PRELIMINARY COMS AOCS DESIGN FOR OPTIMAL OPTICAL PAYLOADS OPERATIONS

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ABSTRACT: COMS (Communication, Ocean and Meteorological Satellite) shall be operated with two remote sensing payloads, MI (Meteorological Imager) and GOCI (Geostationary Ocean Color Imager). Since both payloads have rotating mechanisms, the dynamic coupling between two payloads is very important considering the pointing stability during GOCI operation. In addition, COMS adopts a single solar wing to improve the image quality, which leads to the unbalanced solar pressure torque in COMS. As a result, the off-loading of the wheel momentum needs to be performed regularly (2 times per day). Since the frequent off-loading could affect MI/GOCI imaging performance, another sub-optimal off-loading time needs to be considered to meet the AOCS design requirements of COMS while having margin enough in the number of thruster actuations.

In this paper, preliminary analysis results on the pointing stability and the wheel off-loading time selection with respect to MI/GOCI operations are presented.

KEY WORDS: COMS, AOCS, Remote Sensing Payload, Pointing Stability, Wheel Off-loading

1. INTRODUCTIONS

COMS contract to development COMS satellite and to provide support for system activities has been awarded by KARI to ASTRIUM France. COMS joint project group is composed of KARI and ASTRIUM engineers.

COMS aims to the meteorological measurement of the Earth including the Korean peninsula and the ocean color measurement of the Korean peninsula on the geostationary orbit. (Baek, 2005)

Because of a complex system to operate two remote sensing payloads simultaneously on geostationary, the critical issues are considered at the system and its subsystem design. Especially, the AOCS (Attitude and Orbit Control Subsystem) design is related to the image quality directly.

In this paper, some issues in the AOCS design are introduced based on the preliminary analysis results. Please ask for any reader's consent that the detailed data can not be provided here.

As for COMS, since pointing requirements for GOCI are much stricter than those for MI, operational concepts are proposed in section 2 in order to meet GOCI performance requirements.

COMS has a single solar wing on the opposite side of the payloads to improve the image quality. This effect happens to accumulate the amount of momentum on the transverse wheels, which are changed to the large momentum capacity wheels. But the wheels need the momentum off-loading everyday to keep its capacity. The wheel off-loading strategy is presented in section 3.

2. POINTING STABILITY FOR GOCI MEASUREMENT

The critical pointing stability shall be estimated during measurement of GOCI. To meet the stability requirement, several design approaches are analyzed. Especially, SADM (Solar Array Drive Mechanism) and north/south scanning mechanism of MI mirror impact on the pointing stability. In this section, two operational concepts for AOCS are presented. One is to reduce the disturbance (§2.1) and the other is to accept the effect but to solve using the operation schedule concept (§2.2).

2.1 SADM Effect

The impact of SADM disturbances on COMS free dynamics is shown that coincidence of SADM stepping frequency and solar array flexible modes could occur and induce important pointing stability disturbance.

However, the coincidence of SADM stepping with the first solar array flexible mode is well damped by the high bandwidth rate control. But the coincidence of torsion flexible mode with high harmonic of SADM stepping command is out of the rate control bandwidth. This effect has a low probability to occur, but its impact on pointing stability would be important.

Then, to avoid such coincidence, it will be possible to adapt SADM stepping command as shown in Figure 1. The high and low rates will be defined through the measurement of flexible modes. (Laine, 2005)

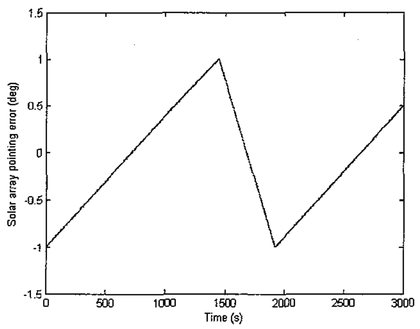

Figure 1. Possible SADM stepping command

2.2 MI N/S Scan Mirror Motion Effect

Typically, the movement of the MI scan mirror is composed of E/W (East/West) full motion followed by N/S (North/South) 1 step motion. For COMS, N/S 1 step motion is 224 micro-rad. Therefore, the effect of the MI N/S 1 step motion is negligible on the pointing stability of GOCI.

However, when moving to the starting position of the MI mirror during GOCI measurement, the pointing stability could be degraded beyond GOCI MTF (Modulation Transfer Function) allocations. Figure 2 shows the sensitivity of GOCI pointing stability budget to MI N/S step. For the MI N/S steps with amplitudes higher than about 6 degrees, the GOCI MTF allocation would be no more fulfilled. (Laine, 2005)

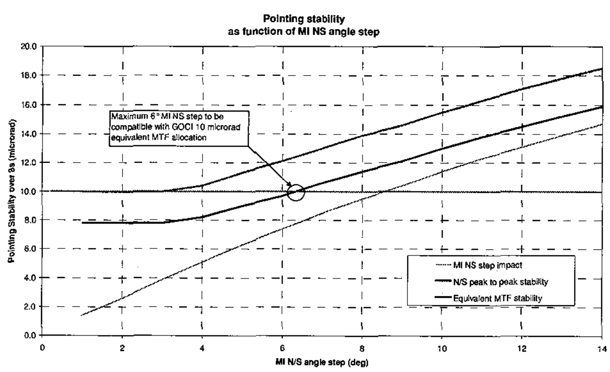

Figure 2. sensitivity of GOCI pointing stability

To solve this problem, the direct movement of MI toward N/S direction could be limited within 6 degrees during the GOCI measurement.

3. WHEEL OFF-LOADING STRATEGY

3.1 Momentum Imbalance

The Figure 3 shows a single solar wing configuration of the COMS. The disturbance torque caused by the solar pressure on the single solar wing is characterized for on year as shown in Figure 4.

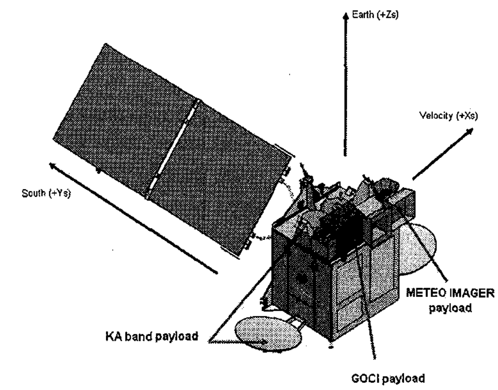

Figure 3. COMS single wing configuration

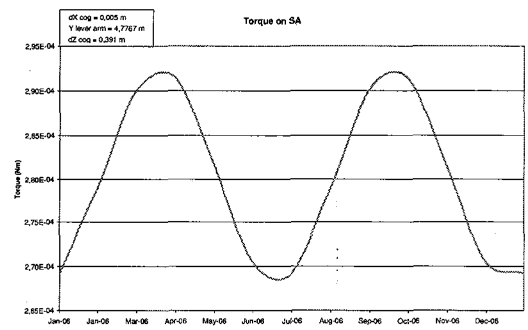

Figure 4. Unbalance torque on the single solar array

Since this unbalanced torque keeps increasing the wheel speed, the COMS should perform wheel off-loading manoeuvres using thrusters to dump the wheel momentum. As for COMS, the maximum accumulated momentum (worst case) is estimated as 25.0 Nms per day near to the equinox (Park, 2006).

3.2 Optimal Wheel Off-loading Scheduling

The induced transverse angular momentum vector towards in the –Xsat axis at midnight, +Zsat axis at 6 hours, +Xsat axis at 12 hours, and –Zsat axis at 18 hours, respectively. As can be seen in Figure 5, thrusters 1, 2 or 3 on the south panel are used for the wheel off-loading depending on SLT.

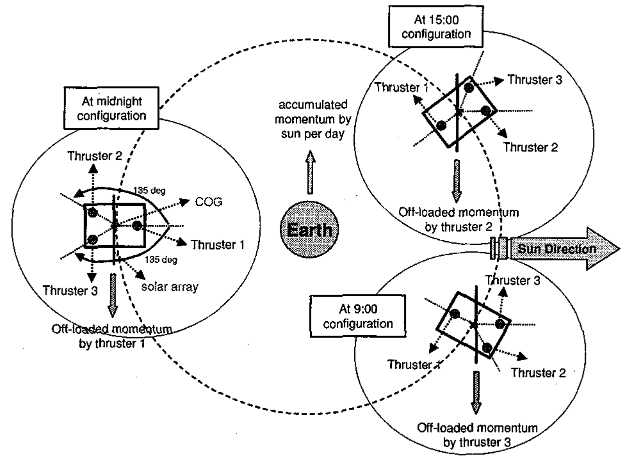

Figure 5. Off-loading strategy by geometrical analysis

Taking into account plume effect, the induced pitch disturbance torque (that shall be controlled by thrusters 6 & 7), the thrust efficiency (that depends on the thrust on-time), the thrust flow rate and the thrust actuation number, the total cumulative mass and the total ON time of thrusters 1, 2, 3, 6, and 7 are obtained in Figure 6.

From this figure, the optimal wheel off-loading times can be estimated as 8:59:33, 14:59:32, and 23:54:52 in SLT (Satellite Local Time). Therefore, if no constraints in the payloads operation in flight are applied, two among these wheel off-loading times can be selected. (Park, 2006)

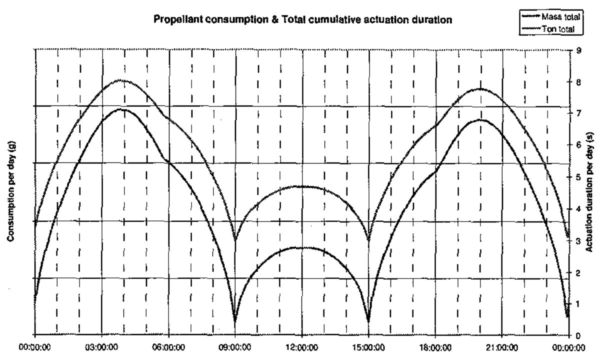

Figure 6. Total propellant consumption for wheel off-loading

3.3 Payloads Operation Constraints

3.3.1 MI Constraints: When the wheel off-loading is planned inside the MI mandatory time slot and the full disk scan slot, it is required to be shifted by a maximum of ± 30 minutes in order to be executed outside the MI imaging time slot including a BB-Cal (Black Body Calibration). The direction of time slot shift is chosen to minimize the magnitude of the shift. The BB-Cal. needs to be executed about 30 minutes before each image slot. The wheel off-loading before the BB-Cal. is preferred than that of after BB-Cal., if possible. (Park, 2005)

3.3.2 GOCI Constraints: The GOCI imaging duration shall be less than 30 minutes and the interval between successive images shall be one hour. The GOCI daytime observation schedule in Korean local time (135°E) is as follows :

- Summer season – 8:15 ~ 15:45 (7 hours 30 minutes, 8 images)
- Winter season – 9:15 ~ 16:45 (7 hours 30 minutes, 8 images)

The summer season is between March 22nd and September 21st and the winter season is between September 22nd and March 21st.

So far, the exact schedules of night time scan and GOCI calibration time are not defined. However, the night time scan and calibration time have a lot of available time space. Thus, no conflicts in the night time scan of GOCI and in the calibration time is assumed because mission planning is established to avoid conflict with wheel off-loading. The night time is defined as 22:00 ~ 02:00 Korean local time. (Park,2005)

3.4 Sub-optimal Wheel Off-loading Scheduling

In order to clarify the conflict between the constraints and the optimal wheel off-loading time, all the times are unified using UT (Universal Time). Figure 7 shows the best wheel off-loading center time in UT taking into account payloads constraints. The orbital longitude of COMS is assumed as 116.2°E. As can be seen, the GOCI seasonal constraint causes no effect on wheel off-loading. (Park, 2006)

The relation between UT and SLT is given by

$$UT = SLT - longitude\ of\ SLT\ [\deg E] * 24\,[hour]/360\,[\deg] \quad (1)$$

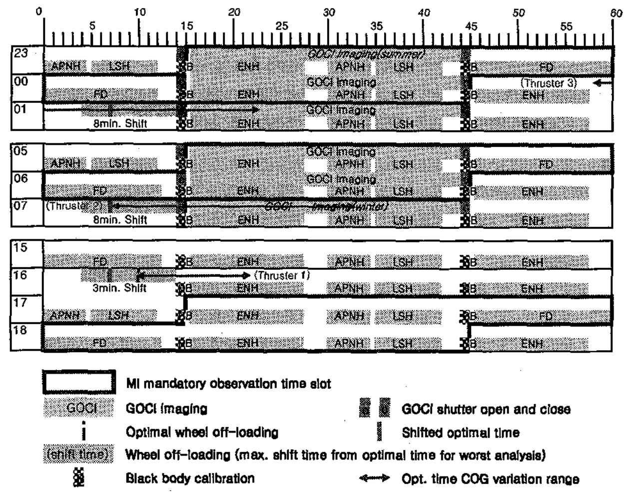

Figure 7. Wheel off-loading time taking into account constraints of payloads

In Figure 7, the unit of the horizontal axis is the minutes and that of the vertical axis is the hours. The abbreviations which aren't displayed in the legend are related with the assumed MI operations of COMS.

The wheel off-loading is composed of the momentum off-loading using thrusters and the tranquilization for normal mode operation. In Figure 7, the shifted optimal time in solid bar denotes the center of the momentum off-loading part.

4. CONCLUSIONS

These design concepts must be verified by the ground verification tool taking heritage. In case of the shifted sub-optimal wheel off-loading, the performance in the AOCS point of view is degraded but the efficiency in the COMS mission point of view is better. Of cause, these results are obtained within the AOCS constraints.

These analysis results are preliminary, then the exacted results will be obtained through a lot of trade-off analysis and the results in this paper would be changed.

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ACKNOWLEDGEMENTS

This paper is a part of products from COMS development project supported by MOST (Ministry Of Science and Technology).