GOES 8/12 TRANSITION PLAN

(January – April 2003)

GOES/SOCC Engineering

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1. Introduction

GOES-8, which has been the East operational spacecraft since early 1995, will exceed the inclination control requirements of +/- 0.5 deg in April 2003. No propellant will be available after that time for inclination adjustment, although sufficient margin will be maintained for East/West station management and End-of-Life de-orbit. At that time it will be necessary to replace GOES-8 as the East operational spacecraft at 75W longitude. GOES-12, launched in July 2001, has been chosen to be the replacement for GOES-East.

This document describes the detailed mission operations procedure to replace GOES-8 with GOES-12 as the GOES-East spacecraft. It includes milestones for the various maneuvers required to position GOES-12 at 75W, management of Radio Frequency (RF) conflicts between GOES-8 and GOES-12, allocation of ground resources, and the steps required to support product testing and commission GOES-12 as GOES-East. Not covered are the steps required by OSDPD to transfer product generation from GOES-8 to GOES-12.

The GOES-East swap activities must be closely coordinated with the move of GOES-9 to 205W and activation of the Fairbanks operation, which will occur during the same time period. An integrated GOES operations activity calendar is attached as Appendix B.

2. Operational Scenarios

There are many options for repositioning GOES-12 to 75W and switching products between GOES-8 and GOES-12 that are feasible from the SOCC operations perspective and acceptable for spacecraft health & safety. GOES engineering/SOCC has coordinated closely with the Satellite Analysis Branch (SAB) to represent user interests in determining the optimal method to perform the swap. In particular, SAB conducted an informal poll among the general population of GVAR users to select preferred options. Preferences of the user community were heavily weighted in selecting the procedure presented below. The main user criteria for performing the swap were to: 1) provide a sufficient testing period to evaluate the performance of the revised GOES-12 ingest systems by OSDPD and other capable users, 2) not require general users to re-point their antennae to track a moving spacecraft in order to receive operational GVAR imagery data, and 3) maintain continuous GOES-12 GVAR once it is returned to on-orbit mode by performing a single switch from GOES-8 to GOES-12 as the operational GVAR stream.

One swap of operational GOES spacecraft has occurred, in August 1998, when GOES-10 was moved from 105W to 135W to replace GOES-9 as GOES-West. The procedure in that case was to use GOES-10 as the operational West spacecraft throughout the drift, which required GVAR users to continuously re-point their antennae. That swap was planned and performed rapidly in response to the sudden degradation of the GOES-9 momentum wheels.

3. Radio Frequency Constraints

RF conflicts dominate the constraints that drive the operational plan to swap GOES-8 for GOES-12. All GOES-I/M spacecraft share identical uplink and downlink frequencies. The only flexibility is in selection of the 3 diverse engineering telemetry downlink frequencies available to each spacecraft. In particular, the processed data relay (GVAR) downlink requires the greatest separation between spacecraft, due to the relatively low gain of the typical user receive antenna. The following longitude separations are defined conservatively to preclude uplink and downlink RF interference during the close approach and cross-over of GOES-8 and GOES-12:

Minimum GVAR downlink (1685.7 MHz) interference separation is 6.0 deg
Minimum CMD uplink (2034.2 MHz) interference separation is 2.0 deg
Minimum Telemetry downlink S-Band & L-Band interference separation is 2.0 deg
Minimum Sensor Data downlink (1676.0 MHz) interference separation is 2.0 deg
Minimum MDL downlink (1681.5 MHz) interference separation is 2.0 deg
Minimum WEFAX/EMWIN, DCPI uplink interference separation is 2.0 deg

These separations will determine the periods of interference and consequent swap-out periods during the drift and co-location near 75W. In addition, no other communication services (DCS, WEFAX/EMWIN, SAR) will be operated on GOES-12 until the final handover from GOES-8 occurs at the 75W longitude station. The Multi-use Data Link, which supports SXI on GOES-12 and the ADS on GOES-8, will be required for GOES-12 SXI from the time it is returned to on-orbit mode and can always take precedence over the GOES-8 MDL diagnostic data.

As GOES-12 approaches 77W, the telemetry downlink frequencies shared with GOES-8 will be reconfigured. GOES-12 will maintain the 1694 MHz frequency (CDA transmitter) as prime, with the 2209 MHz frequency (DSN-A transmitter) as backup. The GOES-8 CDA transmitter will be turned OFF and the DSN-B transmitter (2208 MHz) will be turned ON to use as prime. The GOES-8 DSN-A transmitter will be left ON as a backup. Although some interference in the 2209 MHz backup downlinks may occur, this configuration is desirable in the case of a failure of the prime telemetry transmitter on either of the two spacecraft.

Note that once GOES-12 is within 2 deg of GOES-8, no simultaneous commanding of the two spacecraft will be possible. GOES-8 commanding will be curtailed except for brief daily housekeeping activities that will interrupt GOES-12 commanding (but may be scheduled, for instance, during a GOES-12 full disk with little interference). Command hand-over may also be required to complete the last few nights of eclipse commanding.

4. GOES-12 / GOES-8 Swap Procedure: Hybrid ‘Instant Switch’ Method

This method eliminates GVAR user antenna repositioning to track GOES-12 for East operational products through its drift, and satisfies the requirement of continuous GOES-12 product data once the initial switch is performed. It provides for a very rapid fall-back

to GOES-8 for operational products, should a significant problem arise. However, simultaneous imaging of both GOES-8 and GOES-12 is not possible within about 6 deg collocation (same as for other options). It provides an advantage over the 'moving hand-over' in that when GVAR is swapped from GOES-8 to GOES-12, the GVAR relay S/C (GOES-8) is not moving. During the period that GOES-12 is operational while drifting toward 75W, however, the images will reflect an approximate 0.4 deg/day drift. This may be accommodated by periodically updating the reference longitude.

The sequence of events for the proposed GOES-12 commissioning process is as follows (all dates are approximate):

1. Perform DSN ranging on GOES-12 while in storage [1/2/03]

2. Plan North/South maneuver based on DSN solution

3. Return GOES-12 to on-orbit mode (w/ 7 nights contamination avoidance) [1/9]

4. Perform GOES-12 N/S maneuver [1/14]

5. Perform DSN ranging on GOES-12 for post-N/S solution [1/15]

6. Plan Eastward drift maneuver

7. Start GOES-12 Eastward drift from ~110W towards 75W (~0.4 deg/day) [1/17]

8. Perform DSN ranging on GOES-12 for quick INR start-up [1/18]

9. Turn on SXI High Voltage Power Supply (HVPS), and begin imaging. [1/20]

10. Perform INR recovery during drift; reach spec [1/20 –1/24]

11. Accommodate (advanced) user testing during drift via imaging schedule, and GOES-12 GVAR relayed through GOES-12. [~1/24-3/31]

12. GOES-12 drifts to ~81W [circa 3/31]

13. Near 81W, perform swap of GOES-12 imagery data for GOES-8 as GOES-East:
    This constitutes the switch to GOES-12 as GOES-East
    i. Bring down GOES-8 PDR
    ii. Patch GOES-12 GVAR via IF distribution panel into GOES-8 uplink
    iii. GOES-8 PDR contains GOES-12 imagery; users don't re-point antennae
    iv. Swap back quickly to GOES-8 PDR via patch if required

14. Continue generating GOES-8 daily command schedules. If required to re-establish GOES-8 for products, patch GOES-8 PDR into GOES-8 transponder; use last IMC profile & perform mini-INR start-up for GOES-8.

15. As GOES-12 approaches 77W, discontinue GOES-8 routine commanding [~4/16]
    i. In CMD interference region, hand-over CMD uplink to GOES-8 for 1 consolidated daily Housekeeping: SA/TT adjust, Momentum Unload, possible eclipse commanding
    ii. Also, turn OFF GOES-8 Sensor Data xmtr to prevent interference w/ GOES-12 S-band downlink (maintain GOES-8 WEFAX/EMWIN, DCS, SAR)

16. *GOES-12/GOES-8 cross-over occurs* [~4/20]

17. Perform stop maneuver to position GOES-12 at 74.5W (plan to have GOES-8 near 75.5 W).
    i. Turn on GOES-12 S-band Receiver
    ii. Switch GOES-12 GVAR data from GOES-8 to GOES-12 PDR transponder (out of hybrid mode).
    iii. Switch ancillary communication services (DCS, WEFAX/EMWIN, SAR) from GOES-8 to GOES-12. [4/22]

18. Perform GOES-8 Westward drift maneuver (hand-over CMD to GOES-8 for ~2 hrs) [4/24]

5. Communication Services Swap

As GOES-East, GOES-12 will support all ancillary communication services (Data Collection System, WEFAX/EMWIN, Search and Rescue). Because of the wide geographic coverage of these systems, the swap from GOES-8 to GOES-12 for the ancillary communications services will be performed just after the drift stop maneuver when GOES-12 is initially on-station at 74.5W, and GOES-8 is near 75.5W. The procedure for the swap will consist of having WCDA drop the East uplinks for WEFAX/EMWIN and DCPI (DCP report pilot need not be dropped) while the GOES-8 S-band receiver, DCPR transponder, and DCPI transmitter are turned OFF and the GOES-12 S-Band receiver, DCPR transponder, and DCPI transmitter are turned ON. This activity must therefore coincide with the swap of Processed Data Relay (GVAR) from GOES-8 to GOES-12. The GOES-12 SAR transmitter will also be turned ON and the GOES-8 SAR transmitter turned OFF at this time.

The GVAR swap from GOES-8 hybrid mode to direct mode will consist of dropping the PDR uplink carrier, configuring the IF distribution patch of GOES-12 data from the GOES-8 antenna to the GOES-12 antenna (i.e. de-configure from the hybrid mode), and restoring the GOES-12 PDR uplink through the GOES-12 antenna system.

The GOES-12 MDL transmitter will be turned ON when the spacecraft is returned to on-orbit mode to support SXI operations. When GOES-12 approaches 77W on its drift, the GOES-8 MDL transmitter will be turned OFF to prevent interference. (The GOES-8

MDL is used only for diagnostic data, so no operational capability will be lost.) Likewise, the GOES-8 Sensor Data transmitter will be turned OFF when GOES-12 approaches 77W.

Appendix A contains the detailed communications and RF systems configuration through each phase of the swap-out.

6. Image Navigation and Registration (INR) Start-up

GOES-12 INR start-up will be based on the successful GOES-11 start-up procedure. INR start-up operations will commence following the GOES-12 Eastward drift maneuver, based on the DSN post-maneuver orbit solution. Initial daily command schedules will be adapted to the INR start-up phase, such as a 24-hour continuous star schedule followed by a modified full-disk schedule. Imaging operations during the ~0.4 deg/day drift will require one update per day of the reference longitude. Note that GOES-12 is targeted to stop on-station at 74.5W to initiate a full East/West stationkeeping cycle.

Since no GOES-12 flight data exists for trim tab start-up during the January-April timeframe, an *a priori* estimate for the GOES-12 will be made based on the GOES-8/10 seasonal profiles, adjusted for center-of-mass offset determined during the summer/fall 2001 GOES-12 operation. The solar array will be centered 8 times per day to reduce solar torque accumulation.

No GVAR ranging will be possible for either GOES-8 or GOES-12 during the approximately 2-week period of hybrid GVAR configuration. Analysis has been performed that demonstrates no significant image navigation error due to propagating a single orbit state vector for 2 weeks. If the necessity arose, DSN ranging could be requested during this time, but this is not planned.

7. Scheduling

GOES-12 will require daily command schedules as soon as it is returned to on-orbit mode. Special INR start-up schedules will be based on previous GOES-11 templates. During the drift from ~110W to 81W, a full-disk schedule will be run for GOES-12 (image and sounding sectors may require periodic adjustment throughout the Eastward drift). When GOES-12 approaches 81W, the schedule will switch to the East Routine as GOES-12 becomes GOES-East. GOES-8 daily command schedules will be continued as a back-up even after the swap to GOES-12 operational products, until the region of command conflict when GOES-12 approaches 77W.

All GOES-12 special events, including return to on-orbit mode, North/South and East/West drift maneuvers, will be executed via script and will not require scheduling support.

8. Eclipse/KOZ Operations

The GOES-12 drift period will encompass the Spring 2003 eclipse season. Nightly eclipse commanding will be performed for GOES-12, just as for GOES-8. The ~0.4 deg/day drift rate will cause eclipse times to shift approximately 2 minutes earlier each night. This will be reflected in the Imager and Sounder frames deleted for eclipse and Keep-Out-Zone. Eclipse season will be ending in mid-April as GOES-12 approaches 77W, and the 2 deg command constraint with GOES-8. Nightly eclipse commanding may therefore have to be coordinated with GOES-8 for the last few nights.

Imager and Sounder Spring KOZ will occur from mid-February through late April. Because of the complexity of planning recoverable KOZ frames through the drift, no special effort will be made to include all possible GOES-12 frames through extensive KOZ analysis. All Imager and Sounder frames within 6 deg of the Sun will be excluded during KOZ season. Normal KOZ planning will continue for GOES-8 through the swap to GOES-12 as GOES-East.

9. GOES-12 Imager Outgassing

Measurements of the GOES-11 Imager IR detector response during the June 2002 normal mode operation confirmed a general decrease in responsivity occurring after a protracted period of storage. Investigation by ITT points to water ice as the primary culprit. Outgassing the GOES-11 Imager fully restored detector performance to post-launch levels. The indication is that a similar decrease in Imager IR responsivity may be expected for GOES-12 over the approximately 13 months of storage that will have transpired. The plan for GOES-12 Imager decontamination is as follows: It is recommended by ITT that the GOES-12 anti-ice heater not be turned on before the spacecraft is returned to normal on-orbit mode in January 2003, since it is desired to obtain a good measure of current detector responsivities before any heater reconfiguration is performed. Measurements of GOES-12 responsivities in storage mode are operationally complex and will not be performed, since there should be adequate time for all necessary measurements between the return of GOES-12 to normal on-orbit mode in mid-January, and GOES-12 going into service as GOES-East in early April 2003.

After return to on-orbit mode, a responsivity measure will be made, and if responsivities have dropped, a period of anti-ice heater activation will be done (approximately 2 days), while continuous responsivity measurements are taken. If that does not clear the contamination, a short period of outgassing will be done (approximately 3 days) followed by a cooldown and responsivity measure. If further outgassing is needed, a one-week outgas will be performed.

10. Solar X-Ray Imager (SXI)

The SXI will be activated following the Eastward drift start maneuver. Eight times-per-day adjustment of the solar array will be performed to limit E/W pointing error to within 0.06 deg. Routine schedules for basic patrol have been coordinated with SEC-Boulder to

be run continuously. Test schedules will be inserted into these routine schedules and run as requested by SEC-Boulder. An important consideration for SEC-Boulder to receive MDL/SXI data through the drift is their ability to track the spacecraft at the approximate 0.4 deg/day rate.

11. Ground Resources

The ground resources required for GOES-12 throughout the return to normal on-orbit and drift to 75W are:

Antenna/TACTS: A dedicated 18m or 16.4m HR antenna and RTACTS system will be available to GOES-12 from the start of the operation. During critical operations (return to on-orbit mode and North/South maneuver), a backup antenna/TACTS configuration will be requested.

TCS: TCS 1 will be used as the prime TCS for all GOES-12 special and routine operations, while the operational missions will continue using TCS 5 as prime. This configuration has been validated over several periods of 3-spacecraft operations.

SPS: During the GOES-12 drift period, GOES-8 (East) and GOES-10 (West) missions will each have a dedicated SPS/OGE configuration, with one dedicated hot-backup for GOES-8. This configuration will also be the cold-backup for GOES-10. The remaining SPS/OGE configuration will remain on GOES-12 until the scheduled switch to GOES-12 as GOES-East near 81W. The operational backup configuration will be available for GOES-12, with GOES-8 and GOES-10 having priority for the backup in case of a double failure. After the swap to GOES-12 as GOES-East, the SPS configuration described above will be reversed between GOES-12 and GOES-8. When GOES-8 ceases imaging as GOES-12 approaches the command constraint at 77W, SPS configuration will revert to the normal GOES-East/GOES-West implementation.

RPM: Two configurations on the operational server will be dedicated to GOES-12 when imaging begins. Sufficient redundancy exists between the RPM systems that 3-S/C operation will not affect RPM operational support.

OATS: A dedicated configuration on the primary SOATS will be used for GOES-12.

MPS: The MPS system will support GOES-12 SXI operation following the return to on-orbit mode. Normal mode operation during the GOES-12 post-launch test was to use the local MPS at SOCC to provide SXI telemetry to GIMTACS. This mode may be problematic if the local MDL antenna cannot track the 0.4 deg/day Eastward drift. In that case, the MPS stream from the CDA will be made prime. (Note that IPD indicates tracking GOES-12 through the drift should be feasible.)

12. DSN Ranging Schedule (TBR)

To facilitate accurate orbit determination of spacecraft without valid INR, the NASA DSN system must be used for ranging and orbit solutions determined by GSFC Flight Dynamics. GOES-12 will require DSN ranging support in early January prior to removal from storage for return-to-normal mode planning and North/South maneuver planning, again just after the North/South maneuver to expedite INR start-up, and following the drift initiation maneuver. Thereafter, INR will be maintained throughout the drift period and final station acquisition maneuver in late April.

All GOES-12 ranging passes will be documented via standard procedure memoranda. The requested schedule for DSN ranging support is as follows. Note that this schedule is preliminary and is dependent on confirmation from the network.

1/2/03	GOES-12 storage orbit solution update, pre-recovery
1/15/03	GOES-12 post-North/South
1/18/03	GOES-12 post-drift start maneuver

13. GSFC Flight Dynamics Support

Flight Dynamics/SOCC support will be required for the GOES-12 return-to-normal operation. Specifically, out-of-plane DIRA calibration, yaw to orbit-normal determination, Spacecraft Local Time, and XRS Sun elevation angle estimation products are needed from FDF/SOCC. No further real time support by FDF will be required. Planning for the GOES-12 North/South and East/West drift start and stop maneuvers will be performed by NOAA/SOCC using the OATS. However, GSFC Flight Dynamics has been requested to review the OATS drift maneuver plan.

Institutional GSFC Flight Dynamics support for GOES-12 orbit determination via DSN ranging will also be required as defined in the DSN Ranging Schedule.

14. GOES-8 Decommissioning

Care must be taken during the step-by-step decommissioning of GOES-8 subsystems (e.g. comm. and instruments) described above to ensure the final configuration corresponds to a safe storage state. Also, GOES-8 transmitters must be configured so that downlinks do not interfere with any other mission. As of this time, the final disposition of GOES-8 has not been determined. It is planned that GOES-8 will be moved Westward immediately after GOES-12 station acquisition at 75W. This is necessary to eliminate the commanding conflict. (A controlled drift maneuver is desirable so that the GOES-8 semi-major axis is sufficiently changed to not conflict the Air Force mission at 90W.) A decision will then be made as to where GOES-8 should then be stopped, with the 105W station stable equilibrium being the prime candidate at least temporarily.

APPENDIX A: COMMUNICATIONS CONFIGURATION

RF Reconfiguration by Timeline

Phase		G-12 Comm Config	G-8 Comm Config
G-12 RTN	S-Band Rec	ON	ON
& Drift	SD xmtr	ON	ON
	MDL xmtr	ON	ON
	DCPI xmtr	OFF	ON
	DCPR xpndr	OFF	ON
	SAR xmtr	OFF	ON
	SAR Rec	OFF	ON
	Pwr Amp A	ON	ON
	Pwr Amp C(B for G-8)	ON	ON
	CDA Tlm	ON	ON
	DSN-A Tlm	ON	ON
	DSN-B Tlm	OFF	OFF
	PDR u/l	UP (G-12 relay)	UP (G-8 relay)
	WEFAX/EMWIN u/l	DOWN	UP
	CMD u/l	Continuous	Continuous
	DCPI u/l	DOWN	UP
	DCP Pilot		UP

Phase		G-12 Comm Config	G-8 Comm Config
G-12 @ 81W	S-Band Rec	ON	ON
	SD xmtr	ON	ON
	MDL xmtr	ON	ON
	DCPI xmtr	OFF	ON
	DCPR xpndr	OFF	ON
	SAR xmtr	OFF	ON
	SAR Rec	OFF	ON
	Pwr Amp A	ON	ON
	Pwr Amp C(B for G-8)	ON	ON
	CDA Tlm	ON	ON
	DSN-A Tlm	ON	ON

	DSN-B Tlm	OFF	OFF
	PDR u/l	DOWN	UP (G-12 relay)
	WEFAX/EMWIN u/l	DOWN	UP
	CMD u/l	Continuous	Continuous
	DCPI u/l	DOWN	UP
	DCP pilot		UP

Phase		**G-12 Comm Config**	**G-8 Comm Config**
G-12 @ 77W	S-Band Rec	OFF (prevent WEFAX int)	ON
	SD xmtr	ON	OFF
	MDL xmtr	ON	OFF
	DCPI xmtr	OFF	ON
	DCPR xpndr	OFF	ON
	SAR xmtr	OFF	ON
	SAR Rec	OFF	ON
	Pwr Amp A	ON	ON
	Pwr Amp C(B for G-8)	ON	ON
	CDA Tlm	ON (prime)	OFF
	DSN-A Tlm	ON	ON
	DSN-B Tlm	OFF	ON (prime)
	PDR u/l	DOWN	UP (G-12 relay)
	WEFAX/EMWIN u/l	DOWN	UP
	CMD u/l	Continuous*	Intermittent*
	DCPI u/l	DOWN	UP
	DCP pilot		UP

Phase		**G-12 Comm Config**	**G-8 Comm Config**
G-12 @ 74.5W	S-Band Rec	ON	OFF
	SD xmtr	ON	OFF
	MDL xmtr	ON	OFF
	DCPI xmtr	ON	OFF
	DCPR xpndr	ON	OFF
	SAR xmtr	ON	OFF
	SAR Rec	ON	OFF
	Pwr Amp A	ON	ON
	Pwr Amp C(B for G-8)	ON	ON
	CDA Tlm	ON (prime)	OFF

	DSN-A Tlm	ON	ON
	DSN-B Tlm	OFF	ON (prime)
	PDR u/l	UP (G-12 relay)	DOWN
	WEFAX/EMWIN u/l	UP	DOWN
	CMD u/l	Continuous*	Intermittent*
	DCPI u/l	UP	DOWN
	DCP pilot	UP	

*CMD uplink for collocated S/C will be interrupting G-12 commanding for one 10 min period per day for GOES-8 housekeeping

RF Reconfiguration by S/C

G-12 Comm Config	G-12 Drift	G-12@81W	G-12@77W	G-12@74.5W
S-Band Rec	ON	ON	OFF	ON
SD xmtr	ON	ON	ON	ON
MDL xmtr	ON	ON	ON	ON
DCPI xmtr	OFF	OFF	OFF	ON
DCPR xpndr	OFF	OFF	OFF	ON
SAR xmtr	OFF	OFF	OFF	ON
SAR Rec	OFF	OFF	OFF	ON
Pwr Amp A	ON	ON	ON	ON
Pwr Amp C	ON	ON	ON	ON
CDA Tlm	ON	ON	ON	ON
DSN-A Tlm	ON	ON	ON	ON
DSN-B Tlm	OFF	OFF	OFF	OFF
PDR u/l	UP (G-12 relay)	DOWN	DOWN	UP (G-12 relay)
WEFAX/EMWIN u/l	DOWN	DOWN	DOWN	UP
CMD u/l	Continuous	Continuous	Continuous*	UP
DCPI u/l	DOWN	DOWN	DOWN	UP
DCP Pilot				UP

G-8 Comm Config	G-12 Drift	G-12@81W	G-12@77W	G-12@74.5W
S-Band Rec	ON	ON	ON	OFF
SD xmtr	ON	ON	OFF	OFF
MDL xmtr	ON	ON	OFF	OFF
DCPI xmtr	ON	ON	ON	OFF
DCPR xpndr	ON	ON	ON	OFF
SAR xmtr	ON	ON	ON	OFF
SAR Rec	ON	ON	ON	OFF
Pwr Amp A	ON	ON	ON	ON
Pwr Amp B	ON	ON	ON	ON
CDA Tlm	ON	ON	OFF	OFF
DSN-A Tlm	ON	ON	ON	ON
DSN-B Tlm	OFF	OFF	ON (prime)	ON (prime)
PDR u/l	UP (G-8 relay)	UP (G-12 relay)	UP (G-12 relay)	DOWN
WEFAX/EMWIN u/l	UP	UP	UP	DOWN

CMD u/l	Continuous	Continuous	Intermittent*	Intermittent*
DCPI u/l	UP	UP	UP	DOWN
DCP Pilot	UP	UP	UP	

*CMD uplink for collocated S/C will be interrupting G-12 commanding for one 10 min period per day for GOES-8 housekeeping