IMAGE COLLECTION PLANNING OF MULTI-SATELLITE OPERATION FOR KOMPSAT SERIES[i]

Heejin BAE [a], Myungjin CHOI [b] and Tae-Byeong CHAE [c]
[a] System Engineer, Korea Aerospace Research Institute,
115 Gwahangno, Yuseong-gu, Deajeon, Korea; Tel: + 82-42-860-2669
E-mail: chelry@kari.re.kr

[b] System Engineer, Korea Aerospace Research Institute,
115 Gwahangno, Yuseong-gu, Deajeon, Korea; Tel: + 82-42-860-2735; E-mail
prime@kari.re.kr

[c] System Engineer, Korea Aerospace Research Institute,
115 Gwahangno, Yuseong-gu, Deajeon, Korea; Tel: + 82-42-860-2756
E-mail: tbchae@kari.re.kr

KEY WORDS: KOMPSAT, Image collection, multi-satellite, optimization

ABSTRACT: KARI (Korea Aerospace Research Institute) has one satellite, KOMPSAT-2(Korea Multi-Purpose Satellite-2) on operation at present. And we have plans to KOMPSAT-5 being launched soon this year and KOMPSAT-3 being launched next year. Because each KOMPSAT has different sensor characteristics, KOMPSAT series will provide high-level and various services for satellite image. But above all, we should consider operation concept of multi-satellite operation to prepare operation of three satellites.
Image collection planning must be considered to minimize human resource and maximize satellite resource. And, because image collection planning is considered not as single satellite but as multi-satellite, the process will be so complicated.
Therefore, we will study operation concept for multi-satellite for efficient operation in this paper. Specially, multi-satellite operation for image collection plan directly related to commercialization and order of satellite image will be studied in this paper.

1. INTRODUCTION & BACKGROUND

KARI has one satellite, KOMPSAT-2 on operation at present. And we have plans to KOMPSAT-5 being launched soon this year and KOMPSAT-3 being launched next year.
KARI has KOMPST-2 launched in 2006 on operation at present. KOMPSAT-2 can provide 1m panchromatic and 4m multispectral image.
KOMPSAT-3 continues satellite earth observation after KOMPSAT-1 and KOMPSAT-2 to meet national need, provides the high-resolution EO (Electro-Optical) images required for GIS (Geographical Information Systems) establishment and the applications for environmental, agriculture and ocean monitoring. And KOMPSAT-3 can provide the 0.7m panchromatic and 2.8m multispectral image.
KOMPSAT-5 has GOLDEN mission: Geographic Information System (GIS), Ocean Management, Land Management, Disaster Monitoring, Environment Monitoring and National Security Application. And KOMPSAT-5 can provide the 1m, 3m and 20m X-band SAR (Synthetic Aperture Radar) images.
Because KOMPSAT series have various sensor types, KOMPSAT series can provide high-level and various services for satellite image.
As explained as above paragraph, each KOMPSAT series have different sensor characteristic and different operation system. Because operation system of satellite is established for KOMPSAT series, operation also must be performed for each satellite. This lowers efficiency of human resource, time and cost. In addition, it means that KARI has and operates three satellites to provide high-level and various services for satellite image. The results are expected to increase the commercial demand of satellite image. And KOMPSAT-2 operation is performed by operator manually.
Therefore, it is necessary to study operation concept for multi-satellite for efficient operation. Specially, multi-satellite operation for image collection plan directly related to commercialization and order of satellite image will be studied in this paper.

2. MULTI-SATELLITE OPERATION

Because only one satellite, KOMPSAT-2 is operated, multi-operation concept is not needed. But if we have KOMPSAT-5 being launched in this year and KOMPSAT-3 being launched next year, multi-operation concept must be needed for this efficient satellite operation.
We assume only three satellites; KOMPSAT-2, KOMPSAT-3 and KOMPSAT-5.
At first, because they have different sensor's characteristic, ordinary product order will be requested considering sensor's characteristic of each satellite in normal operation. For such a reason, multi-operation concept can be considered as operation concept for integrated system.
Next, we have to consider emergency situation. If we get the order request to get satellite image as soon as possible only for specific region not considering sensor's characteristic, the operation concept in normal operation must be changed in the emergency situation. The critical factors that influence on the image collection planning are physical position like as orbit and weather information except for priority. Although possible to determine whether imaging, conflict check must be considered for existing order. If conflict occurs, image collection plan for existing order is cancelled and must be newly updated.
In this regard, two processes are considered. 1) Image collection planning is performed for each satellite. After that, real image collection planning is performed and reflected to one-day schedule only for available satellite as soon as possible. In this case, because real image collection planning is changed only one satellite, change of existing image collection plan is minimized. 2) Image collection planning is performed for each satellite and reflected to real one-day schedule for all three satellites. This process can prepare the failure of achievement for satellite image only one imaging. Therefore, this process allows for stable operation. But existing image collection planning must be newly updated for all three satellites in this process.
In conclusion, the multi-satellite operation concept for KOMPSAT series can be considered as the operation concept of integrated system considering emergency operation.

3. IMAGE COLLECTION PLANNING PROCESS

Image collection planning of KOMPSAT series is both time dependent collection objectives and complex constraints defining the limits of satellite performance.
Efficient image collection planning process is composed of long term planning process and daily scheduling included optimization algorithm.
Figure 1 shows long term planning process.

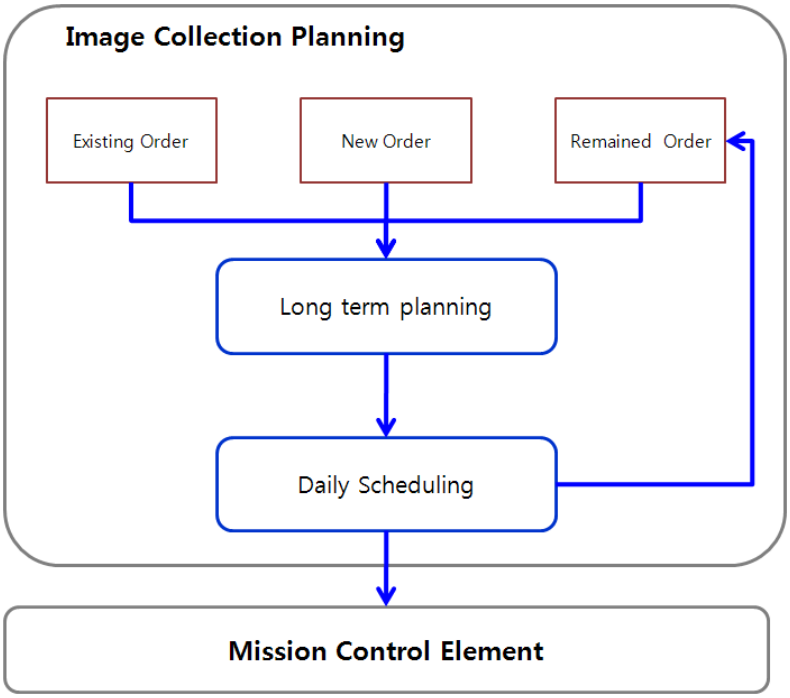

Figure 1. Image Collection Planning Process

Figure 2 shows image collection planning environment with considering factors.

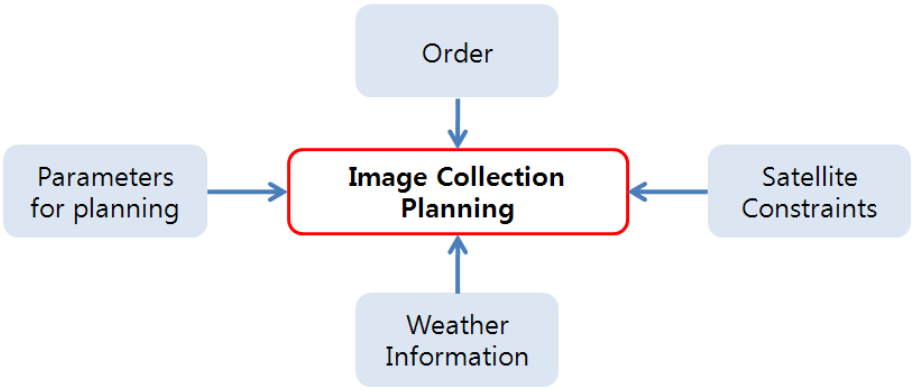

Figure 2. Image Collection Planning Environment

3.1 Long Term Planning Process

Because current image collection planning for KOMPSAT-2 is performed manually by operator, it is difficult to establish long term planning and only one-day image collection planning is performed. But it is necessary to introduce the long term planning process efficient management of product order.
The main purpose of long term planning is divided into management of product order and pre-process for one-day scheduling.
Long term planning process models the collection planning problem from an imaging time allocation viewpoint. Long term planning is performed with current product order, new product order and order remained from one-day scheduling. Specially, long term planning can be database to reject/accept new product order based on resource feasibility.
Long term planning is performed daily like as scheduling job. In the process, daily long term planning is not performed newly. Instead, existing long term planning is updated considering product order status of that day. And first day planning of long term planning is reflected to one-day scheduling job.
Parameters for long term planning is priority, amount of cloud & snow, the number of order in planning area, planning period, roll angle, roll tilt angle amount of remained scene.
Order with high level priority and order of maximum permissible value most similar to the predicted cloud cover value, the highest number of orders included in planning, order with the closest period of the order's due date, the smallest roll angle of requested order, the smallest roll tilt angle in planning and the smallest number of orders with remained scene are considered for planning in advance. Specially, weather (cloud & snow) is a critical factor in the quality of an optical image like as KOMPSA-2 and KOMPSAT-3. Generally, if there is significant cloud (or snow) cover over AOI, the image will be of marginal quality.
Long term planning is performed with above parameters.
If there is conflict for each order with the identical priority, conflict resolution is needed. Following sequential step is the method of conflict reolution.

1) Cloud
2) Snow
3) Including the highest number of order
4) End data of order
5) Roll tilt angle
6) Size of AOI(Area of Interest)

3.2 Image Collection Optimization Process

KOMPSAT series, commercial satellite, must perform thousands of order for different AOI within tight time constraints. To manage these orders effectively and create best image collection plan, image collection optimization process is needed.
Optimization algorithm maximizes the summation of the score considering image collection parameters and the weighting factor of the parameters. From the result, the image collection planning with the highest score is chosen.

3.3 Daily Planning & Scheduling

After long term planning, the result is transferred to one-day scheduling stage. Scheduling is performed on a daily basis and the result from scheduling is transferred to mission control element.

Scheduling job is performed based on the long term planning result. For scheduling, satellite resource is checked. Considering memory, power consumption and receiving schedule, scheduling is performed. If there is remained order from that day planning of long term planning in scheduling, the remained order is sent to long term planning next day.
Daily scheduling is comprised four major functions: collection resource allocation; candidate filtering and weighting; imaging scheduling; collection assessment. The purpose of collection resource allocation is modified fully allocate satellite imaging time consistent with satisfying long term planning process and collection opportunities. Unallocated imaging time in collection resource allocation indicates an under-utilization of the satellite on that day. The output of collection resource allocation is imaging time allocated to AOI by priority. Candidate filtering and weighting is controlled by imaging time allocations to AOI, priority from collection resource allocation. Image scheduling is performed for the long term planning to optimize the use of satellite agility in determination of the highest valued image collection parameters. Collection assessment is the final step in daily scheduling. This process is performed the image collection satisfaction messages and updates the database in preparation for the next day's planning. It helps newly updated collection planning to complete.

4. SUMMARY & FUTURE DEVELOPMENT

Each KOMPSAT series have different sensor characteristic and different operation system. Because each operation system of satellite is established for KOMPSAT series, operation also must be performed for each satellite. Therefore, operation concept for multi-satellite for efficient operation is studied. Specially, multi-satellite operation for image collection plan directly related to commercialization and order of satellite image is studied in this paper.
Image collection planning of KOMPSAT series manages its product with an integrated long term planning and daily scheduling approach that consistently provides a high quality planning of satellite images.
Because the multi-satellite operation concept for KOMPSAT series can be considered as the operation concept of integrated system considering emergency operation, image collection planning system will be implemented as multiple single satellites for future development considering multi-satellite operation.

5. REFERENCE

References from Journals:
William, Martin, 2002. Satellite image collection optimization, Opt. Eng. 41 (9), pp. 2083-2087.
Alexander, F Herz & Adeena, Mignogna, 2006. Collectioni Planning for the OrbView-3 High Resolution Imaging Satellite, Space Ops 2006.

References from Books:
R. Bellman and R. Kalaba, Dynamic Programming and Modern Control, Academic Press, New York (1966)

References from Other Literature:
Orbit Logic Inc., Collection Planning System User's Manual, DemoCPS Software Version 1.1, 2007

[i] This works was supported by 2010 technology royalties program (Technical Development of Optimized Image Collection Planning for Multi-Satellite) of The Ministry of Education, Science and Technology.