Study on the Coverage by COMS OCI FOV

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Abstract: Communication, Ocean and Meteorological Satellite (COMS) has been developed by Korean Aerospace Research Institute (KARI) since 2003. Ocean Color Imager (OCI) is the one of COMS payloads, which will monitor the marine environment around Korean peninsula routinely with the intermediate resolution. But considering COMS is to be located in the geostationary orbit, required geographical coverage is not positioned in the nadir direction of COMS but in specific location with horizontal and vertical offsets from the nadir. In this study, coverage by OCI Field Of View (FOV) is analyzed. First of all, OCI is modeled as the sensor which is a 2,500 × 2,500 sized 2-D CCD and the pixel resolution is about 500m. And then, OCI is simulated to be controlled to target the required coverage accurately. As a result of it, coverage by OCI FOV is determined. Finally, all coverages by OCI FOV are mapped.

Keywords: COMS, OCI, FOV, Coverage

1. Introduction

COMS has been developed since 2003 to be launched at 2008. COMS is the first Korean satellite for the meteorological and oceanic mission in the geostationary orbit.

In addition to the payload for meteorological application, Meteorological Imager (MI), Ocean Color Imager (OCI) will be installed to the COMS. Its mission is to monitor the marine environment of East-Asia 8 times a day according to the mission schedule.

It is noted that COMS is to be located in the geostationary orbit, where its position is to be (0°N, 116°E) with 35,786km altitude. Considering the geometric relation between the required geographical coverage and the position of COMS, the required geographical coverage around the Korean peninsula is not positioned in the nadir direction of COMS but in specific location with horizontal and vertical offsets from the nadir. In this case, OCI should be installed with intentional misalignment in its optical axis compared to COMS' coordinates or should be controlled mechanically to point the required coverage, which means that horizontal and vertical biases should be applied to each OCI pointing.

In this study, coverage by OCI FOV is analyzed based on the latter case. First of all, OCI is modeled as the sensor which is a 2-D CCD with intermediate resolution. And then, OCI is simulated to point the whole required coverage. As a result of it, whole coverages by OCI FOV are determined and mapped.

2. Instrument Requirements of OCI

Technical instrument requirements for OCI are summarized in Table 1.

Table 1. Technical Instrument Requirements for OCI

No. of Channel	8 channels (6-Visible and 2-NIR)
Spatial Resolution (IFOV)	500m × 500m
Coverage (FOV)	2,500km × 2,500km
Spectral Coverage	400 ~ 900nm (for 8 bands)
Digitization	≥ 11bits
Data integration, readout, and download rate	< 30minutes

According to Table 1, the required coverage for COMS OCI at 116°E longitude is at least 2,500km × 2,500km around 36°N latitude and 130°E longitude, which bounds the Korean Seas and surrounding ocean regions. The ground resolution shall be 500m × 500m for the entire required coverage [1].

3. Operational OCI Model

According to instrument requirements of OCI, the operational OCI was modeled in the test. Before proceeding, it is noted that OCI is supposed to be installed to COMS, which is located at geostationary orbit and its nominal position is (0°N , 116°E) at 35,786km altitude. It is supposed that there is no misalignment or orientation between OCI sensor coordinates and those of COMS spacecraft body. And then, OCI is modeled to be a 2-D CCD sensor where its dimension is 2,500 × 2,500 and the spatial resolution of one pixel is about 500m. As a result, OCI is modeled to provide a square snapshot for 1,250km × 1,250km coverage. So, it is concluded that there needs at least 4 snapshots for OCI to provide observations for required coverage in the test. That is, OCI stares at the specific part of the required coverage and gather oceanic information around that area during integration time and this routine operation is executed 4 times for the whole required coverage observation. Table 2 shows characteristics of the operational OCI model.

Table 2. OCI Model

Type	2-D CCD
Dimension	2,500 × 2,500
Spatial Resolution of 1 pixel	0.5km
Nominal Observation Position	(0°N , 116°E) at 35,786km
Misalignment between Spacecraft and OCI coordinates	No

4. Simulation of Coverage by OCI FOV

1) Dividing the Required Coverage into 4 Sectors

As the coverage which is covered by the OCI model is to be about 2,500km × 2,500km, which is smaller than that of the whole required coverage for OCI, the whole required coverage should be divided into some sectors. This means that there must be a number of observations for imaging the whole required coverage for OCI. Using the coverage requirement, the whole required coverage in terms of geographical range can be calculated. And then, the whole required coverage for OCI was finally divided into 4 sectors as Fig. 1 using 4 Apices of the whole required coverage and the center point of OCI observation, (36°N, 130°E). In Fig.1, numbers in each square mean sequences of OCI observation for each sector. That is, OCI is set to observe each sector successively in the test.

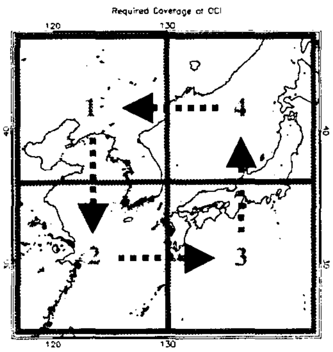

Fig. 1 Required Coverage after Dividing into 4 Sectors

Table 3 describes geographical ranges of 4 sectored coverages in terms of latitude and longitude. Fig.2 shows geographical ranges of 4 sectored coverages, where they are projected using nominal geometry between the Earth and COMS. Table 4 shows resultant geographical information for center points of 4 sectored coverages. That is, it is supposed that each snapshot for 4 sectored coverages is acquired by staring at each center point successively with proper integration time.

Table 3. 4 Sectored Coverages from the Required Coverage

Sector	Sectored Coverage	
	Latitude (N, deg)	Longitude (E, deg)
1	36.0 ~ 47.2018	116.802 ~ 130.0
2	24.7982 ~ 36.0	116.802 ~ 130.0
3	24.7982 ~ 36.0	130.0 ~ 143.198
4	36.0 ~ 47.2018	130.0 ~ 143.198

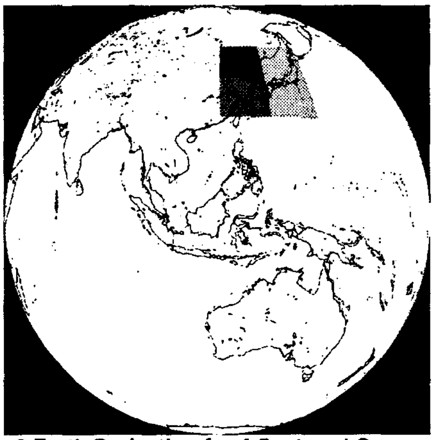

Fig. 2 Earth Projection for 4 Sectored Coverages

Table 4. Center Points for 4 Sectored Coverages

Sector	Center Points	
	Latitude (N, deg)	Longitude (E, deg)
1	41.6009	123.401
2	30.3991	123.401
3	30.3991	136.599
4	41.6009	136.599

2) Determining Pointing Angles from COMS to 4 Sectored Coverages

After dividing the whole required coverage into 4 sectored coverages and acquiring geographical information on center points of 4 sectored coverage, 4 pointing angles from COMS nominal position to center points of 4 sectored coverages can be determined in terms of both elevation and scan angle using the geometry between those points and COMS nominal position [2]. Here, each center point is set to be the pointing target for 4 sectored coverage.

Table 5 shows pointing angles for center points of 4 sectored coverages in terms of both elevation and scan angles. Table 6 shows both elevation and scan angle ranges for covering each sectored coverage. Here, it was supposed that the yaw axis of the spacecraft directs to the nadir and the orientation angle of the spacecraft is 0°.

3) Determining OCI FOV Coverage

According to Table 1, the OCI IFOV shall be 500m × 500m for the whole required coverage observation. In

Table 5. Elevation and Scan Angles for Each Center Point

Sector	Pointing Angles for Each Center Point	
	Elevation (deg)	Scan (deg)
1	6.4209183	-0.94180497
2	4.9950821	-1.1069931
3	4.9481493	-2.9962038
4	6.3706271	-2.5528050

Table 6. Elevation and Scan Angle Ranges for 4 Sectored Coverages

Sector	Ranges for Each Sector	
	Elevation (deg)	Scan (deg)
1	5.7272737 ~ 7.0192719	-1.9266862 ~ -0.092022979
2	4.1583660 ~ 5.7540113	-2.1964373 ~ -0.11194621
3	4.0984789 ~ 5.7272737	-4.0923014 ~ -1.9266862
4	5.6561018 ~ 6.9930947	-3.5962961 ~ -1.5851448

the test, IFOV can be fixed by calculating the IFOV when viewing the earth point of (36°N , 116°E) from the COMS nominal orbital location. The resultant IFOV is about 12.3 μrad. So, the OCI FOV coverage is about 1.7673° × 1.7673°, which is covered by 2,500 × 2,500 detectors. As a result, OCI is set to observe 4 sectored coverages by pointing each center point with the determined OCI FOV coverage.

Table 7 shows both elevation and scan angle ranges when pointing each center point of 4 sectored coverages with the determined OCI FOV coverage and Table 8 shows geographical information induced from 4 apices determined by OCI FOV coverage. Finally, Fig.3 shows the covered area for each sectored coverage, which is covered by OCI FOV coverage and Fig.4 shows mapping result. Here, symbol + mean each center point for 4 sectored coverages and asterisk symbol means the center point for the whole required coverage, which is suggested by the OCI requirement, (36°N, 116°E).

Table 7. Elevation and Scan Ranges for Each Sector by FOV

Sector	Ranges for Each Sector	
	Elevation (deg)	Scan (deg)
1	5.5372625~ 7.3045740	-1.8254607 ~ -0.058149349
2	4.1114264 ~ 5.8787383	-1.9906490 ~ -0.22333725
3	4.0644932 ~ 5.8318059	-3.8798591 ~ -2.1125476
4	5.4869719 ~ 7.2542824	-3.4364609 ~ -1.6691492

4) Adjusting the Pointing Angle of OCI

In Fig.3 and Fig.4, it is noted that there are a small gap between the covered area by OCI FOV coverage for sector 2 and that for sector 3, which is not covered by both coverages. In addition there are overlapped areas.

Table 8. Geographical Information of Each Sector by FOV

Sector	Ranges for Each Sector	
	Latitude (N, deg)	Longitude (E, deg)
1	34.3271 ~ 50.7015	116.407 ~ 133.554
2	24.3438 ~ 37.2265	117.396 ~ 130.750
3	24.1688 ~ 37.5938	129.370 ~ 146.441
4	34.0876 ~ 51.4636	127.761 ~ 151.964

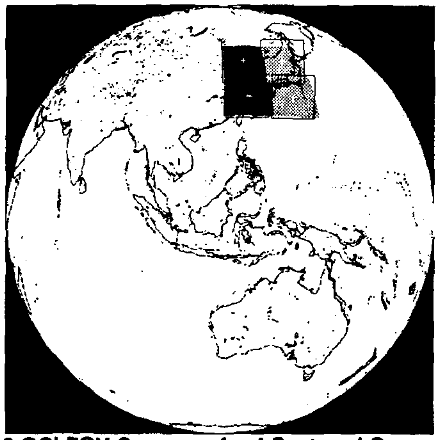

Fig. 3 OCI FOV Coverage for 4 Sectored Coverages

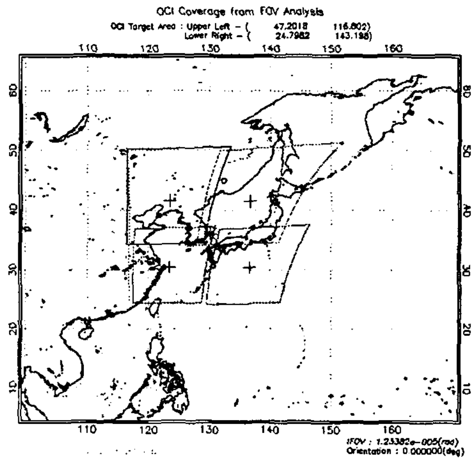

Fig. 4 OCI FOV Coverage After Mapping

In this case, those problems can be removed with minimum loss of imaging coverage by changing or adjusting the pointing angle of OCI operationally.

In the case of a small gap area, it can be resolved by changing the pointing angle of OCI for sectored coverage 3 to new one which has some offsets in the longitudinal direction compared to the previously determined pointing angle for sectored coverage 3. But in this case, the oceanic information of the lower right part of the sectored coverage 3 cannot be acquired. But considering that the ocean area around Korean peninsula is the most concern for OCI operation, the lower right part of the sectored coverage 3 can be sacrificed to get the oceanic information for a small gap between sectored coverage 2 and 3. That is, it is supposed that the imaging priority of a small gap between sectored coverage 2 and

3 is higher than that of the lower right corner part of the sectored coverage 3 in this study.

And it is also noted that OCI is the sensor not for the land cover but for the oceanic environment. Considering this, current pointing angles for all sectored coverages can be changed to new ones which have lower latitudes to remove worthless observation for the land above Korean peninsula and to acquire more oceanic information. This adjustment is also preferable in that coverages by OCI FOV coverage are moved to lower position and this provides the earlier monitoring of the creation and the path of Typhoon.

Meanwhile, overlapped areas can be minimized to acquire oceanic information by changing pointing angles to new ones. As a result, the oceanic information for larger oceanic area can be acquired as Fig. 5.

Considering these adjustments, 4 pointing angles are finally derived and suggested as Table 8. Table 9 shows final elevation and scan angles of OCI resulted from the test.

Table 8. Center Points for Each Sector

Sector	Center Points	
	Latitude (N, deg)	Longitude (E, deg)
1	39.6009	123.401
2	26.5991	122.401
3	26.4991	134.199
4	39.6009	137.199

Table 9. Elevation and Scan Angles for Each Center Point

Sector	Pointing Angles for Each Center Point	
	Elevation (deg)	Scan (deg)
1	6.1893881	-0.97402574
2	4.4470790	-0.99881997
3	4.3976574	-2.7799976
4	6.1357143	-2.7113597

Table 10. Geographical Information of Each Sector by FOV

Sector	Ranges for Each Sector	
	Latitude (N, deg)	Longitude (E, deg)
1	32.5953 ~ 48.1477	116.618 ~ 132.841
2	20.8355 ~ 32.9492	116.699 ~ 129.100
3	20.6115 ~ 33.0915	127.614 ~ 142.581
4	32.3556 ~ 48.8355	128.612 ~ 151.348

5. Conclusion

In this study, the whole required coverage of OCI was analyzed using the operational OCI model. For this, OCI sensor with 2-D CCD was modeled. With the OCI sensor model, pointing angles of OCI were induced and 4 Observations were proposed for covering the whole required coverage.

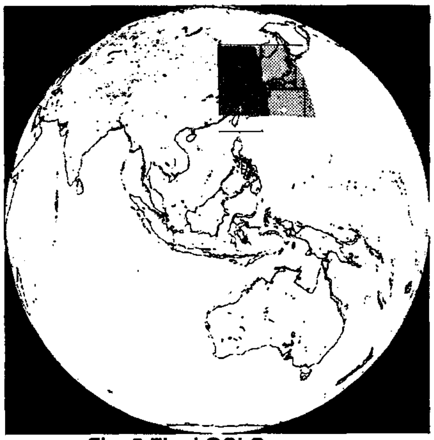

Fig. 5 Final OCI Coverage

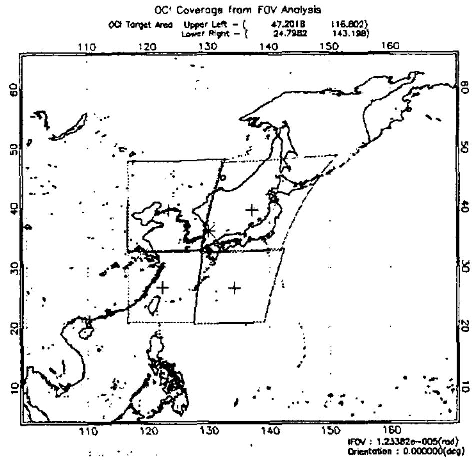

Fig. 6 Final OCI Coverage After Mapping

As a result of the study, it is proved that the whole required coverage can be covered with minimum imaging loss by OCI test model.

In this study, it is supposed that the COMS nominal position is kept fixed and there are no misalignment between COMS and OCI. But actually, it is expected that various perturbations and disturbances result in changes in orbit and attitude of COMS. So, pointing angles of OCI should be controlled for the right positioning as time goes by compensating coming orbit and attitude perturbations in operational phase.

References

[1] KORDI, 2003, Preliminary studies and the user requirements of the ocean payloads in geostationary orbit satellite, MOMAF

[2] VCS Aktiengesellschaft, 2002, 2met! XPIF Reference Manual Issue 1.2