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A New Data Archiving and Service System Specialized for South Korea Satellite Data Policy

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Abstract

With the expectation of the enhancement for operating low earth orbit (LEO) satellites of the Korea aerospace research institute (KARI), it is essential to devise a new satellite operation system including multiple antennas and an effective system for satellite data archiving and service. As a part of the satellite operation system of KARI, a new sub-system specialized for South Korean data policy, named data system (DS), is devised. It is composed of a data archiving system (DAS) and data service system (DSS). DAS is devised to generate satellite image products, whether or not there is a request from user to generate image products. The storage size for achieved satellite data was assigned through the calculation for the expected data size from the operating LEO satellites, as planned in the "3rd Basic Plan for Space Development Promotion" of South Korea. DSS includes a function of authorization on each different user with each access level, leading to prompt satellite data delivery. Moreover, several special functions on a webpage are equipped, including image clip function on high-resolution satellite images and image comparison function on two satellite images on the same observation region.

Keywords: Big-data system, Data archiving, Data policy, Satellite image web service.

Acronyms/Abbreviations

Korea aerospace research institute (KARI), Korean multi-purpose satellite (KOMPSAT), Compact advanced satellite 500 (CAS500), Korea space launch vehicle-II (KSLV-II), Korea pathfinder lunar orbiter (KPLO), Low earth orbit (LEO), Network-attached storage (NAS).

1. Introduction

KARI draws up a blueprint for the operation of 70 Earth observation satellites in 2030, facing the New-Space era for expanding the market size of the space industry in South Korea. In 2019, KARI began developing a new ground operation system to efficiently handle those 70 satellites, such as the KOMPSAT series, CAS500 series, and other micro-satellites. Simultaneously, a new operation facility was constructed on Jeju Island in South Korea, and thus it will be officially opened in September 2022.

In particular, compared with the existing deployment system, the new system has improved delivery performance of satellite image products to users. Under the satellite data policy of South Korea, distributed satellite images should be checked on several issues in image processing; thus, requiring a wait for a rather long time to receive the image products. To overcome this time delay issue on product delivery, we devised a new sub-system, named data system (DS), which is one of the six sub-systems in the new ground operation system.

In this paper, we introduce DS for the following two tasks: archiving task and the service task. For the archiving task, the sub-system automatically generates and saves the images as popular format products, if there are few clouds in the scene. Therefore, in the case of a product order from the already archived data, it does not need to take a check procedure related to the data policy. In addition, in order to save this huge amount of data, we built tens of petabytes of storage consisting of both online NAS and tape storage with a real-time loading system. Using this new delivery system, authorized users could check the ready state of the interesting image product for fast delivery process. Meanwhile, for the service task, it includes an authorization function to classify the access level of users. Because it is not allowed for all users to access the entire satellite image, DS would be utilized for system manager to assign an authority level to each user, concerning the scene site, product level, utilizing satellite, etc. Furthermore, DSS is equipped with various useful services with remote sensing functions on webpage: 1) Displaying original high-definition satellite images on the webpage, 2) Downloading the clipped image from original high-definition satellite images, 3) Comparing two original images with the same region, and 4) Producing video product with time series browser images (i.e., catalogue images).

2. New Korea Satellite Operation System

In 2022, there were several big achievements in KARI. The first achievement is the success of KSLV-II for carrying 1.5 tons of satellites to low-earth orbit (600~800km) [1]. The second one is the launching of KPLO, carried by Falcon 9 of Space-X. In particular, the orbiter carries high-resolution optic camera for exploring the proposed landing site for future lunar landing module [2]. The last achievement of KARI in 2022 is the new launch of Korea satellite operation centre in Jeju island, South Korea [3].

As the blueprint for the operation of 70 Earth observation satellites in 2030, the institute devised and built a new operation centre with the goal of stable operation for those LEO 70 satellites. Indeed, it really needs to large area for building many antennas to operate the diverse satellite. Especially, in order to contact satellite constellations, multiple antennas are required to send tele-command data and receive telemetry data and imaging data between the ground station and satellites. Not only for the satellite constellations, but it is also required to prohibit overlapped contact with the satellite on each antenna.

From 2019, all sub-systems (mission control and image reception subsystem, user support subsystem, image processing subsystem, antenna subsystem, and information technology subsystem) in the ground system have been developed. Originally, those subsystems have been devised and utilized in the original satellite operation system; however, they were developed to integrate many functions to operate diverse satellites effectively. Contrary to other previously utilized subsystems, the data system we introduce here is newly devised in KSOS project, to improve the distribution ability of satellite image data toward users.

3. New Data Archiving and Service System

3.1 Conventional Data Flow

Any people, who tries to use satellite information in South Korea, should follow several data policies. In the view of access-level, each satellite image would be assigned among three levels: public-open, restriction on public-open, not-open. It depends on the resolution of satellite image, observing area, geometric dimension, and etc. In order to use restricted satellite images, the user should be granted an access right, by the data policies. Furthermore, the regulated range of offering satellite data is different to users having different authorities. To respond to each user with respective permission, KARI organized and operated a front desk system with an order management system on the satellite information database (KSATDB) system and satellite image search and order (Arirang) system [5]. Even though the systems provide a proper response to user requirements, it is required to wait for a long-time to offer high-quality satellite images with processing procedure of order management at the front desk, user's permission check, satellite image check about public control area, high-quality image generation, and distribution in the front desk. With the enhanced number of satellite images from newly launched satellites, it is estimated that the utilization of satellite images in diverse fields. Thus, a new satellite data offer system is demanded to respond to the tremendous requests for satellite images from users. Furthermore, to improve the effectiveness of satellite images, shorten offering procedure is needed to provide satellite images to users promptly. For these reasons, KARI devised a new subsystem related to satellite image archiving and service system, named data system.

3.2 Data System

It is clearly stated that the LEO satellites are used to acquire satellite images with enhancing their usability in various application fields. Therefore, to enhance the usability of LEO satellites, an effective data distribution system between user and satellite data should be devised. KARI has devised a new data service system named the data system, which is composed of a data archiving system (DAS) and a data service system (DSS).

3.2.1 Estimated Satellite Data Size and Archiving System

Having the increase of the operating LEO satellites, the expected amount of satellite data must have been extremely enhanced. Thus, it is required to estimate the amount of satellite data acquired from satellites, which may be planned in the "3rd Basic Plan for Space Development Promotion" [4] of South Korea. Fig.1 shows the expected operating satellites in KARI at each year. In 2022, four-KOMPSATs, KOMPSAT2, 3, 3A, and 5, and CAS500-1, were applied in earth monitoring. Actually, there was a plan to launch KOMPSAT 6 and CAS500-2 in 2022; however, it is delayed due to the diplomatic problem with the Soyuz launcher of Russia. Those two satellites and KOMPSAT7 are expected to be launched and operated in 2023.

With the development of flagship or advanced models such as the KOMPSAT series and CAS500 series, both micro satellite and small satellite are planned to be produced from 2025. In particular, about 40 microsatellites are planned to be launched and 2027, as shown in Fig.1. As a result, the estimated number of operating satellites in 2030

is 78, including 67 LEO satellites for Earth observation and 11 other satellites, such as GEO sat., augmentation sat. and deep space sat.

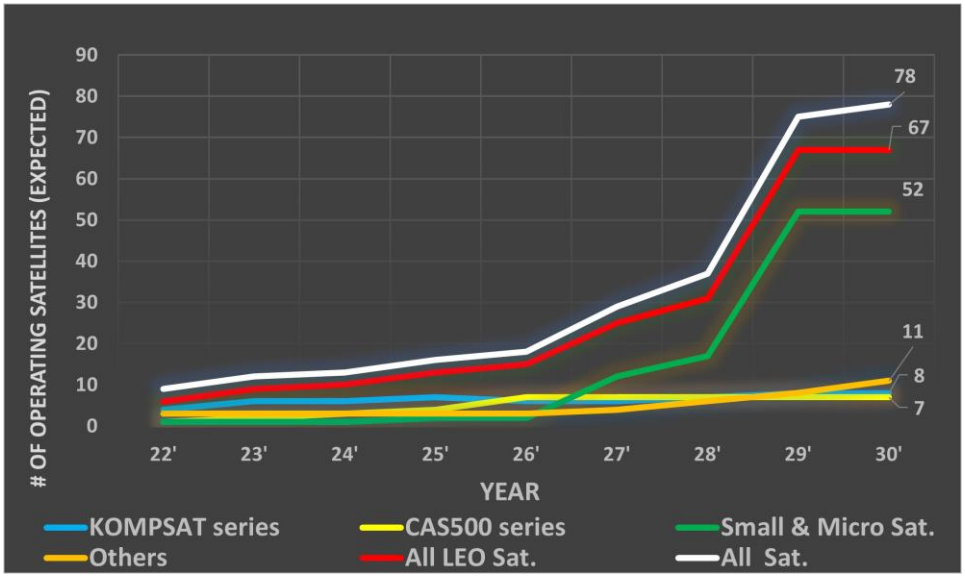


Fig. 1. The expectation of the number of operating satellites

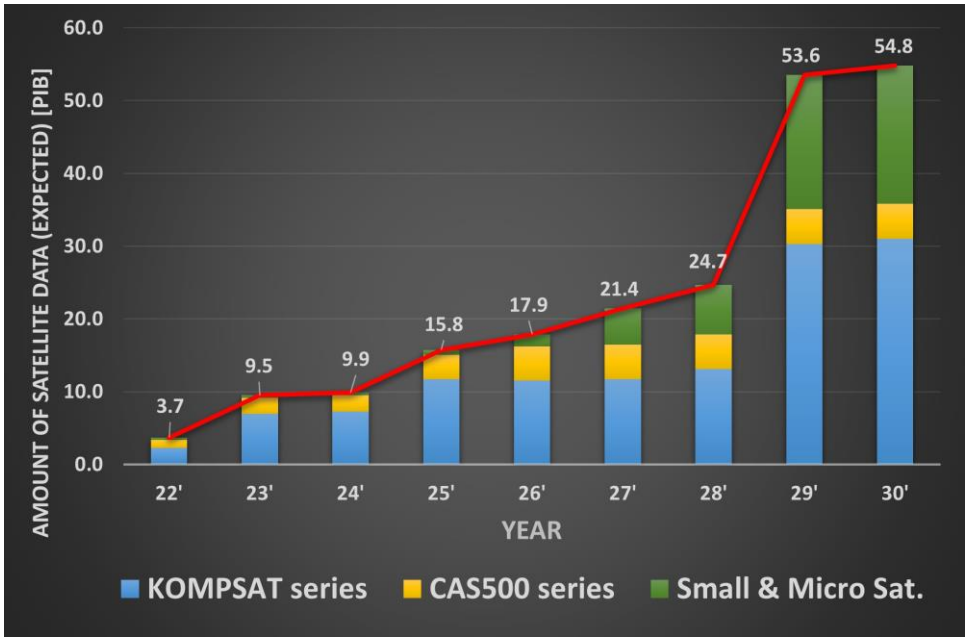


Fig. 2. The expectation of the amount of archiving satellite image data in DAS

It is clear that tremendous satellite image data would be obtained from these multiple LEO satellites. The data system in KSOS is devised to provide high-quality satellite images to users promptly by pre-creating the standard satellite images with the most widely used formats. Thus, it is required to assign the image format pre-created, providing them to users promptly. In this project, we assigned the format of automatically generated satellite image product on optic satellite: radiometrically corrected image file (L1R), the geometrically corrected image on L1R image (L1G), and pan-sharpened high-resolution image on L1G image (L1G-PS) [6, 7]. With operating front desk facing user's requests, these formats are widely utilized in the remote sensing field. However, it is impossible to make all data provide high-quality images in the view of resource management, due to the storage size issue for archiving the tremendous image files. It is inefficient to archive entire satellite images with high-quality images,

especially for satellite images with heavy clouds. Owing to the heavy cloud, it is hard to utilize the image on remote sensing or defence field. For this reason, we decide to automatically create the satellite images only with under 25% cloud average, whose results come from cloud analysis base on deep learning techniques.

On the other hand, KARI has operated not only optic satellites but also radar satellites such as KOMPSAT 5. Furthermore, there is a plan to launch radar satellites such as KOMPSAT 6, CAS500-5, and several small radar satellites in the future. Contrary to optic images, radar images from radar satellites would provide fine satellite images regardless of the weather. Therefore, the generated image from radar satellite would be generated as a high-quality satellite image without considering the cloud average. In this Data system, we assigned the radar image format for an automatic generation as complex radar image format (L1A) and geometrically corrected real radar image format (L1D) [8].

Fig. 2 represents the expected data size of automatically generated satellite images. As increasing of satellites in Fig. 1, the size of generated satellite image data would enhance as Fig. 2. Especially, with the radical enhancement of small and microsatellites in 2028, the generated data size would radically increase. In addition, 54.8 PiB of satellite data is estimated to be generated in 2030. The data system is devised to archive only recently collected high-resolution product images. The satellite images of the Korea Peninsula would be retained in data storage until 3 years from collection date, and the other would be retained only for the data within last 1 year. In the data system, KARI built data storage with 16 PiB size, including 4 PiB of NAS and 12 PiB of tape library storage.

3.2.2 Data Service System

Contrary to DAS, DSS is devised to support direct data delivery to a user, especially with image products. Firstly, it is essential to assign the user's authority about the accessibility of the satellite image. Under the data policy, the authority of each user on satellite image products should be classified in advance, so the assigning function in DSS can be utilized in authorization on all accessible users. Based on the archived and databased satellite data on this system, it is possible for users to get respectively accessible satellite data, as fast as possible. Furthermore, it can be utilized to send not only standard image products such as L1R, L1G, and L1G-PS of optical images and L1A and L1D of the radar image, but also high-resolution tile image, named service products, on the webpage. Fig. 3 shows the high-resolution satellite image provided by DSS on the webpage. Actually, to provide high-resolution satellite images, DSS would produce service products based on L1G-PS satellite data, whose resolution is much finer than L1G with corrected geometric information. For the radar image data, L1D satellite data with corrected geometric information is utilized in high-resolution service product services in DSS. In particular, those high-resolution satellite images can be used in providing cutting clip images, so users would obtain high-resolution clip satellite images using the DSS web service.

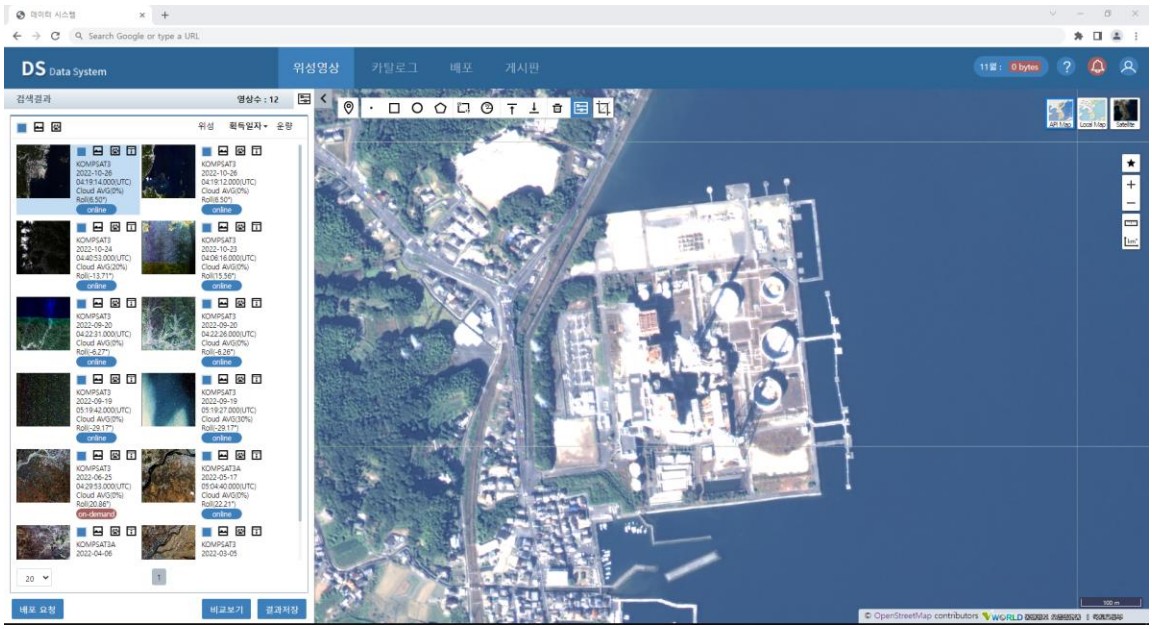
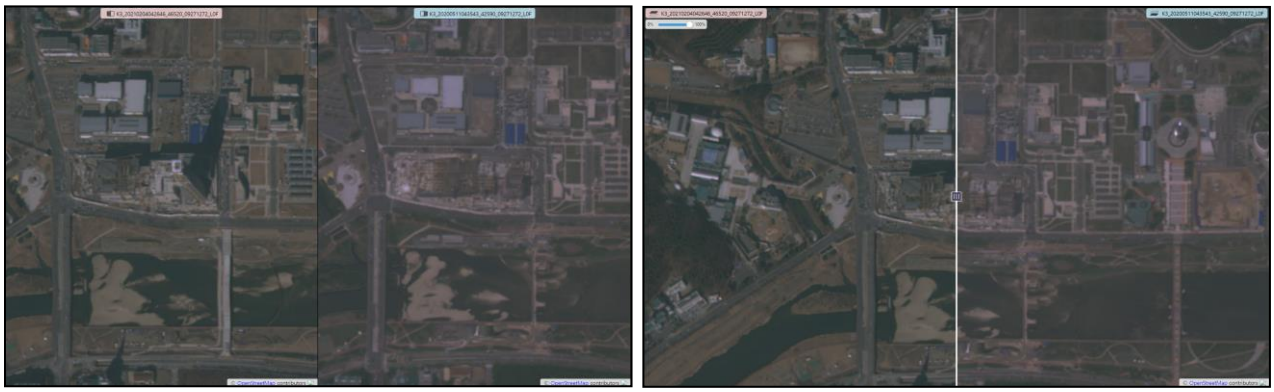


Fig. 3. High-resolution satellite service product on web-site

This system would provide several fine useful remote sensing functions based on the online web page. The first one is comparing two original images with the same region. Change detection is one of the widely utilized functions in remote sensing technologies. Thus, it is essential to compare two satellite images focusing on the same ground region. Actually, most users would have utilized those time different satellite images using computing tools, after downloading satellite images. In DSS, we provide two versions of comparison functions on high-resolution satellite images: Geo-linkage comparison and Curtain-view comparison. Fig. 4 shows examples of two comparison versions. The geo-Link version is utilized to exhibit two sides of the same region satellite images as shown in Fig. 4(a). On the other hand, Fig. 4(b) exhibits the Curtain-view style comparison, overlapping two satellite images with control based on the curtain bar. Another developed function is video production of time series browser images. As mentioned before, satellite images have been importantly utilized in the detection of change on a wide area on the ground. Because of the acquisition of time-serial satellite images to monitor the change in long duration, satellite imagery on a certain area has been frequently provided. DSS can be used in generating time-series satellite images, in order to watch changes in certain areas. Furthermore, it can provide the video clip for the time serial image data.

4. Results

In this paper, we introduce a new satellite data system specialized for South Korea satellite data policy, included in the new developed KSOS. The system is devised to promptly distribute satellite data to requester by creating high-resolution satellite image product in advance, and the pre-created satellite data has been stored in 16 PiB storage. Furthermore, several fine remote sensing functions are equipped on a webpage of the data system, leading to efficient application on high-quality satellite images. In view of management, it is very useful in control authorization on different users by assigning the access level in the view of satellite, searching region, product level and etc.



(a) Geo-linkage comparison (b) Curtain-view comparison

Fig. 4. Comparison function on multi-satellite images of an observation area

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