# GEMS DEVELOPMENT STATUS

2019. 9. 26

Korea Aerospace Research Institute
Payload Development Division

# GEO-KOMPSAT-2B E/V Tests

- Vibration Tests Finished
- T/V Tests Finished
- Preparing EMI/EMC Tests
- Will ship it after EMI/EMC Tests
- Launch is on Feb. 2020

# Launch and Orbit Transfer

| Event | Instrument Mode | Description of tasks/configuration of Instrument |
|---|---|---|
| Prelaunch | Survival | Launch Configuration with Cal Wheel in closed position, Survival heaters are powered |
| Launch | Survival | |
| Transfer to GEO | Survival | Spacecraft performs orbit raising and adjustments necessary to achieve final orbital position.<br>NOTE : The host spacecraft will spend <5days in a GEO transfer orbit with a perigee <8000km or in a spiral orbit beginning at <8000km |
| Spacecraft Outgassing and Activation | Survival | Spacecraft activation and outgassing for at least 30 days prior to instrument power up. This time is may be adjusted based on a contamination control assessment of the spacecraft and other payload cleanliness. |

# Post Launch Activities

## Initial Activation and Check-out (IAC)

- Functional Tests
- Telemetry Monitoring / Command Uploading
- Operation by CBM and CSM

## In-Orbit Tests (IOT)

- Performance Tests
- Verification of GEMS Requirements (Selective)

## In-Orbit Calibration (IOC)

- Monitoring of the GEMS Performances
- Update Calibration Tables and Coefficients
- Special Operation Scenarios beyond GEMS Normal Operations

# IAC

| Activity | Duration (months) | L0 | L0+1m | L0+2m | L0+3m | L0+4m | L0+5m | L0+6m |
|---|---|---|---|---|---|---|---|---|
| LEOP(GTO to GEO) | 1 | | | | | | | |
| BUS IOT(start from drift orbit) | 0.5 | | | | | | | |
| GOCI-II Activation | 0.5 | | | | | | | |
| GEMS Activation | 1 | | | | | | | |
| GOCI-II/GEMS INR Test | | | | | | | | |
| | | | | | | | | |

**Instrument Activation and Commissioning Timeline**

- **GEMS-Specific Activation duration is 30 days**
  **out of 6 months of GK2B IOT Phase**
  **to avoid the GEMS-GOCI II Mission Operation Confliction**

# IAC

| Event | Approx. Day | Description of tasks/configuration of Instrument |
|---|---|---|
| Initial Power On | 1 | Power ICE and transition to Operate mode. Operational heaters enabled at FSW (Flight SoftWare) default values. Spacecraft must maintain ICE above its low operating temperature for power on to begin. |
| Instrument Self-Test | 2 | Confirm proper instrument operation prior to proceeding to dryout. Requires calibration wheel motor to be at operating temperature. |
| Dryout and Decontamination | 2-17 | Optical bench heaters will be enabled with set points set to achieve bench temp of 40°C; FPA window will be enabled with a set point of 50°C. |
| Image Data Transfer Test | (during Dryout) | Checkout of the data transfer to the spacecraft and its downlink using FPE (Focal Plane Electronics) test patterns. |
| Cooldown to Operational Temperatures | 17-24 | Dryout is complete and bench heaters are returned to operational set points. FPA (Focal Plane Assembly) window heater set point will return to operational set point on last day of cooldown. |

# IAC

| Event | Approx. Day | Description of tasks/configuration of Instrument |
|---|---|---|
| Dark Collect | 25 | All temperatures are within operational limits. Perform dark collect and evaluate data prior to proceeding to initial calibrations. |
| On-board LED Source Collect | 25 | Collect data from on-board LED Source. Evaluate data prior to proceeding to initial solar diffuser calibrations. |
| Scan Mechanism Functional Test | 25 | Perform functional test sequence to verify proper operation of scanner. Cal wheel remains closed. |
| Command Loads Testing | 26-28 | Upload and execute loads and review telemetry for proper functionality: 30-min collection sequence (demonstrates the ability to upload and operate from a command sequence), Daily collection sequence (demonstrates the ability to upload and operate safely from a full day's command sequence), Solar Calibration and other loads as required. Cal wheel to remain closed for safety. |
| Solar Diffuser Observations | 28-29 | Collect data from Working and Reference diffusers on successive days. Provides the initial on-orbit calibration. |
| Checkout Complete | 30 | Ready for Normal Imaging. |

# Command Blocks for the IOT

| Function Name | CBM Block ID | Description | Time (sec) |
|---|---|---|---|
| SCAL_WORK | 120 | Working Diffuser Solar Calibration | 80 |
| SCAL_REF | 122 | Ref. Diffuser Solar Calibration | 110 |
| SCAL_WORK_REF | 123 | Working and Ref. Diffuser Solar Calibration | 132 |
| LIN_DARK | 125 | LED Dark | 181 |
| LIN_LED | 127 | LED Image | 337 |
| SELF_TEST | 150 | Self Test | 60 |

# GSD/Aspect Ratio

## REQ. 100 and 101

1. Collect L1b data at 12:45 Local Time through 2440454B
2. Select pixel position(y) of 516$^{th}$ column and scan number(x) which covers 126.98E, 37.57N then calculate center lat. and long. of that pixel
3. Calculate center lat. and long. of (x, y-2), (x, y+2), (x-1, y), and (x+1, y)
4. Make sure that those pixels are cloud-free pixels
5. Calculate distance between (x, y-2) and (x, y), (x, y+2) and (x, y) with WGS84 model then average them : Vertical Distance @ Seoul -> Y_GSD_1245
6. Calculate distance between (x-1, y) and (x, y), (x+1, y) and (x, y) with WGS84 model then average them : Horizontal Distance @ Seoul -> X_GSD_1245
7. Req. 100 : Y_GSD_1245 $\leq$ 7 km
8. Req. 100 : Y_GSD_1245 $\times$ X_GSD_1245 $\leq$ 56 km$^2$
9. Req. 101 : 1/3 $\leq$ Y_GSD_1245 / X_GSD_1245 $\leq$ 3
10. Repeat 2~9 at 13:45 and 14:45

# Raw Data/Transmission Resolution

## REQ. 105 and 220

1. Collect L0 data at 12:45 Local Time through 2440454B
2. Select data at 100$^{th}$ Scan step
3. Load image part of an output file
4. Calculate array size of the image part
5. Req. 105 : Row size ≥ 2112
6. Req. 220 : Column size ≥ 1068
7. Repeat 2~6 at 13:45 and 14:45

# Spectral Feature

## REQ. 570

1. Run CBM BlockID 180 with a longer integration time for 36 days (IOC BlockID)
2. Collect L1b data of 300 – 360 nm data through 2440454B with a binning option ‘on’
3. Make sure that the image is more than 50% filled of the full well capacity and discard pixel values less than 50% filled (Edge field)
4. Average each days data and normalize them to remove daily bias
5. For every 15 pixels interval(~ 3nm), calculate the STD(σ)
6. Run CBM BlockID 180 with a shorter integration time for 14 days (IOC BlockID)
7. Collect L1b data of 360 – 500 nm data through 2440454B with a binning option ‘on’
8. Make sure that the image is more than 50% filled of the full well capacity and discard pixel values less than 50% filled (Edge field)
9. Average each days data and normalize them to remove daily bias
10. For every 15 pixels interval(~ 3nm), calculate the STD(σ)
11. Req. 570 : STD(σ) ≤ 0.05%

# Spectral Stability

## REQ. 580

1. Collect 8 L1b data through 2440454B
2. Use a modified ‘g_spectral_shift.m’ when using the 2440454B
3. Check if ‘g_spectral_shift_m_vXX.m’ file exists in the code
4. Discard un-illuminated column along a spatial direction ( approximately, : # < 20 and # >2030)
5. Store ‘wvl_fit(1)’ of ‘finalwvlfit’ that corresponds the spectral-shift term
6. Find min. of ‘wvl_fit(1)’ and max. of ‘wvl_fit(1) across spectral direction for 8 L1b data
7. Find ‘max. – min.’ of above values which match spatial index (~ 2000) : $\Delta$wavelength_shift
8. Req. 580 : $\Delta$wavelength_shift $\leq$ 0.02 nm

# Bandwidth

## REQ. 210

1. Collect Solar L1b data through 2440454B
2. Use a modified 'fit_isrf_simgems.pro' when using the 2440454B
3. Check if 'fit_isrf_simgems.pro' file exists in the code
4. Discard un-illuminated column along a spatial direction (approximately, : # < 20 and # > 2030)
5. Store values of 'fwhmor' that corresponds to the bandwidths of derived SRFs (in-flight SRF) and prelaunch SRFs
6. Find 'values of fwhmor(*,0)' for 7$^{th}$ fitting windows, which are determined based on prelaunch SRFs
7. Repeat 2~9 for along a spatial direction

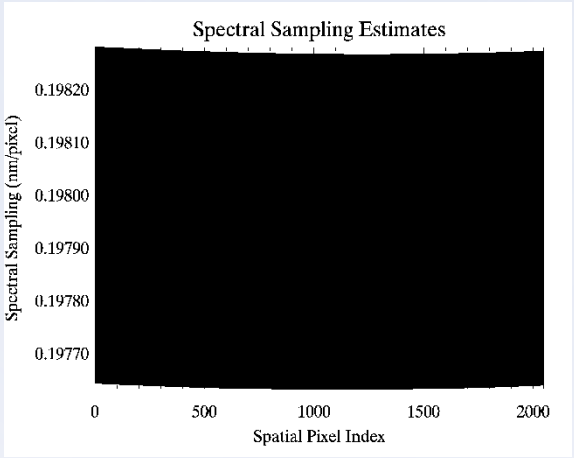
Req. 210 : Bandwidth < 0.6 nm

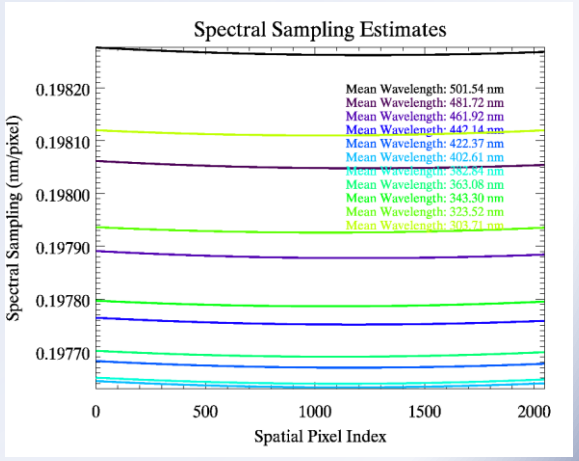
# Spectral Sampling

## REQ. 220

1. Collect Solar L1b data through 2440454B
2. Use a modified 'g_spectral_shift.m' when using the 2440454B
3. Check if 'g_spectral_shift_m_vXX.m' file exists in the code
4. Discard un-illuminated column along a spatial direction ( approximately, : # < 20 and # >2030)
5. Store values of 'finalwvlfit' that corresponds to the corrected wavelength
6. Calculate difference of wavelength between $(i+1)^{th}$ and $i^{th}$ spectral pixel (i= 1:1032) for each spatial pixel

Req. 210 : Spectral sampling < 0.2 nm



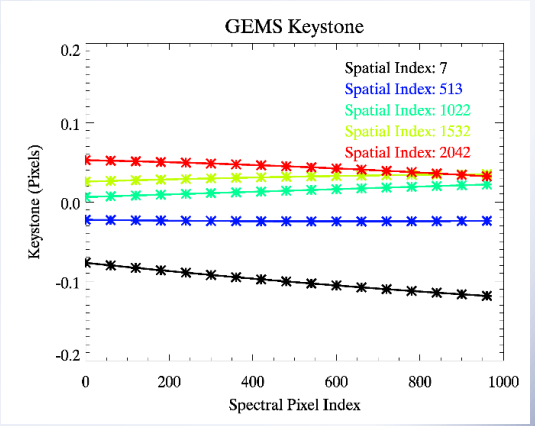



# Keystone

## REQ. 110

1. Collect Solar L1b data through 2440454B
2. Use a modified ‘g_spectral_shift.m’ when using the 2440454B
3. Check if ‘g_spectral_shift_m_vXX.m’ file exists in the code
4. Discard un-illuminated column along a spatial direction ( approximately, : # < 20 and # >2030)
5. Store values of ‘finalwvlfit’ that corresponds to the corrected wavelength
6. Calculate averaged wavelength for each spatial pixel index (1033 average wavelengths)
7. Calculate difference btw wavelength at each spatial pixel and mean wavelength
8. Divide each difference by spectral sampling to present the pixel unit

Req. 110 : keystone < 0.2 pixel



# Signal to Noise Ratio (SNR)

## REQ. 300

1. Collect Solar L1b data through 2440454B for long time (more than a month)
2. Select by choosing all the data within a narrow elevation range ( for OMI is within a ±3° elevation angle)
3. Calculate the difference between the measured irradiance and the average of irradiances from adjacent wavelengths for each wavelength step in each exposure and each FOV
4. Bin the RMS values of these differences over wavelength steps (for OMI is 11 wavelength steps) and averaged over all rows
5. REQ. 300 : Table1

| Spectral Range (nm) | Nominal Radiance [W/(m$^2$ sr μm)] | Maximum Radiance [W/(m$^2$ sr μm)] | Signal to Noise Ratio |
|---|---|---|---|
| 300-315 | 7.98 | 23.94 | *252 @ 300 nm* |
| 315-325 | 43.36 | 131.25 | 720 @ 320 nm |
| 325-335 | 86.63 | 260.18 | 1273 @ 325 nm |
| 335-357 | 91.39 | 283.61 | 1370 @ 357 nm |
| 357-423 | 108.66 | 384.59 | 1504 @ 357 nm |
| 423-451 | 130.75 | 505.24 | 1500 @ 430 nm |
| 451-500 | 145.49 | 592.35 | *1459 @ 500 nm* |

Table 1. GEMS Input Radiance and Signal to Noise Ratio requirements

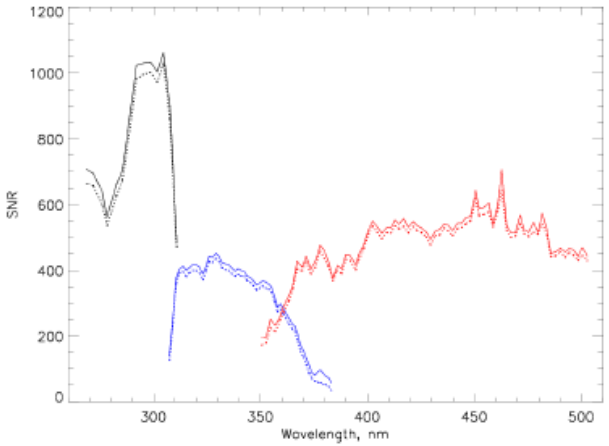
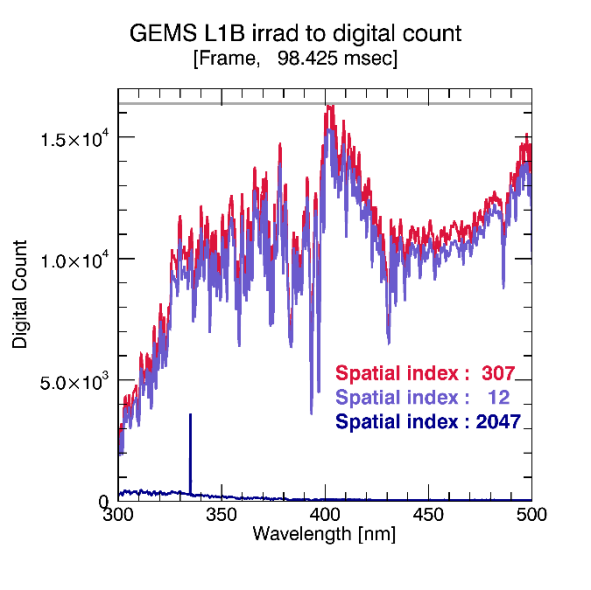


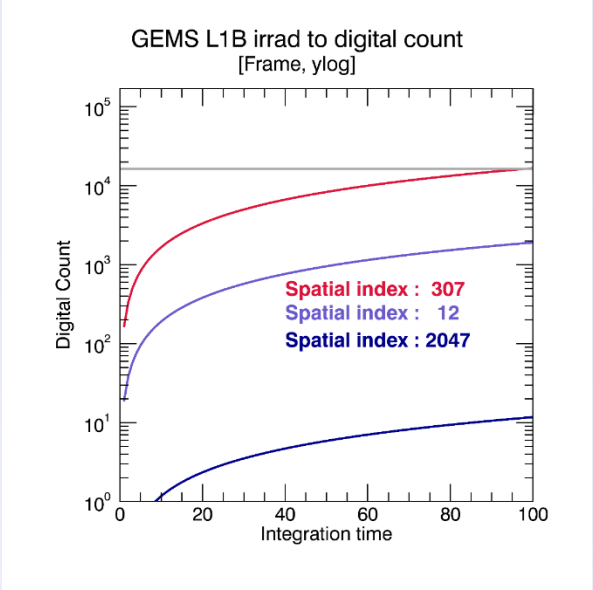

**Figure 17.** The wavelength- and time-binned solar irradiance SNRs for January 2005 (full lines) and January 2016 (dots) in UV1 (black), UV2 (blue) and VIS (red) channels.

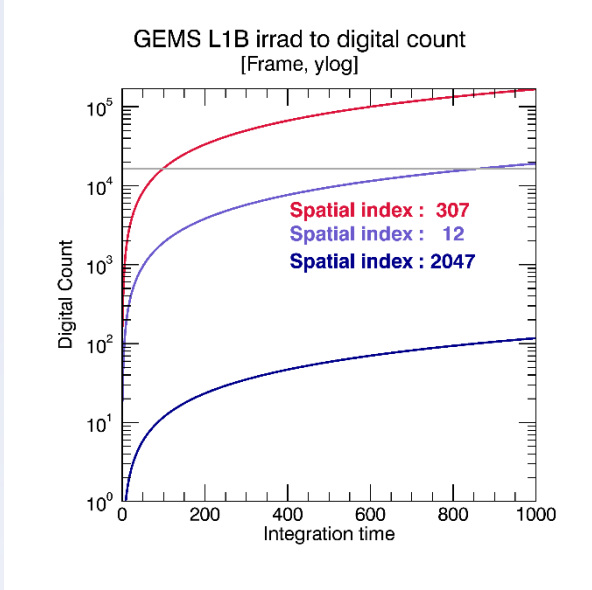
# Integration time for saturation

## REQ. 350

1. Collect Solar L0 data with different integration time through 2440454B [per frame]
2. Integration time before the digital count of one pixel reach the saturation threshold would be 98.425 msec and integration time after the digital count of all pixel reach the saturation threshold would be 859.382 msec
   - ✓ Discuss integration time interval
3. REQ.350 : Check the GEMS saturation and saturation threshold



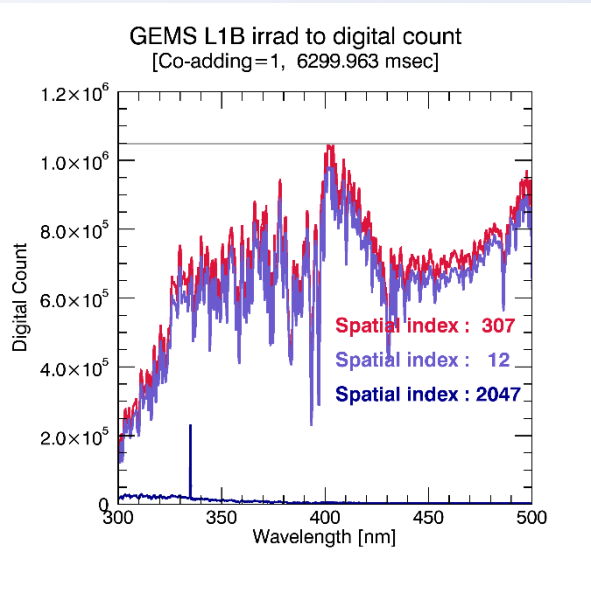



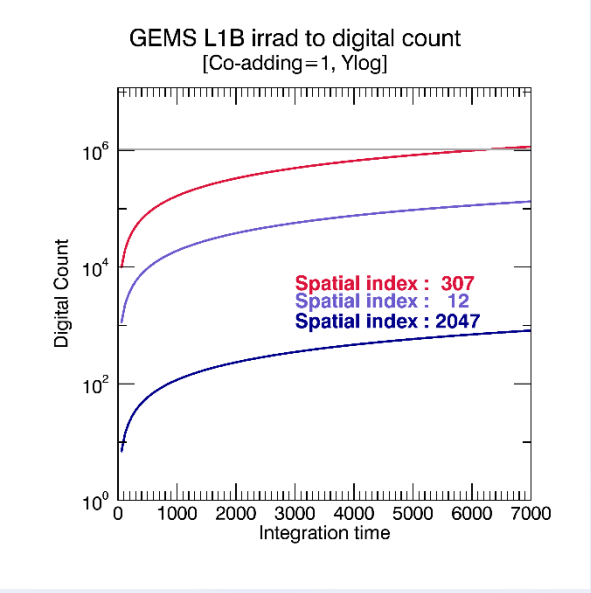



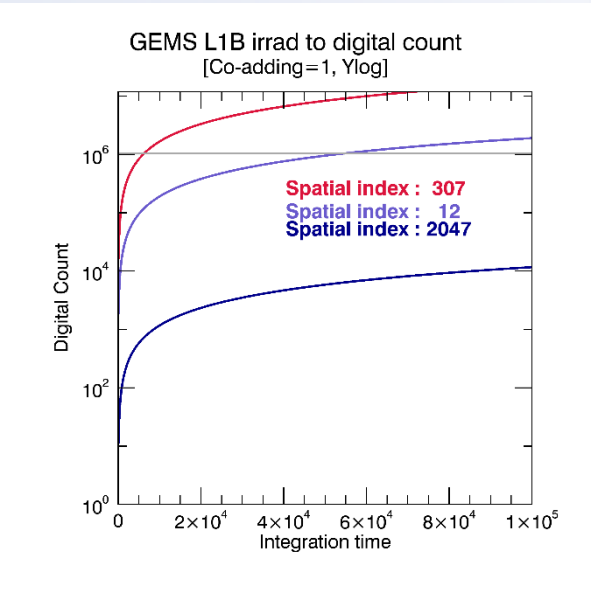
# Integration time for saturation

## REQ. 350

1. Collect Solar L0 data with different integration time through 2440454B [per co-adding]
2. Integration time before the digital count of one pixel reach the saturation threshold would be 6299.963 msec and integration time after the digital count of all pixel reach the saturation threshold would be 55007.021 msec
   - ✓ Discuss integration time interval
3. REQ.350 : Check the GEMS saturation and saturation threshold



# Linearity (Optional)

## REQ. 380

1. Run CBM BlockID 181 (This block is not for the IOT but for the IOC)
2. Collect 20 L1b data through 2440454B with a stray light option ‘off’
3. Average or add every pixel values of quadrant A for 20 L1b data
4. Last 3 values are saturation values
5. Discard data less than 5% of saturation value and more than 95% of saturation value
6. Fit them with a linear regression
7. Yi is the ideal response and Ym is a measured value
8. Req. 200 : $(Yi - Ym) / Ym \leq \pm 2\%$
9. Repeat 3 ~ 8 for quadrant B, C, and D

# PRNU (Optional)

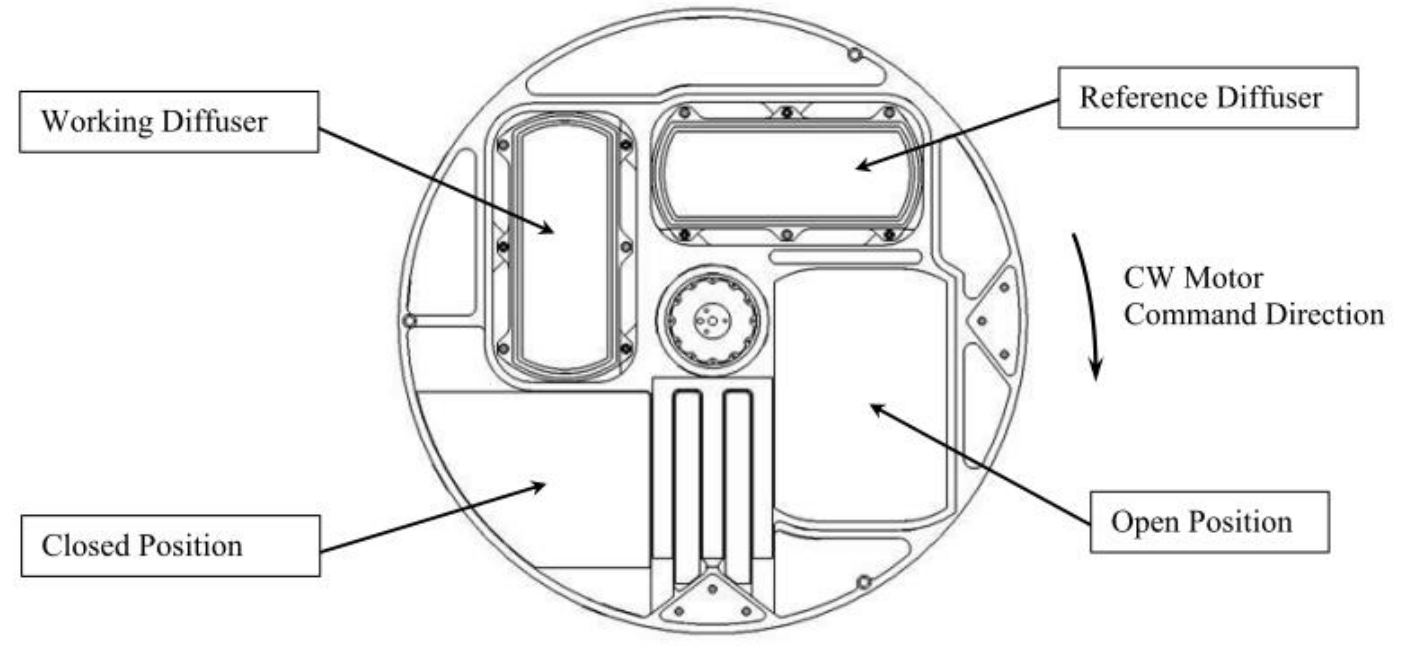
## REQ. 390

1. Run CBM BlockID 125 and 127
2. Collect L1b data of 9th image through 2440454B with a stray light and binning option 'off'
3. Make sure that the image is more than 50% filled of the full well capacity and discard pixel values less than 50% filled (Edge field)
4. Convolve the output image with a 3 by 3 square kernel (or 5 by 5 if necessary)
5. Divide the L1b data with a convolved data
6. Req. 390 : STD($\sigma$) $\leq$ 7%
7. Repeat 2 ~ 6 for quadrant 21th and 33th image

# Command Blocks for the IOC

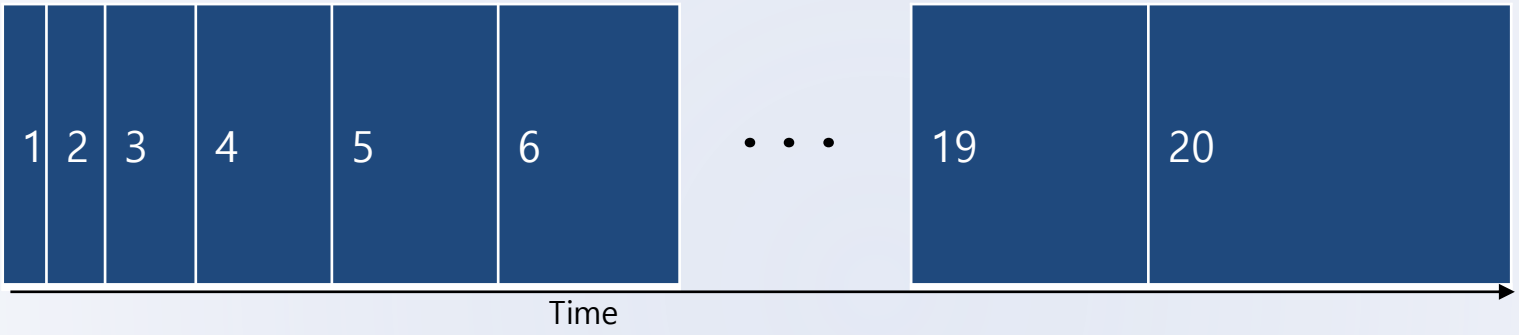
| Function Name | CBM Block ID | Description | Time (sec) |
|---|---|---|---|
| EXT_SOLAR | 180 | Longer Exposure to the Sun | 106 |
| LIN_SOLAR | 181 | Solar Linearity | 231 |
| SCAN_SOLAR | 182 | Solar Measurement while Scanning | 340 |
| MAX_DARK | 183 | Max. Dark Image | 1200 |
| EDGE_OBS. | 184 | Earth Obs. At Scan Edge Angle | 198 |
| | | Day-long Dark Observation | |

# Extended Solar Measurement (ID : 180)




- **Integration time : 350 ms (Normal : 161 ms)**
- **Co-add Number : 55**

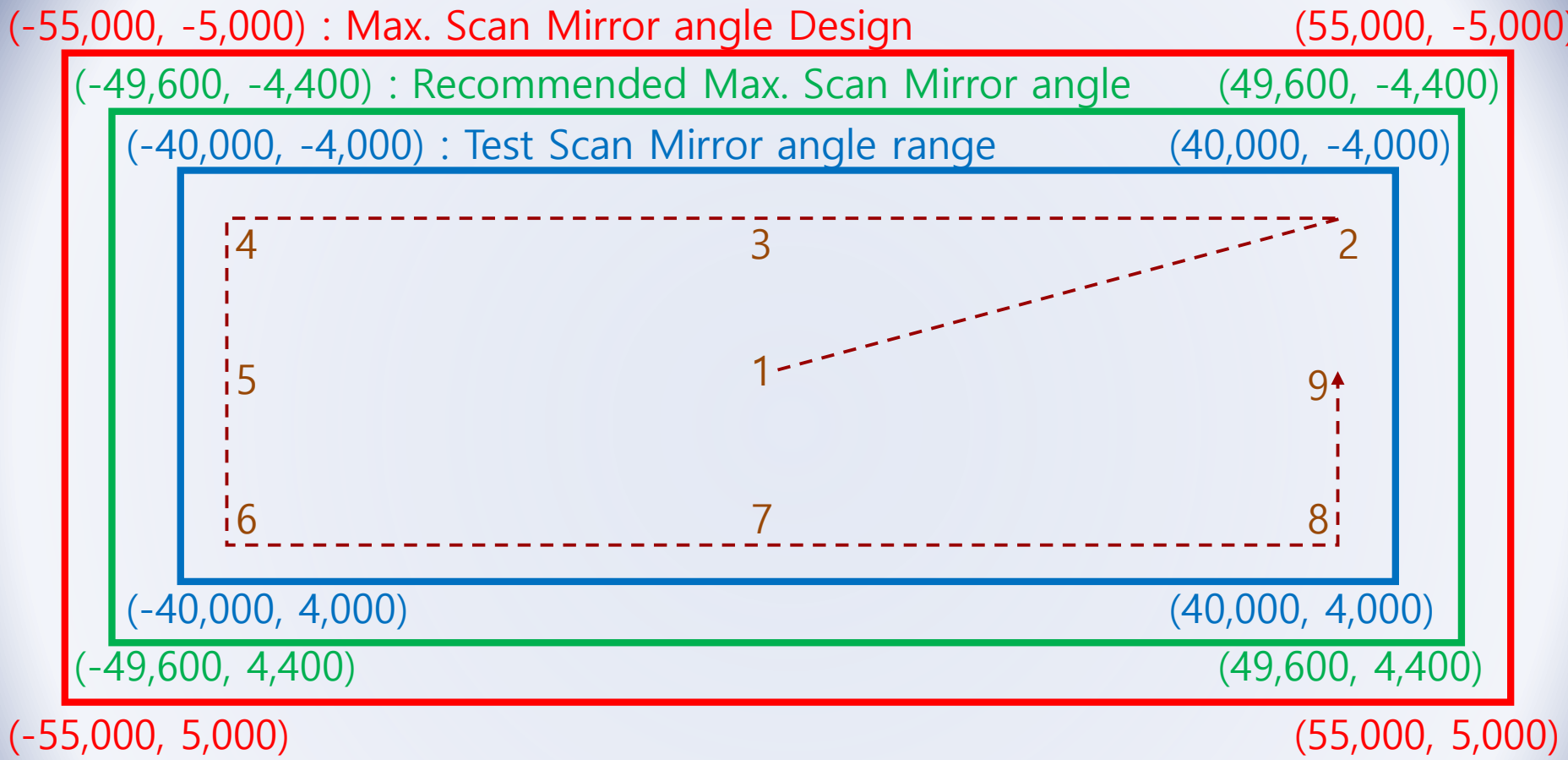
# Solar Linearity (ID : 181)




* Image not scaled

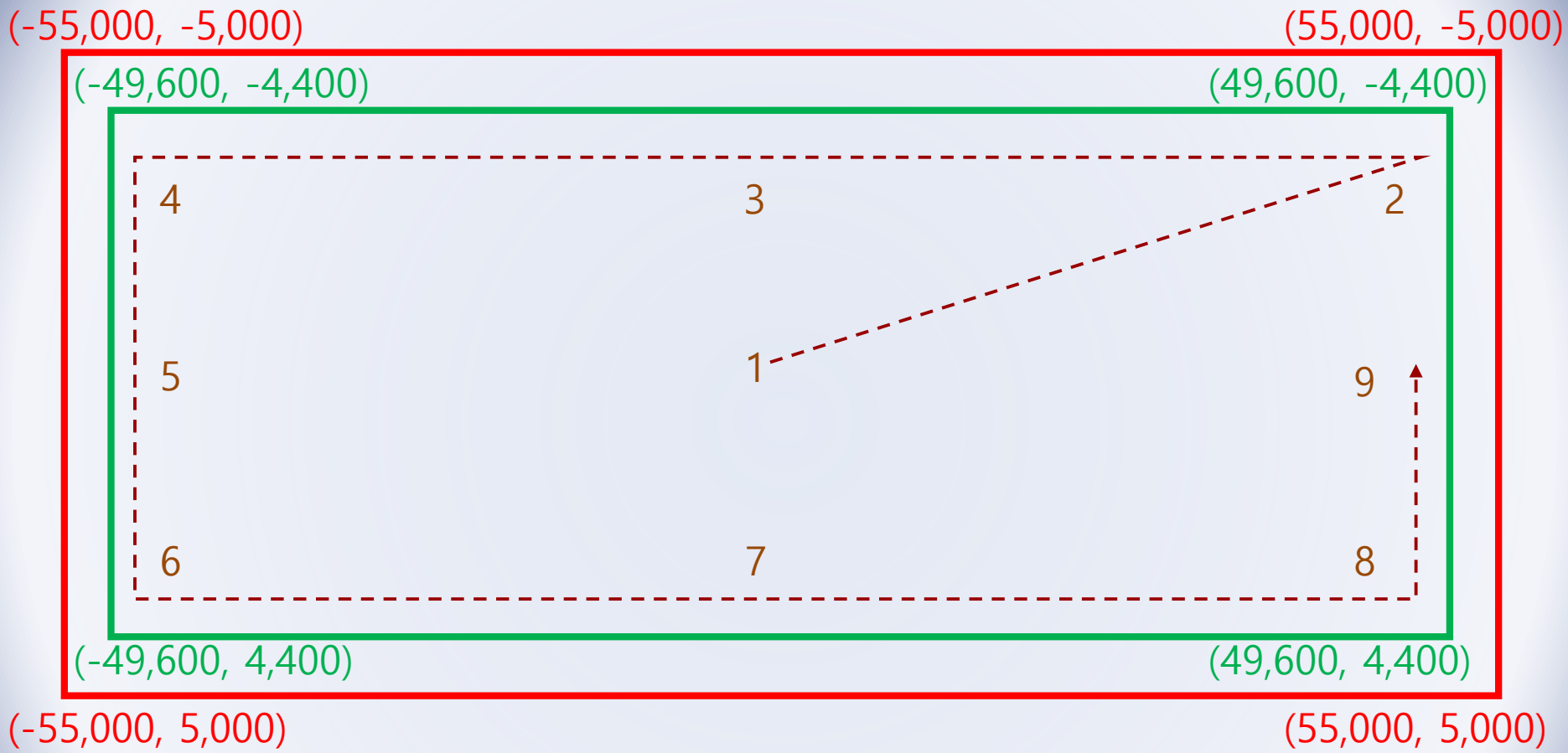
- **Multiple Solar Imaging while increasing Integration Time**
- **0, 125, 250, 375, … 2,250, 2,375 ms (20 images)**

# Scan Solar (ID : 182)



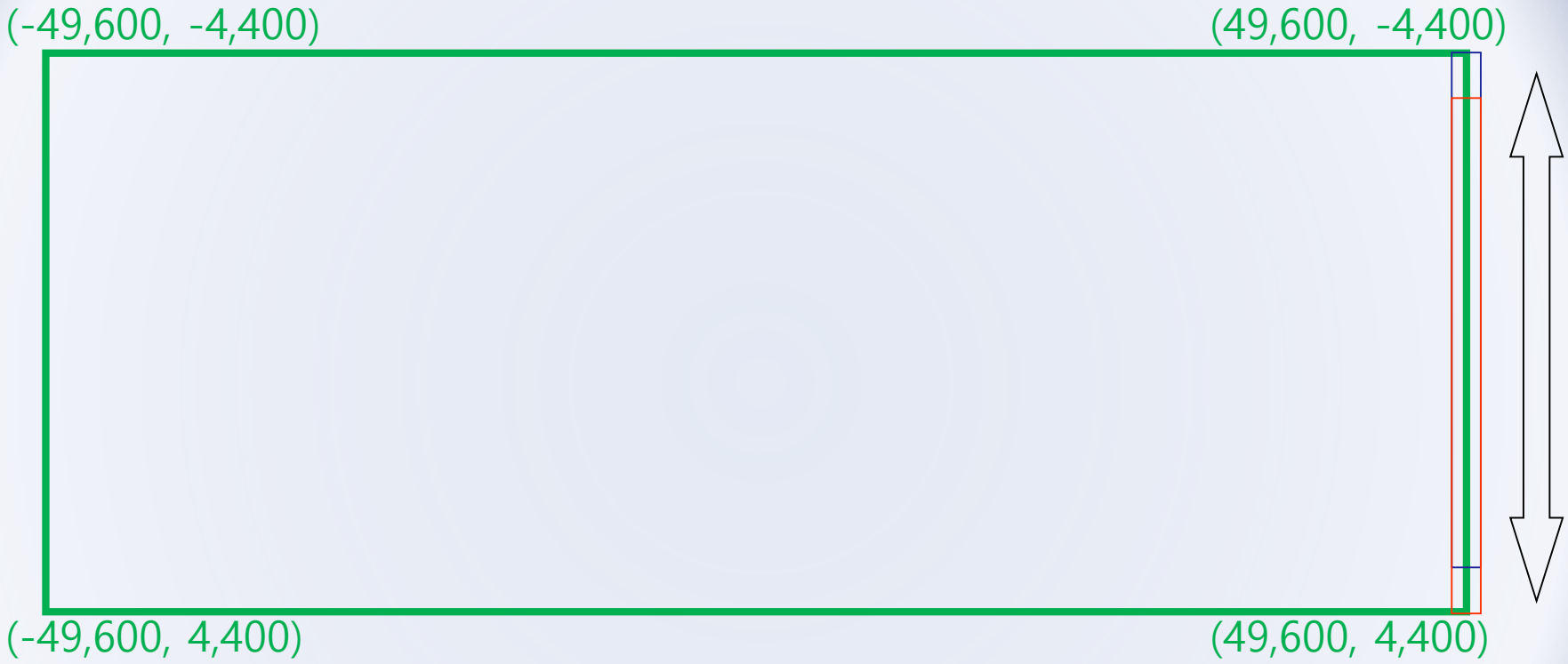

- **Nominal Solar Measurement at 9 Scan Mirror Positions**
- **Due to the Solar Exposure limit, Max. 9 points are allowed**

# Edge Observation (ID : 184)




- **Nominal Earth Measurement at 9 Scan Mirror Positions**
- **Clean sector and Scan angle dependence**

# Side Slither




- Detector Non-uniformity
- Even/Odd Amplifier parity check

# GEMS Mission Scheduler - UI

UI Figure

**Daily Azimuth and Elevation array of GEMS Angle for LOS**

Day 1 | Day 2 | Special

Local Day (YYYYMMDD): 20200831

Solar Cal. Mode: ○ WD ○ RD ◉ WD + RD

☑ LED

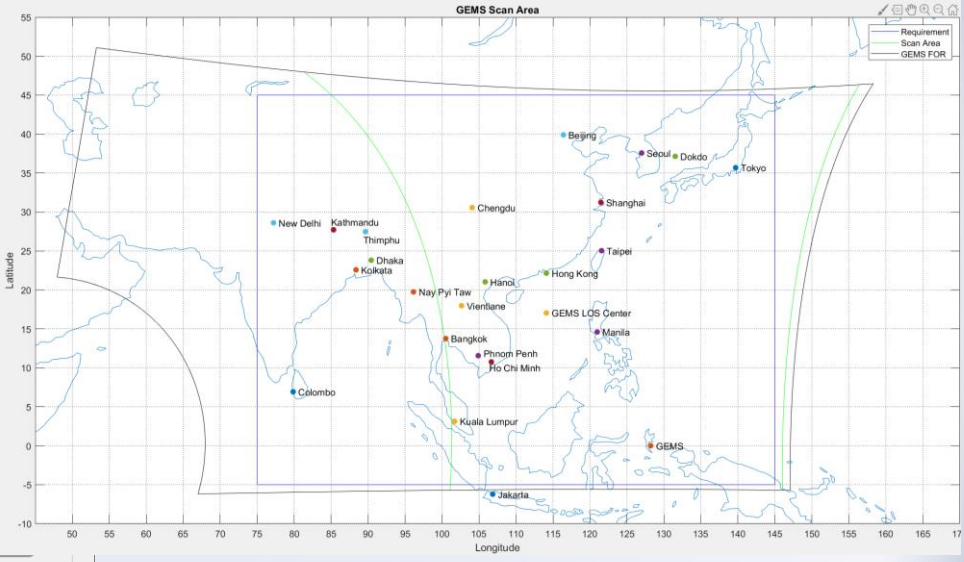
CMA Open: No Move ▾ Time: 30-Aug-2020 23:14:00

| | | Start Time (UTC) : | | | Duration (sec) | Start Long. : | Width : | |
|---|---|---|---|---|---|---|---|---|
| 01 | ☐ | 30-Aug-2020 22:45:00 | CMA MOVE | ● ● | 1800 | 153.86400 | 3.81500 | Map V |
| 02 | ☑ | 30-Aug-2020 23:45:00 | CMA MOVE | ● ● | 1800 | 153.86400 | 3.81500 | Map V |
| 03 | ☑ | 31-Aug-2020 00:45:00 | CMA MOVE | ● ● | 1800 | 152.01900 | 7.63100 | Map V |
| 04 | ☑ | 31-Aug-2020 01:45:00 | CMA MOVE | ● ● | 1800 | 152.01900 | 7.63100 | Map V |
| 05 | ☑ | 31-Aug-2020 02:45:00 | CMA MOVE | ● ● | 1800 | 152.01900 | 7.63100 | Map V |
| 06 | ☑ | 31-Aug-2020 03:45:00 | CMA MOVE | ● ● | 1800 | 152.01900 | 7.63100 | Map V |
| 07 | ☑ | 31-Aug-2020 04:45:00 | CMA MOVE | ● ● | 1800 | 152.01900 | 7.63100 | Map V |
| 08 | ☑ | 31-Aug-2020 05:45:00 | CMA MOVE | ● ● | 1180 | 139.22000 | 5.00300 | Map V |
| 09 | ☑ | 31-Aug-2020 06:49:00 | CMA MOVE | ● ● | 1560 | 139.22000 | 6.61400 | Map V |
| 10 | ☑ | 31-Aug-2020 07:45:00 | CMA MOVE | ● ● | 1800 | 139.22000 | 7.63100 | Map V |
| 11 | ☐ | 31-Aug-2020 08:45:00 | CMA MOVE | ● ● | 1800 | 139.22000 | 7.63100 | Map View |
| 12 | ☐ | 31-Aug-2020 09:45:00 | CMA MOVE | ● ● | 1800 | 139.22000 | 7.63100 | Map View |
| 13 | ☐ | 31-Aug-2020 10:45:00 | CMA MOVE | ● ● | 1800 | 139.22000 | 7.63100 | Map View |
| 14 | ☐ | 31-Aug-2020 11:45:00 | CMA MOVE | ● ● | 1800 | 139.22000 | 7.63100 | Map View |

CMA Close: No Move ▾ Time: 31-Aug-2020 08:46:00

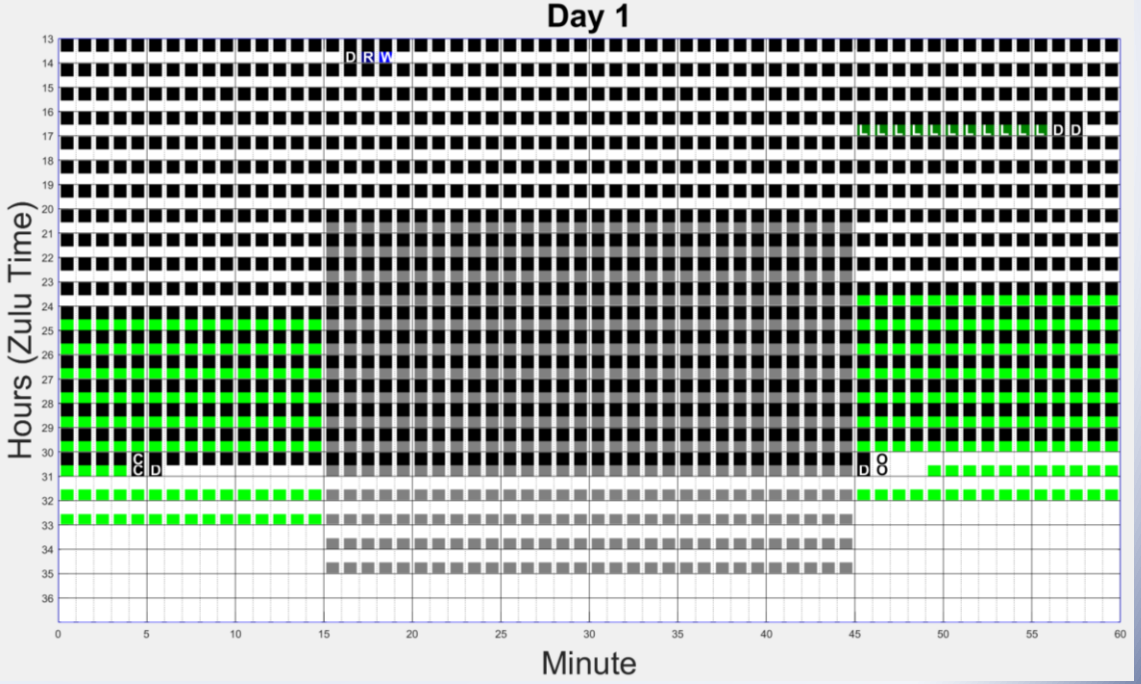
**Load / Save Current Scheduling Data**

Load | Save



# GEMS Mission Scheduler - Outputs

| | | | |
|---|---|---|---|
| GEMS_CSM_PRIMARY_2020-08-30.13-16-29.bin | 2019-09-26 오후 4:59 | BIN 파일 | 99KB |
| GEMS_CSM_SECONDARY_2020-08-30.13-16-29.bin | 2019-09-26 오후 4:59 | BIN 파일 | 99KB |
| GEMS_NON_CRITICAL_CBM_2020-08-30.13-16-29.bin | 2019-09-26 오후 4:58 | BIN 파일 | 29KB |
| GEMS_SCAN_TableID35_2020-08-30.13-16-29.bin | 2019-09-26 오후 4:58 | BIN 파일 | 33KB |
| GEMS_SCAN_TableID36_2020-08-30.13-16-29.bin | 2019-09-26 오후 4:58 | BIN 파일 | 33KB |
| GEMS_SCAN_TableID37_2020-08-30.13-16-29.bin | 2019-09-26 오후 4:58 | BIN 파일 | 33KB |
| GEMS_SCAN_TableID38_2020-08-30.13-16-29.bin | 2019-09-26 오후 4:58 | BIN 파일 | 33KB |
| GK2B_GEMS_MR_2020-08-30.13-16-29.osl | 2019-09-26 오후 4:59 | OSL 파일 | 10KB |
| GK2B_GEMS_MR_2020-08-31.13-16-48.osl | 2019-09-26 오후 4:59 | OSL 파일 | 10KB |
| DAEGAL_CBM_21.txt | 2019-09-26 오후 4:59 | TXT 파일 | 18KB |
| DAEGAL_CSM_22.txt | 2019-09-26 오후 4:59 | TXT 파일 | 12KB |
| DAEGAL_SMA_Table_1.txt | 2019-09-26 오후 4:59 | TXT 파일 | 12KB |
| DAEGAL_SMA_Table_2.txt | 2019-09-26 오후 4:59 | | |
| DAEGAL_SMA_Table_3.txt | 2019-09-26 오후 4:59 | | |
| DAEGAL_SMA_Table_4.txt | 2019-09-26 오후 4:59 | | |
| GEMS_CSM_PRIMARY_2020-08-30.13-16-29.txt | 2019-09-26 오후 4:59 | | |
| GEMS_NON_CRITICAL_CBM_2020-08-30.13-16-29.txt | 2019-09-26 오후 4:59 | | |
| GEMS_SCAN_TableID35_2020-08-30.13-16-29.txt | 2019-09-26 오후 4:59 | | |
| GEMS_SCAN_TableID36_2020-08-30.13-16-29.txt | 2019-09-26 오후 4:59 | | |
| GEMS_SCAN_TableID37_2020-08-30.13-16-29.txt | 2019-09-26 오후 4:59 | | |
| GEMS_SCAN_TableID38_2020-08-30.13-16-29.txt | 2019-09-26 오후 4:59 | | |



# Summary

- 12x and 18x Command Blocks can not be uploaded at the same time due to the CBM file size limit
- All 12x and 18x Command Blocks have been tested through the GEMS EEM2
- Analysis codes for the outputs of the above command blocks are ready and tested at the EEM2 level (CCSDS or GRDDP)
- Create / Modify pseudo L1B Codes which can handle and process output data
- Mission scheduler is being upgraded reflecting user suggestions

# Completion of Commissioning

## Before the On-orbit Acceptance Review

- Collect earth scans with nominal operating parameters
- Collect and analyze data necessary to demonstrate compliance to instrument performance spec.
- Demonstration of ability to operate out of a 48 hr command load and to transition from one load to the next
- Perform normal radiometric calibration activities with both working and reference diffusers
- Perform normal spectral calibration activities with both working and reference diffusers
- Trend data acquired with LED
- Demonstrate ability to image over selected FOR
- Additional activities as defined by User Group