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TITLE: WFPC and the Take-Data Flag

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ABSTRACT

The WFPC microprocessor Application Program AP-17 controls the shutter during long (>300 seconds) exposures. Usually the program is passive, but when the spacecraft take-data flag falls, AP-17 will close the shutter. This report examines the telemetry data associated with an exposure which was while the take-data flag changed state. AP-17 affects total exposure time and shutter blade parity. The latter effect is important for preflash calibration.

A. Introduction.

On Day 237 there were two sequences of five exposures each scheduled for WFPC. The first five were 300 seconds each, through filter F368M, the last five were 100 seconds each, through filter F547M. The target was the same for all ten exposures. The WFPC shutter was controlled by the on-board application program, AP17, which closes the shutter when the Take-Data Flag (TDF) falls. The TDF is maintained by the spacecraft DF-224 computer. During exposures of less than 300 seconds duration, WFPC ignores the TDF. Among the conditions which cause the TDF to fall are downgrading of tracking from fine-lock to coarse track or from coarse track to gyros.

The fifth of the 300 seond exposures was underexposed by a factor of two compared to the previous images in the sequence. The Standard Header Packet for the image showed non-zero entries in the shutter closing activity fields, but the numbers were nonsensical (*e.g.*, 0.33295E-08). (Similarly strange numbers were seen early in the mission for such fields as exposure time and duration. The fix to correct the decoding of these fields should be straightforward.)

B. Analysis.

The record of the TDF is available through the OMSAT software tool on IDTVAX on request from the OMS staff. Examination of the TDF for Day 237 gives Timeline 1:

Timeline 1 — TDF Up on Day 237

17:09:10	–	18:00:59
18:44:16	–	19:14:52
19:17:46	–	19:37:04
20:21:59	–	20:51:59

The following lines are from the standard header packets for the problem exposure (W0CE0105) and the exposure immediately preceding it.

Sample portion of standard header packet from preceding exposure:

```
                                  / TIME CONVERSION KEYWORDS
CLKDRFTR=  0.1413348447722E-16 / spacecraft clock drift rate
CLKRATE =  0.1250000005429E+00 / spacecraft clock rate
SPCLINCN=             23541596 / spacecraft clock at UTC0
UTC01   =            356619520 / bytes 5-8 of UTC0
UTC02   =              9664005 / bytes 1-4 of UTC0
WCANLTIM=        0.2620900E-08 / time of cancel operation command
WEXPTMHI=                 1295 / time of major frame pulse preceding exp start
WEXPOCMD=                  565 / expose command image
WEXPODUR=                  300 / desired duration of exposure (sec)
WEXPOTIM=        0.2607600E-08 / time of major frame pulse preceding exposure st
WFCSTAT =                49665 / control/status word for exposure
WFOCTM01=        0.2860800E-08 / time of first close B shutter
WFOCTM02=        0.0000000E+00 / slot for second open B shutter time
WTIMEXPO=        0.2860900E-08 / time of 110 msec expose command
EXPTIME =        0.3000000E+03 / Exposure time in seconds
PSTRTIME= '1990.237:19:09:37 ' / predicted obs. start time (yydddhhmmss)
PSTPTIME= '1990.237:19:21:37 ' / predicted obs. stop time (yydddhhmmss)
PLAN_EXP= 0.300000000000000E+03 / proposed time per exposure
EXPOSURE=        0.3000000E+03 / exposure duration (seconds)--calculated
EXPSTRT =        0.2607600E-08 / exposure start time (seconds)
EXPEND  =        0.2860800E-08 / exposure end time (seconds)
```

Sample portion of standard header packet from the problem exposure:

```
CLKDRFTR=  0.1413348447722E-16 / spacecraft clock drift rate
CLKRATE =  0.1250000005429E+00 / spacecraft clock rate
SPCLINCN=             23541596 / spacecraft clock at UTC0
UTC01   =            356619520 / bytes 5-8 of UTC0
UTC02   =              9664005 / bytes 1-4 of UTC0
WCANLTIM=        0.3196900E-08 / time of cancel operation command
WEXPTMHI=                 1295 / time of major frame pulse preceding exp start
WEXPOCMD=                  565 / expose command image
WEXPODUR=                  300 / desired duration of exposure (sec)
WEXPOTIM=        0.3183600E-08 / time of major frame pulse preceding exposure st
WFCSTAT =                49666 / control/status word for exposure
WFOCTM01=        0.3197200E-08 / time of first close B shutter
WFOCTM02=        0.3317200E-08 / slot for second open B shutter time
WFOCTM03=        0.3436800E-08 / slot for second close B shutter time
WFOCTM04=        0.0000000E+00 / slot for third open B shutter time
WTIMEXPO=        0.3436900E-08 / time of 110 msec expose command
EXPTIME =        0.3000000E+03 / Exposure time in seconds
PSTRTIME= '1990.237:19:21:37 ' / predicted obs. start time (yydddhhmmss)
PSTPTIME= '1990.237:20:29:37 ' / predicted obs. stop time (yydddhhmmss)
PLAN_EXP= 0.300000000000000E+03 / proposed time per exposure
EXPOSURE=        0.3000000E+00 / exposure duration (seconds)--calculated
EXPSTRT =        0.3183600E-08 / exposure start time (seconds)
EXPEND  =        0.3436800E-08 / exposure end time (seconds)
```

Comparison of the two sets of SHP data shows that there were additional shutter activities in the second exposure. Also, the event times are ascending in value when considered in logical sequence, despite the unusual units:

Time	Event
0.31969E-08	Cancel operation command
0.31972E-08	First close shutter
0.33172E-08	Second open shutter
0.34368E-08	Second close shutter

The previous exposure looks like the other normal exposures of the series and each exposure was expected to be 300 seconds in duration. The SHP also tells us that the clock rate is approximately eight ticks per second (see keyword CLKRATE above). This would lead to $300 \times 8 = 2400$ ticks in the normal exposure. The difference in the equation above is

$$0.28608\text{E} - 08 - 0.26076\text{E} - 08 = 253.2\text{E} - 12 = (2400 + 132)\text{E} - 13$$

According to the WFPC Microprocessor Controller Software Guide (JPL), each exposure begins 16.41 seconds after the previous major frame boundary. Now, 16.41 seconds $= 8 \times 16.41 = 131.28$ ticks, therefore the units of the times in the SHP are 1.0E-13 ticks, and the duration of the normal exposure was 300 seconds + 16.41 seconds.

Using this derived scale factor, the shutter timings of the problem exposure can be computed:

$$0.31972\text{E} - 08 - 0.31836\text{E} - 08 = 0.00136\text{E} - 08$$

$$\frac{0.00136\text{E} - 08}{1.0\text{E} - 13} = 17.0 seconds$$

Of the 17.0 seconds, 16.41 were before the shutter opened, leaving 0.59 seconds of exposure time between the time the shutter opened and the time the AP reported having closed the shutter because of the state of the TDF. The next events in the sequence, similarly, give the net exposure time for this image:

$$\frac{0.34368\text{E} - 08 - 0.33172\text{E} - 08}{1.0\text{E} - 13} = 1196 ticks = 149.5 seconds$$

This gives a total exposure time of $0.59 + 149.5 = 150.09$ seconds, of which the first half-second may not have been pointed correctly or steadily.

Examination of the images show many stars in the field of view. The average of the extended register pixels for each image gave bias levels of 378.82 for W0CE0104 and 378.66 for W0CE0105. For several of the stars in the images, 32×32 pixel square areas were summed after bias subtraction. The sums are present in the following table.

Location	Counts in 105	Counts in 104	Ratio
(375, 90)	3056	9203	0.332
(449, 90)	2530	6202	0.408
(414, 174)	5864	14722	0.398
(494, 190)	5859	1566	0.379
(492, 192)	7508	15426	0.487
(493, 188)	6006	15898	0.378
(385, 356)	1511	4824	0.313

Note that these images were not flat fielded nor were particle events removed from the images. The numbers presented above are very coarse and are intended to show only the trend between the two exposures. These numbers are consistent with the net exposure time derived from the SHP analysis. Better than one per cent photometry would be necessary to detect the extra half second of exposure time caused by the TDF being down at the beginning of the exposure. Such precise work cannot be done at this time, but the effect should be remembered when the instrument has been fully calibrated.

In addition, in order to restore the WFPC to its normal state at the end of an exposure, AP-17 generates an exposure command for a 0.110 second exposure which WFPC then executes. This adds a small amount of additional exposure time to the image and it changes the placement of the shutter blades. Since AP-17 has control only over shutter blade B, when it ends an exposure, whether due to TDF activity or to exposure time expiration, the WFPC is left with blade B closed. After the 0.110 second exposure finishes the long exposure, the shutter blades have moved and the WFPC is left with blade A closed.

C. Conclusions.

All of the above discussion leads to some unexpected results. One is that the shutter blades do not alternate parity between long exposures. The preflash of an exposure which follows an exposure controlled by AP-17 will always be a Blade A preflash. Fortunately, this behaviour also makes it somewhat easier to collect Blade A preflash images for use in image correction.

A more important side effect to remember is that even if the TDF is down at the beginning of an exposure, light will be collected on the chips for half a second before the shutter is closed to interrupt the exposure. This may result in offset double exposures of bright objects in the field of view. If TDF-generated interruptions are much more common than were expected before launch, then an additional keyword should be added to the WFPC image header to alert observers that AP-17 was active during the exposure. Such a keyword could be derived by the PODPS pipeline software from the existing SHP parameters.

Finally, the 0.110 second exposure which is appended to long exposures by AP-17 should also be brought to the attention of the observers. While the additional exposure time is not yet significant, it eventually will be. Also, this exposure time is also independent of the state of the TDF and should also be made more visible if it occurs while the TDF is down. Implementation of such a flag in the image header would require that the pipeline examine the SHP keywords which record the times when AP-17 last closed the shutter and when it generated the 0.110 second expose command.

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