PASS requirements for FOS GIMP correction

Date: 1 Nov 1991

The ground system has been requested to support the correction calculation for the FOS geomagnetic field deflection response. The FOS photocathode image/spectrum appears to move around in a cyclical fashion. This apparent motion is really caused by the interaction between the FOS internal detector magnetic field and the geomagnetic field. The absolute detector deflection (x,y) coordinates of any given physical point on the photocathode vary with time. That is, the deflection coordinate system is not fixed. The actual image location in detector coordinates at any given time depends on 1) where the telescope is within the geomagnetic field, 2) how the telescope is oriented in this field, and 3) the data acquisition mode.

There will be a patch to the FOS onboard software to inject x and y deflection offsets before any deflection motion is commanded. These deflection offsets must be updated periodically during each FOS exposure so that the deflection pattern remains stationary with respect to the photocathode image space. We must compensate for the magnetic field changes which occur throughout the exposure duration.

There will also be an upgrade made to the FOS Housekeeping Applications Processor to periodically supply the FOS software with the appropriate x and y deflection offsets. This AP will calculate the offsets from a table of third-order polynomial coefficients which is uplinked from the ground. See Glenn Foley's "Requirements and Proposed Design for the FOS GIMP Correction NSSC-1 Flight Software, 3rd Order Polynomial Coefficient Approach".

So, PASS must use its knowledge of the geomagnetic field, the spacecraft ephemeris and the data acquisition mode to compute the delta-x and delta-y motions of the deflection coordinate system as a function of time.

Adopted ground system method: Upload polynomial fit coefficients

The SMS will provide information about the data acquisition mode, the telescope position, the computation start time, and (optionally) the computation duration time. PASS will calculate delta-x and delta-y deflection offsets to cover the whole computation duration time. One offset (x,y) pair will be calculated every 15 seconds starting with the SMS-supplied computation start time. Using a standard least-squares fitting technique, PASS shall compute a 3rd-order polynomial fit to the data, one equation for the x-offset motion and another for the y-offset motion.

For $T(t) = T0 + 15sec*t$ where $t=0,1,2,...$
and $T0$ = computation start time

1. Compute the geomagnetic field B(v1,v2,v3) in gauss in s/c coordinates from the SMS supplied s/c orientation and the orbital location at time T(t).

2. Compute the geomagnetic field components along the digicon axes, B(x,y,z), by successive cartesian coordinate rotations. See attached diagram.

    a. Rotate about v1 axis by -135 degrees

```
B0_x = cos(theta)* B_v2 + sin(theta)* B_v3
B0_y = -sin(theta)* B_v2 + cos(theta)* B_v3
B0_z = B_v1
                        where theta = -135 degrees
```

b. Rotate about v2-v3 bisector by -23 degrees

```
B1_x = B0_x
B1_y = cos(delta)* B0_y + sin(delta)* B0_z
B1_z = -sin(delta)* B0_y + cos(delta)* B0_z

                        where delta = -23 degrees
```

c. Rotate about the detector Y axis

```
B_x = cos(alpha)* B1_x + sin(alpha)* B1_z
B_y = B1_y
B_z =  not needed for further calculations

                        where alpha = 8 deg for red detector
                              alpha = -8 deg for blue detector
```

d. Reverse sense of the x component

```
B_x = - B_x
```

4. Compute effective geomagnetic field B_eff(x,y), correcting for ExB electron-optical drift, by rotating about the detector z axis by 17.6 degrees

```
B_eff_x = cos(beta)* B_x + sin(beta)* B_y
B_eff_y = -sin(beta)* B_x + cos(beta)* B_y

                        where beta = 17.6 degrees
```

5. Compute GIMP(x,y) offsets by scaling B_eff(x,y) with a scale factor located in the SICF PDB file. The scale factor is dependent on detector and data acquisition mode. The units will be detector deflection steps per gauss. The SMS will supply a mnemonic to use in retrieving the correct scale factor.

SICF lookup table:

SMS mnemonic	x_scale_factor	y_scale_factor	
ACCUM1	***	***	red detector
IMAGE1	***	***	red detector
ACCUM2	***	***	blue detector
IMAGE2	***	***	blue detector

The actual values are TBD but should be in the range of -200 to +200.

```
GIMP_x = x_scale_factor * B_eff_x
GIMP_y = y_scale_factor * B_eff_y
```

Determine the equation coefficients to be uploaded to the NSSC-1.

1. Using a standard least-squares fitting technique, compute a

X-gimp = A t**3 + B t**2 + Ct + D
Y-gimp = Z t**3 + Y t**2 + Xt + W

where t is in units of 15 sec
(aka a GIMP tick)

2. Scale the polynomial coefficients by constants to accomodate the integer math of the NSSC-1.

A = A * 2**24	Z = Z * 2**24
B = B * 2**16	Y = Y * 2**16
C = C * 2**12	X = X * 2**12
D = D * 2**8	W = W * 2**8

3. Place these coefficients and the SMS supplied initial GIMP tick number into a memory load command for the YFGIMPCB table.

YFGIMPCB:	coefficient A
	coefficient B
	coefficient C
	coefficient D
	coefficient Z
	coefficient Y
	coefficient X
	coefficient W
	initial tick #

The SMS input:

Ken, Please comment above these two options. Can we use option 1? This is our preferred method because it will take less spacecraft time.

Option 1

In this option, PASS would load two tables in response to the new data block FOSGIMP, YFGIMPCB (as described above) and the gimp function enable table (mnemonic unknown at this time).

This second table would be loaded with a value of 1 only if the ENABLE parameter is given on the SMS. By having PASS load both these tables the maximum time to setup the gimp correction would be about 40 seconds.

```
FOSGIMP, _OPMODE(ACCUM1,IMAGE1,ACCUM2,IMAGE2)
       , _ORIENT(decimal,decimal,decimal)
       [, _TICK(integer)]
       [, _COMPDUR(integer)]
       [, ENABLE]
       , TIME = time ;
```

keyword	description	type	units	range	resolution
_OPMODE	data acquisition mode	mnemonic	ACCUM1|IMAGE1|ACCUM2|IMAGE2		
_ORIENT	ST position				

(ra,	right ascension	decimal	degrees	0-360	10**-7
dec,	declination	decimal	degrees	-90,90	10**-7
roll)	position angle	decimal	degrees	0-360	10**-7
_TICK	first gimp tick for FOS use	integer	ticks	0-120 (default=0)	2 tick
_COMPDUR	duration range of computation	integer	seconds	0-1800 (default=1800)	30 sec
ENABLE	enable gimp computation in NSSC1	n/a	n/a	n/a	n/a
TIME	reference time for table load and computation start	time	UTC	n/a	n/a

Determination of YFGIMPCB table load time:

Let time on FOSGIMP data block = T
and next MFP + 25 sec = L1
and next MFP - 5 sec = L2
and next MFP - 35 sec = L3
Choose either L1, L2, or L3 for the table load time, use the one which is > T and nearest in value.

Determination of PASS computation start time:

Take the table load time calculated above and add 8 seconds.

Determination of GIMP function enable table load time:

Take the table load time calculated above and add 1 second.

Option 2

In this option, PASS would load one table in response to the new data block FOSGIMP, YFGIMPCB (as described above). By having PASS load only one table the maximum time to setup the gimp correction would be about 95 seconds. This additional overhead would have to be added to every FOS exposure.

```
FOSGIMP, _OPMODE(ACCUM1,IMAGE1,ACCUM2,IMAGE2)
       , _ORIENT(decimal,decimal,decimal)
       [, _TICK(integer)]
       [, _COMPDUR(integer)]
       , TIME = time ;
```

keyword	description	type	units	range	resolution
_OPMODE	data acquisition mode	mnemonic	ACCUM1|IMAGE1|ACCUM2|IMAGE2		
_ORIENT	ST position				
(ra,	right ascension	decimal	degrees	0-360	10**-7
dec,	declination	decimal	degrees	-90,90	10**-7

roll)	position angle	decimal	degrees	0-360	10**-7
_TICK	first gimp tick for FOS use	integer	ticks	0-120 (default=0)	2 tick
_COMPDUR	duration range of computation	integer	seconds	0-1800 (default=1800)	30 sec
TIME	table load time (would be MFsynced)	time	UTC	n/a	n/a

Determination of YFGIMPCB table load time:

Equals the FOSGIMP data block time

Determination of PASS computation start time:

Take the table load time calculated above and add 8 seconds.