

3.3. Process levels

The two types of image products are provided as shown in Table 2.

Table 2 Class of product image

Process level	Process details
Level 1B	a) Radiometric correction and geometric calibration have done, but geometrical projection has NOT been processed.
	b) Radiometric correction and geometric correction (orthorectification) have been processed. The cubic convolution (CC) method is employed for the resampling for geometric projection.

3.4. Compression

The provided image data are compressed by the process shown in Table 3.

Table 3 Types image compression process

Types	Details
Uncompressed (Raw)	No compression processed
Compressed (Comp)	JPEG compression processed. A 12-iit image is converted to an 8-bit image* and JPEG compressed with onboard computer, then it is extended to a 15-bit image on ground. *The data of 98% levels according to the histogram for 12-bit image are extracted for the next resampling process to a 8-bit image.

3.5. Definition of file name

1. Level 1B-a)：Radiometric correction image

   Timetttttttttt_Numxx_SCENEyy_zzzzzzz#_0_active_UTMnns_NMI_**.tif**

   tttttttttt: Satellite time of imaging (seconds since at 0:00:00 on January 1st, 2013)

   xx: Sequence number in the date of imaging (starts 01)

   yy: Scene number for saving (00～63)

   zzzzzzz#: Method of timing control for imaging (autonomous or reserve), and the sequence number for sequent imaging (1or2)

   Autonomous by latitude：RSVLAT

   Reserve by time：RSVTIME

   nn: UTM Zone number (01～60)

   s: The Northern/Southern Hemisphere (N/S)

   ****: Compression process, Uncompressed (Raw) or compressed (Comp)

e.g.) Time0200460630_Num01_SCENE37_RSVLAT1_0_active_UTM04N_NMI_Raw.tif

2. Level 1B-b) Radiometric correction and orthorectification image

   Timetttttttttt_Numxx_SCENEyy_zzzzzzz#_0_active_UTMnns_ORI_**.tif**

   tttttttttt: Satellite time of imaging (seconds since at 0:00:00 on January 1st, 2013)

   xx: Sequence number in the date of imaging (starts 01)

   yy: Scene number for saving (00～63)

   zzzzzzz#: Method of timing control for imaging (autonomous or reserve), and the sequence number for sequent imaging (1or2)

   RSVLAT Autonomous by latitude：RSVLAT

   Reserve by time：RSVTIME

nn: UTM Zone number (01～60)

s: The Northern/Southern Hemisphere (N/S)

****: Compression process, Uncompressed (Raw) or compressed (Comp)

e.g.) Time0184014742_Num02_SCENE31_RSVLAT1_0_active_UTM19N_ORI_Comp.tif