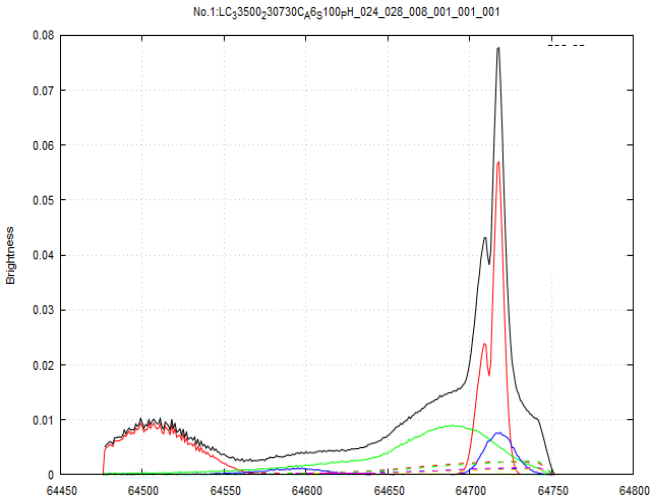
JAXA Space Debris Observation Activities

42nd IADC @ Bengaluru, Apr. 16–19, 2024

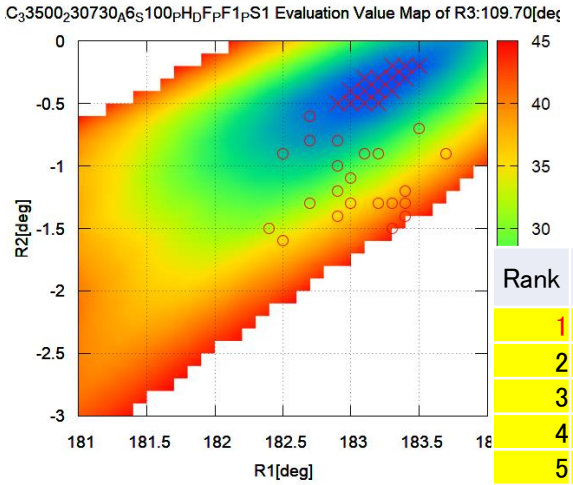
1. Estimation of attitude motion from light curves by comparison with CG and ground experiments

- The light curve simulator using 3D model was improved. A new exhaustive algorithm to find out the optimum solution was developed.
- The precise CG model of H-2A R/B including the optical property of each component was also developed.
- 26 light curves of the same H-2A R/B were obtained and analyzed using the light curve simulator. The results were interpreted that the H-2A R/B was in the stable attitude pointing its PAF to the earth.



Simulated light curve (each component)

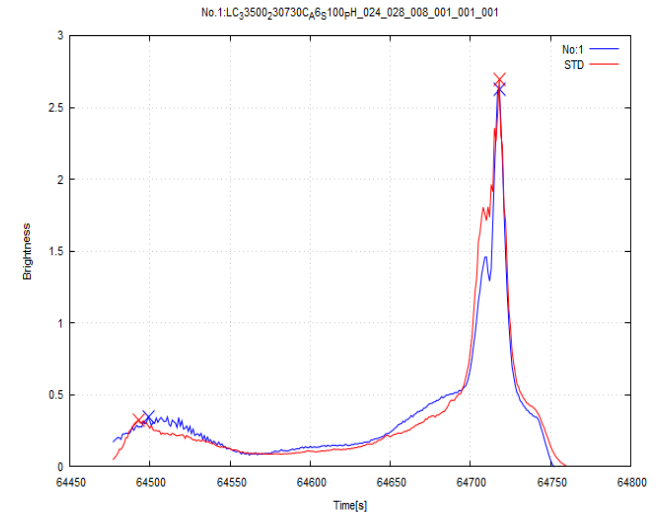
Movie of the attitude of minimum rank(10x speed)



Contour of the rank values (R3=−109.7−degree)

Rank values of top 10

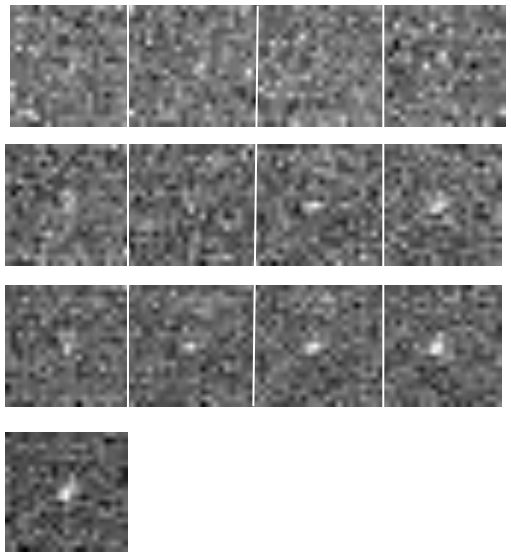
Rank	value	R1[deg]	R2[deg]	R3[deg]
1	17.661	183.3	−0.3	109.7
2	17.703	183.3	−0.3	109.9
3	17.768	183.1	−0.4	109.7
4	17.779	183.2	−0.4	109.8
5	17.796	183.5	−0.2	109.9
6	17.800	183	−0.5	109.6
7	17.835	183.4	−0.3	110
8	17.841	183.3	−0.3	109.8
9	17.860	183.4	−0.2	109.9
10	17.861	183.3	−0.3	110



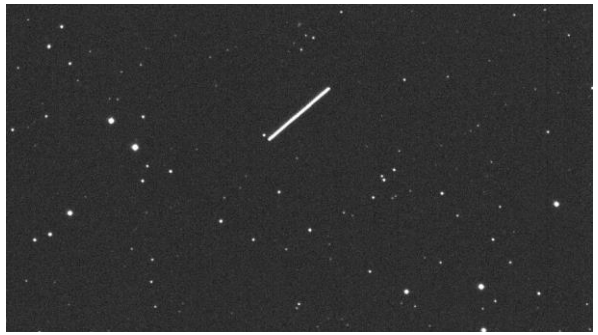
Comparison between observed (red) and simulated light curve(blue)

2. Construction of a pipeline for understanding the low-Earth orbit debris environment

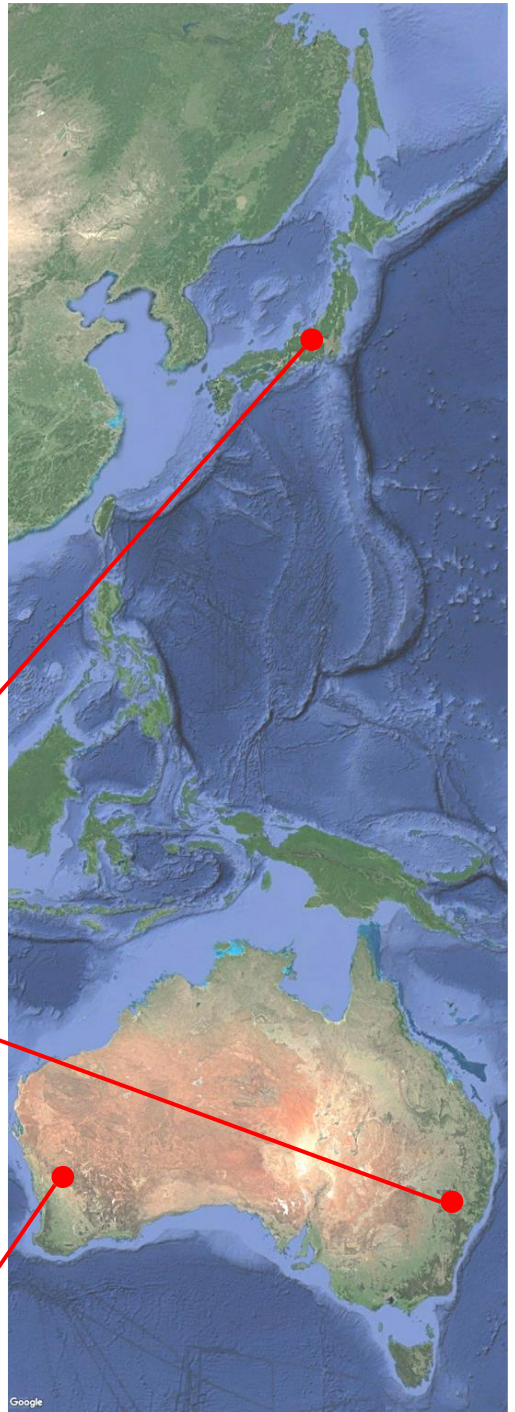
JAXA's Research and Development Division is currently conducting research and development on observation technologies for low-orbit objects by building an observation system as shown in the figure on the right. By making full use of JAXA technology, it is possible to detect a large number of uncataloged objects in low Earth orbit. By tracking and observing uncataloged objects captured at the Australian and Kiso Observatory at other stations, it is possible to determine the orbit of these objects with high accuracy, and we aim to create a database of these objects. We constructed a pipeline to analyze a large number of images obtained at Kiso Observatory and the Australian SSO Observatory at high speed, and at the same time calculate the observation direction of captured objects at other stations.



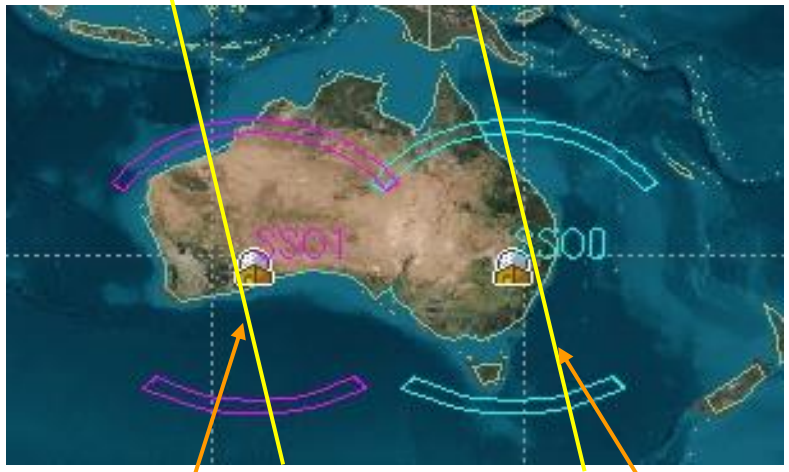
An uncataloged object in low Earth orbit detected by JAXA technology (7 cm size). The first row is a raw image near the detected object, the second and third lines are images of 4 and 8 images stacked, and the figure below is an image of 32 images stacked.



The trajectory of a low-orbit object extracted by JAXA technology from images acquired by the large CMOS camera Tomo-e Gozen installed at Kiso Observatory



2. Construction of a pipeline for understanding the low-Earth orbit debris environment

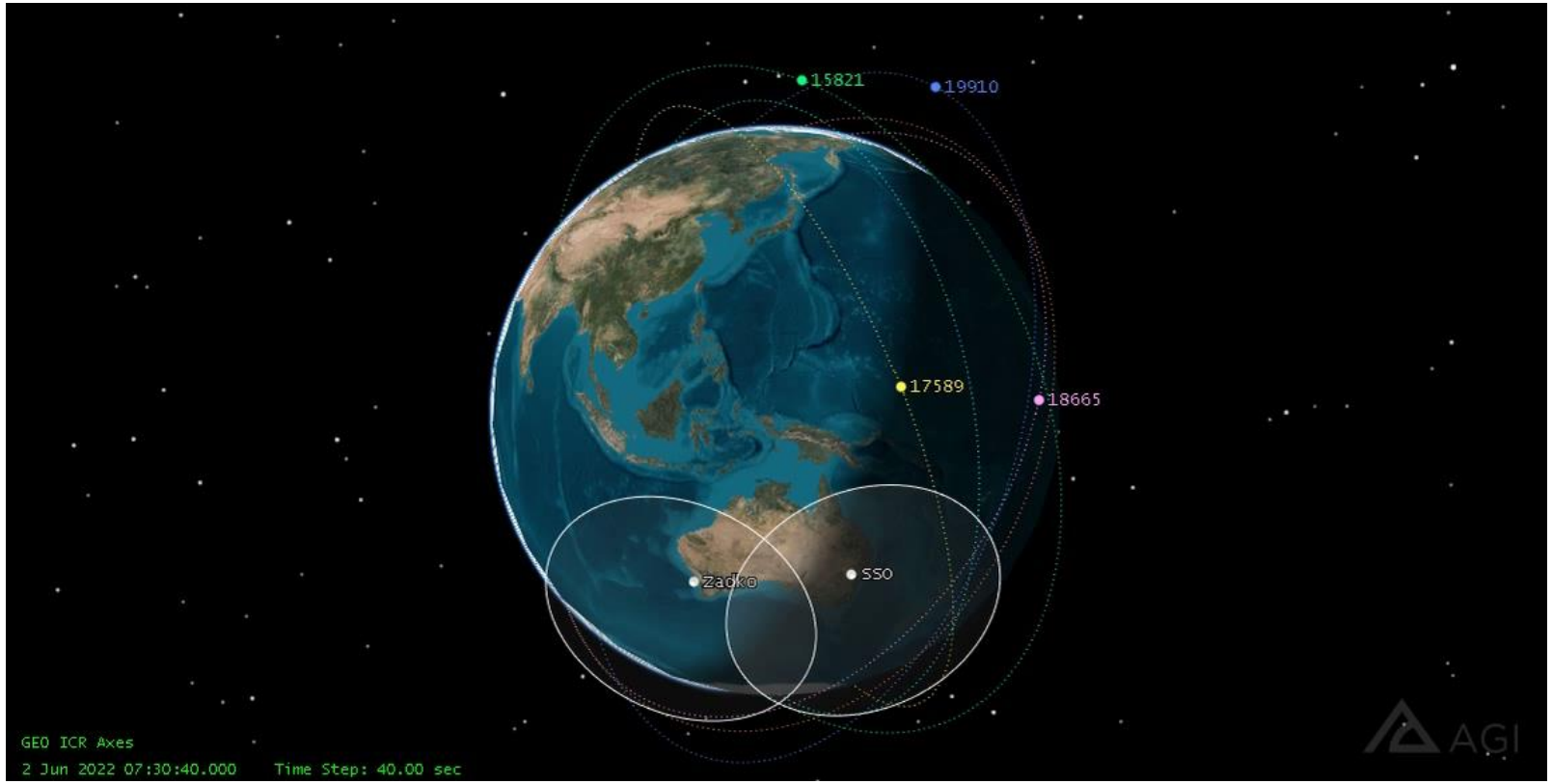


2nd path

1st path

2 consecutive observations using two sites separated by longitude

Concept of the orbital determination



Detection of un-cataloged LEO objects using SSO site or Kiso observatory

→

Determination of the circular orbit using the data from one site

→

Follow-up observation using Zadko site.

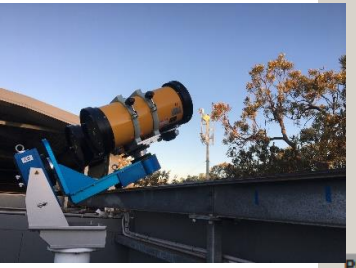
→

Precise Orbital determination using the data from two sites

2. Construction of a pipeline for understanding the low-Earth orbit debris environment

Test observations using pipelines were conducted, and uncataloged objects detected at the SSO station were successfully traced at the Zadko station. The orbit was determined, and the next day, two days, and five days later, both SSO and Zadko stations using this orbit succeeded in follow-up observations. We verified the effectiveness of the pipeline.

Detection at SSO



Follow-up at Zadko

sso_20240124_batch2.csv

Observations at SSO

Circular orbit

n	date	time	a	e	i	Ω	ω	M	m_h	m	file	status	x1	x2	x3	x4	norad	name
1	240124	10.954770	7704.512	0.0	56.218	88.876	0.0	322.076	12.6/12.6/	12.6	batch2-cam1-B1-0	2	813	814	126.90	121.40	N/A	N/A
2	240124	11.152276	7491.648	0.0	123.033	281.312	0.0	217.805	6.0/6.0/5.9/	6.0	batch2-cam1-B1-14	3	1168	1170	55666.65	62211.33	N/A	N/A
3	240124	10.999770	7247.719	0.0	81.423	252.458	0.0	211.172	12.8/12.8/	12.8	batch2-cam1-B1-3	2	894	895	100.55	100.73	N/A	N/A
4	240124	11.007545	7880.236	0.0	5[illegible]896	231.015	0.0	219.338	12.3/12.4/12.5/12.2/12.5/12.5/	12.4	batch2-cam1-B1-4	6	906	911	158.55	139.44	N/A	N/A
5	240124	11.071435	7562.621	0.0	[illegible]975	81.652	0.0	328.842	8.8/8.7/8.6/8.7/	8.7	batch2-cam1-B1-9	4	1022	1025	4218.83	4775.66	11168	COSMOS 1067
6	240124	10.976990	7156.298	0.0	[illegible]386	262.258	0.0	211.368	6.1/6.2/	6.2	batch2-cam2-B2-0	2	853	854	44774.44	39641.14	25789	QUIKSCAT
7	240124	10.986990	7232.037	0.0	[illegible]970	71.928	0.0	328.583	12.3/12.1/	12.2	batch2-cam2-B2-1	2	871	872	147.48	180.89	20846	CZ-4 DEB
8	240124	11.017545	7306.589	0.0	[illegible]2.528	253.338	0.0	211.284	11.3/11.6/	11.4	batch2-cam2-B2-3	2	926	927	347.55	289.57	29301	METEOR 2-17 DEB

Re-observation coordinates at Zadko (JAXA)

Observation direction 1

Observation direction 2

date2	RA_Z2	Dec_Z2	Az_Z2	Alt_Z2	date3	RA_Z3	Dec_Z3	Az_Z3	Alt_Z3	date4	RA_Z4	Dec_Z4	Az_Z4	Alt_Z4
124740	69.849	-52.365	1.919	68.971	124840	84.604	-38.699	-52.431	76.833	124940	94.551	-23.909	75.673	68.298
125640	105.332	-26.659	[illegible]	[illegible]	125740	92.522	-45.288	-41.341	69.669	125840	69.205	-61.234	[illegible]	[illegible]
124120	107.347	-1.572	57.836	43.421	124220	115.246	-21.776	88.169	48.402	124320	126.758	-41.200	-61.051	43.941
125450	72.680	-11.111	359.738	69.758	125550	83.094	-22.323	47.250	77.275	125650	95.454	-32.697	-80.027	71.182
125210	106.242	-50.467	-42.891	58.343	125310	102.044	-32.339	-79.849	64.842	125410	99.646	-13.839	60.898	59.656
123840	122.316	-11.390	80.357	36.841	123940	128.003	-32.828	-71.721	40.640	124040	138.744	-53.330	-44.152	36.566
124040	129.122	-32.210	-72.243	39.769	124140	116.934	-14.463	79.881	43.552	124240	107.324	4.190	52.113	39.552
124340	109.725	-3.597	61.559	43.466	124440	117.456	-22.333	89.806	47.231	124540	128.338	-40.095	-62.425	43.048

Press Enter to view next file OR type 'schedule' to create an schedule file

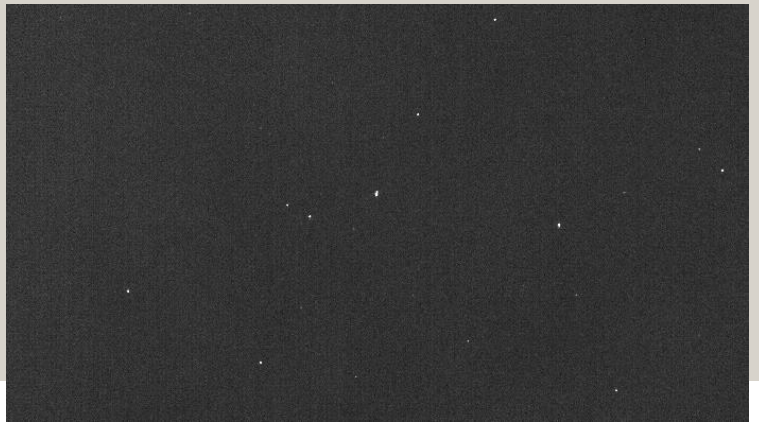


Image taken at SSO next day. The object is passing through almost center of the FOV.

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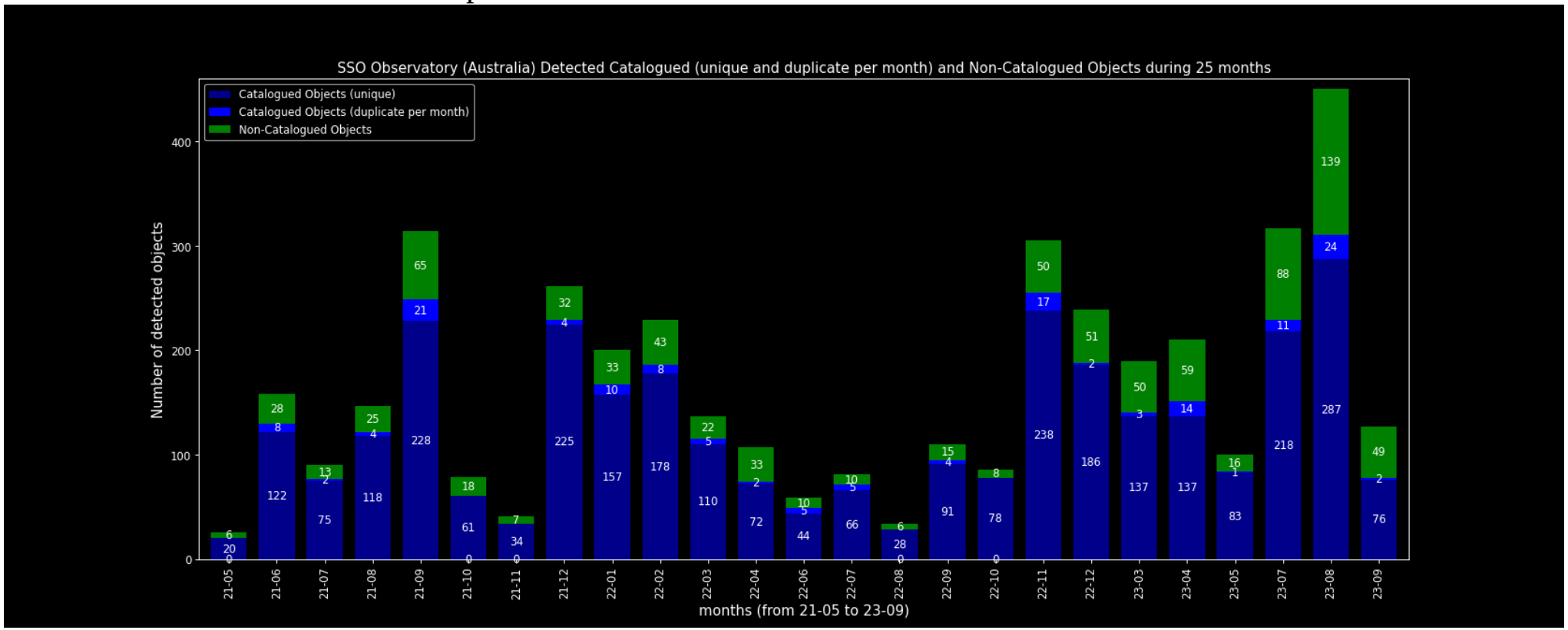
JXLD-0001
1 99999U 99999A   24024.46467792  .00000000  00000-0  10000-3 0    1
2 99999 122.9900 281.2905 0007544 113.0526 104.5759 13.41476022    1
```

Orbital information (TLE) calculated using the data from both sites

We succeeded in observation of the target next day, two days and five days later.

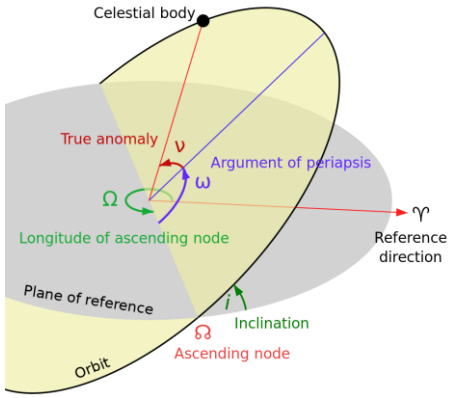
2. Construction of a pipeline for understanding the low-Earth orbit debris environment

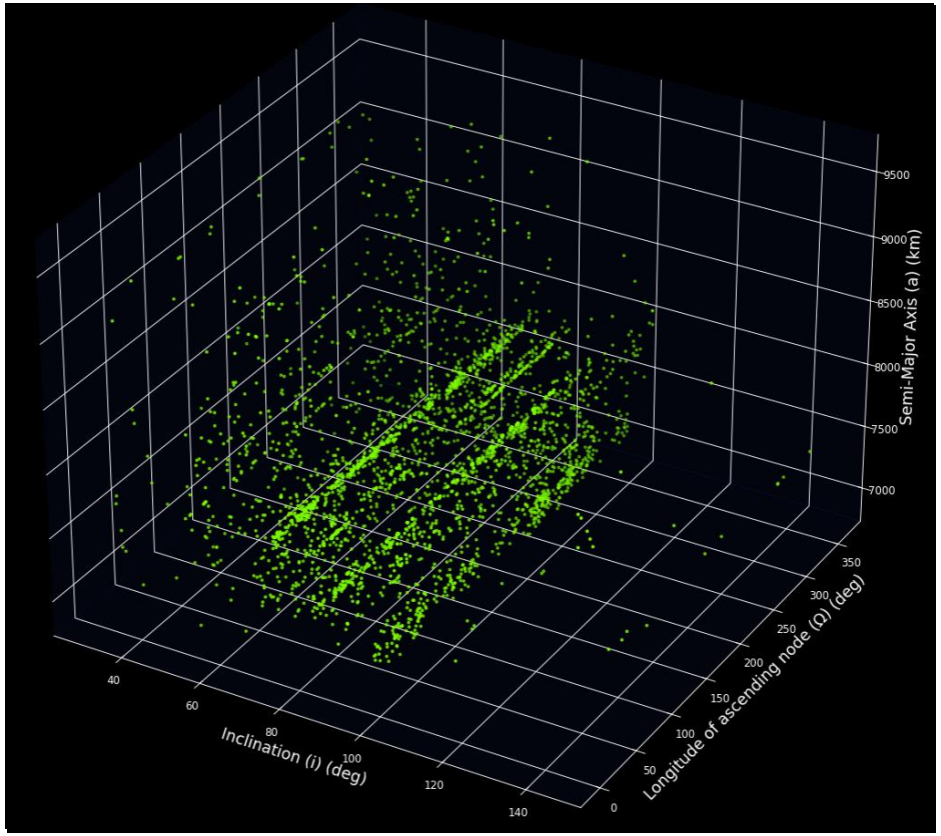
In parallel with the construction of the pipeline, we are conducting surveys of LEO objects using the Australian Remote Observation Facility to the extent permitted by weather and resources. Depending on the weather and orbital conditions, 50-60 objects are detected every day, about 20% of which are uncataloged objects. In addition, the proportion of the same object observed over the past 2.5 years was about 3.8% (calculated from the number of observations of catalog objects). For uncataloged objects, three clusters were identified in the three-dimensional orbital element space.

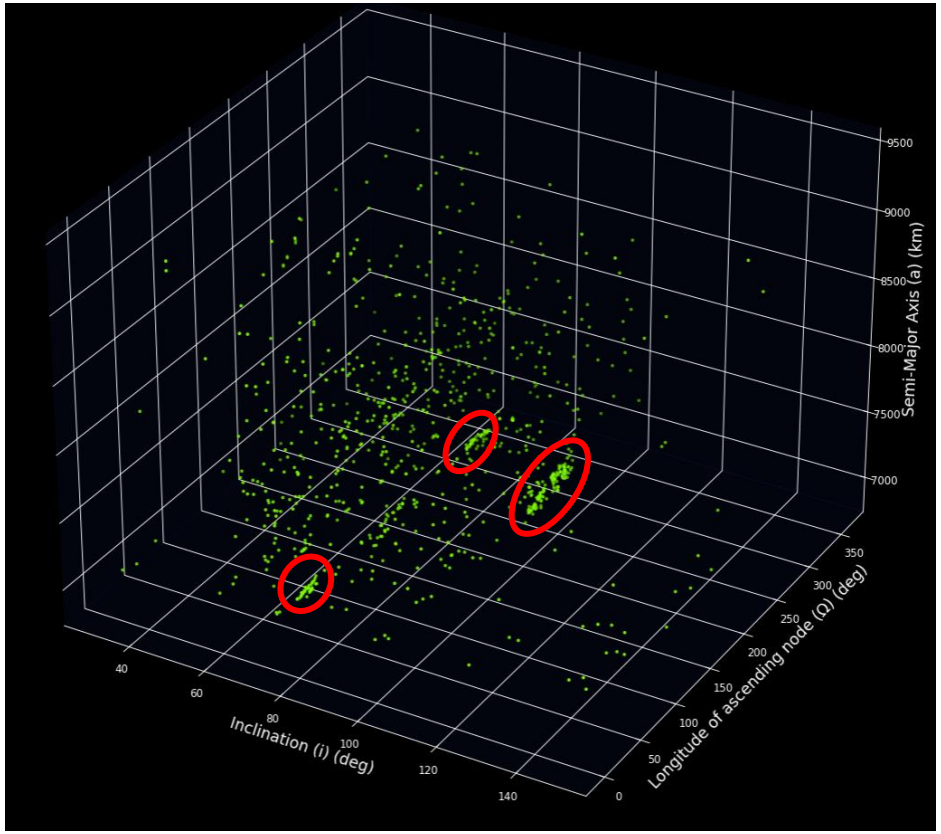


Time vs number of detected objects（blue：cataloged objects，green: un-cataloged objects）

2. Construction of a pipeline for understanding the low-Earth orbit debris environment







Cataloged objects

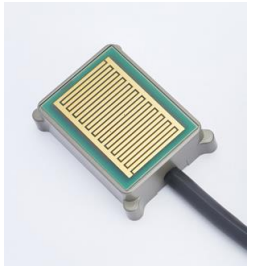
Un-cataloged objects

Plots in inclination-RAAN-Orbital radius space

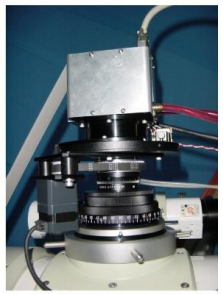
3. Construction of a pipeline for understanding the GEO orbit debris environment

In order to contribute to the understanding of the geostationary orbit debris environment, the Mt.Nyukasa Optical Observatory, which is owned by the Research and Development Directorate, has also started research and development to remoteize the observation system and speed up the analysis pipeline. In order to remoteize the observation system, the telescope, camera, and dome control were remoteized. Since computers and control devices may freeze, a power rebooter is installed to restart them remotely. A network camera is installed so that the inside of the dome can be checked remotely. In order to shut down observations in the event of rainfall, snowfall, or strong winds, a rain and snow sensor and a combined weather sensor were prepared. As for the rain and snow sensors, the sensor readout circuit and program have been created and installed, and the combined weather sensor is currently in the process of checking the operation and creating a readout program, and is scheduled to be installed around April. As for the data analysis, the program was completely reviewed, and the speed of the detection of moving objects by the line detection method and the stacking method was completed, and the speed was about 17 times faster. In the future, we will create a program for orbital determination, etc., and plan to start remote observation and real-time analysis at the site by the end of this fiscal year.

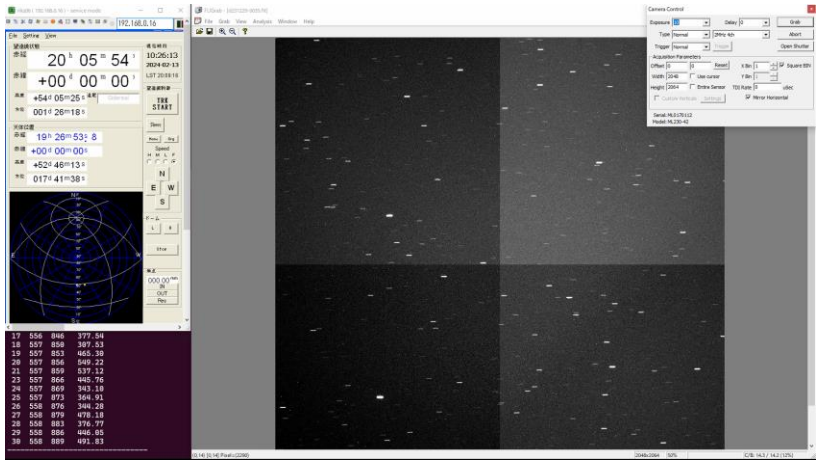
The rain and snow sensor



Mt.Nyukasa Optical Observatory



35cm telescope and CCD camera

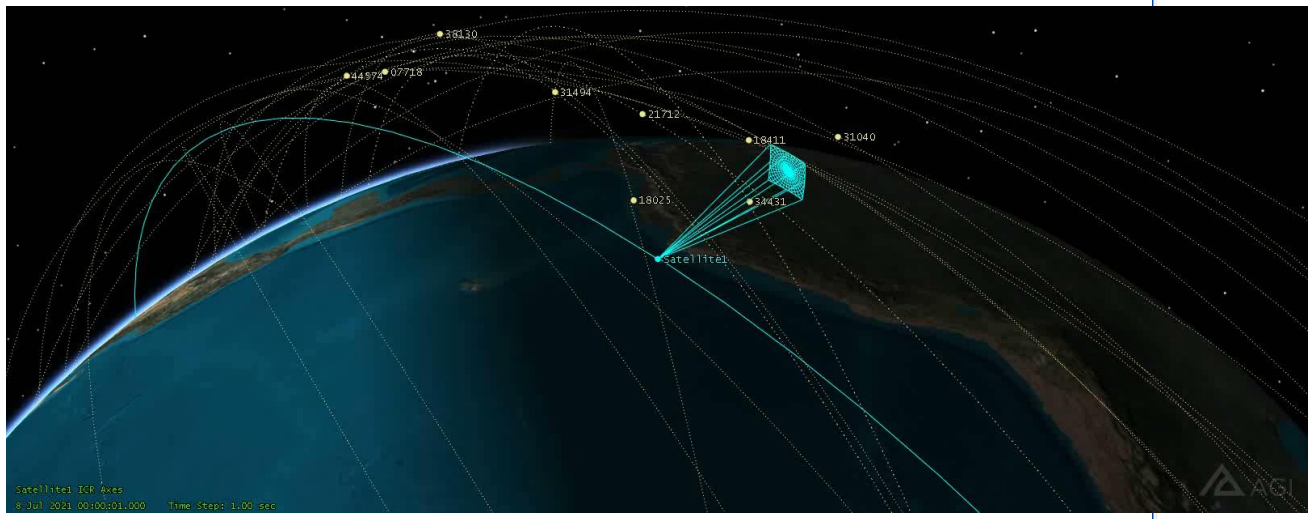


Control panel for remote observation

The combined weather sensor

4. JAXA venture for SSA

JAXA technology detects space objects that appear on Star Tracker (STT) and ground observation images, builds a unique database by integrating data from STTs from multiple satellites and ground observation, and provides services for space situation monitoring and collision avoidance operations. We examined the feasibility of the business we offer using internal funds and established a company (Star Signal Solutions Co.,Ltd) with JAXA Venture certification.



Simulation of space objects detections using STTs

Web site of the company (Star Signal Solutions Co.,Ltd.)