COMMANDING FOS TARGET ACQUISITION

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ABSTRACT

The three methods of Mode 2 FOS Target Acquisition; Firmware, Binary Search, and Peak Up are summarized. The event flags that control the interaction between the Applications Processors and the Relative Time Command Sequences, and the command blocks that run the processors are described. The parameters and the default values for the three methods of acquisition are described.

I. INTRODUCTION

The FOS, through the use of Applications Processors (AP), and Real Time Command Sequences (RTCS), has the capability to perform three kinds of target acquisition (TA). These are Firmware, Binary Search, and Peak Up. The basic idea behind these methods is described below, and the event flags, command blocks, and parameter settings are discussed in Section II. Detailed descriptions of Firmware and Binary Search are given in FOS/CAL 027 and 023, respectively, along with default settings for TA parameters.

Firmware TA is a Mode 2 type target acquisition which is internal to the FOS, coded on the FOS microprocessor (the Central Electronics Assembly, or CEA) and run through AP 28. The Firmware was designed and coded by R. Hier and the AP was coded by G. Peters to automatically find a target in the $4''.3 \times 4''.3$ aperture. Firmware does this by mapping the aperture in given x-steps and y-steps, filtering the data, and fitting a centroid to the peak. Firmware aborts if more than one target is found in the aperture within the count window.

Binary Search is a Mode 2 type TA which is run through AP 32. It was designed by H. Ford, and coded by G. Peters and T. Gasaway. It automatically finds a target by mapping the $4''.3 \times 4''.3$ aperture in three y-steps, locating the target in one of the three, and driving the target to the y edge of the diode array. It does this by trying to move the target off the array if it is on, and by trying to move it on if it is off. Each step size is half the size of the previous step, and there is a limit of a maximum of eight steps. Binary Search accepts up to four targets in a y-strip, with up to twelve targets in the whole aperture.

When a high degree of accuracy is needed, the target acquisition must be done together with an aperture acquisition because of the floppiness of the filter grating wheel (FOS-CAL 010). For an aperture acquisition, the camera mirror and science aperture are in place, the entrance port is closed, and the TA LED is turned on. Then a Firmware or a Binary Search acquisition is performed. It differs from a target acquisition only by reversing the sign of the final slew that is requested after the acquisition is finished. This is set the through the parameter YTAINV.

Peak Up and Peak Down are intended for use with the occulting bars. In practice they will probably follow a Firmware or BS target acquisition. Peak Up and Peak Down can be used with different scan patterns. For example, to ensure that a target is positioned behind the occulting bar, a series of dwell scans can be done in the y direction. At each position, data is taken, the total counts are summed, and the time and position of the exposure are recorded. When the dwell scan pattern is completed, Peak Up returns the position at the time of minimum counts, and the telescope is repointed to the corresponding position. This method requires a lot of interaction between the NSSC-1 and the DF-224, and is difficult to test.

II. TARGET ACQUISITION COMMAND BLOCKS

a) Basic Flow

The target acquisition command blocks all work in the same basic fashion. The three different methods described here all require the configuration of the Control Unit and Science Data Formater (CU/SDF), the configuration of the FOS data acquisition parameters and the FOS mechanism positions, and the invocation of an RTCS. The RTCS interacts with the AP via event flags (EF's) to control the actual TA. All of the configuration must be done before dumping the unique data log (UDL) and standard header packet (SHP). However, the order of configuration does not matter as long as it is completed before the UDL and SHP are dumped and the TA RTCS is invoked.

The blocks will in practice be run in a combination of relative time command sequences (RTCS), and absolute time command sequences (ATCS). Some ATCS blocks (see Table 5) have already been translated from the Spacecraft Automated Testing System (SATS) into the Science Planning and Scheduling System of the Science Operations Ground System (SPSS/SOGS). The TA command blocks discussed below were developed for use during aliveness and verification testing (A&V) and are expected to evolve as we move towards flight usage due to restrictions on the use of branching and due to the difference between SATS and SOGS.

The AP's are designed to accomodate branching in case the acquisition does not succeed. This is done by setting the pre-planned branch flag, YPB, or by setting the raster scan parameters, YRSNV, YRSMVS, YXMV0-YXMV7, and YYMV0-YYMV7. These parameters are included in Tables 3 and 4. Based on experience in VAP and A&V there will be limitations on the amount of branching allowed from the standpoint of operations. This is due to scheduling conflicts of shared resources.

Command blocks and examples of their usage are given in the Appendices. Appendix 1 contains a sample RTCS source listing for firmware TA, FWRTCS, followed by the command blocks invoked in the source listing, YTDFC28 and YS28TA. Appendix 2 contains a source listing for binary search TA, BSRTCS and the command blocks invoked in BSRTCS, YS32TA, YTDFC, and YRSEW. Appendix 3 contains the source listing for peak-up, peak-down, PURTCS, and the command block YPKUP.

b) Event Flags

The only control over branching possessed by an RTCS is the mechanism of event waits and event wait timeouts. This mechanism is utilized by the FOS TA AP's to control the execution of the TA related RTCS's and provide for error path processing. Firmware and Binary Search both utilize FOS event flags 4, 6, and 12. Peak Up utilizes event flags 4 and 9. The various modes of TA require that the relevant RTCS clear the event flags at the correct time, and then the AP will set or not set the event flags as appropriate.

EF 4 is set if, on the successful completion of either BS or Firmware TA, a target is not found. EF 6 is set if branching, either in the form of pre-planned branch or raster scan, is allowed when the target is not found. EF 12 is then set if the branch is pre-planned branch and not raster scan.

Firmware requires that FOS event flags 4, 6, and 12 be cleared before invoking the Firmware TA AP. Firmware requires that the TA RTCS reinitiate data acquisition for all steps of the raster scan. The meaning of the EF status at the end of the TA invocation is summarized in Table 1.

Binary Search also requires that FOS event flags 4, 6, and 12 be cleared before invoking the Firmware TA AP. If BS TA initiates raster scanning, then the acquisition of new data occurs automatically and does not need to be explicitely invoked from the RTCS. The meaning of the EF status at the end of the Binary Search TA invocation is summarized in Table 2.

Peak Up utilizes event flags 4 and 9, and requires that they both be cleared before initiating the TA. EF 9 is used to control the looping in block YPKUP which occurs while taking data at each dwell point. For each of the first n-1 steps of a Peak Up, EF 9 and EF 4 are both set. On the last step, if the Peak Up request is sent by the AP, then EF 4 will be set and EF 9 will timeout.

c) Firmware Command Blocks

Firmware can be initiated in two very different ways, as discussed in FOS/CAL 027. We here discuss the commanding of Firmware TA only one of the two ways; by sending the YTA command. The other way; setting the TA bit in the YACQMODE command, has not been written into an RTCS yet. This will hopefully be done and included in a future version of this document.

The Firmware TA is performed in the following steps: 1) The CU/SDF and FOS parameters are set to perform a standard aperture map. The camera mirror is put in place, the desired aperture is selected, and a series of x-steps and y-steps are programmed which will allow the FOS to scan through the desired portion of the image. The UDL and SHP are then dumped. These functions should be done in absolute time. 2) The RTCS command block, which is listed in Appendix 1, is started, causing the FOS to acquire the data, to perform the desired mode of TA, and to invoke AP 28 for translating the results of the TA into a small angle maneuver (SAM).

FWRTCS consists of two blocks, YTDFC28 and YS28TA, which must be enacted in the order they appear in Appendix 1. YTDFC28 chooses between aperture acquisition and target acquisition, and then performs the data acquition. YS28TA loads the variables required to process the data, enables AP 28, and invokes firmware TA on the FOS microprocessor.

YTDFC28 is an example of a block that must be changed for flight usage. Currently, aperture acquisition is done by explicitly turning on the ion gauge to which the LED is attached, and by turning off the ion gauge at the end. In flight, the parameter YTAINV should be passed to YTDFC28, and the ion gauge should be turned on only for YTAINV of 1, or aperture acquisition. In addition, YTDFC28 should command the FOS entrance port to close for YTAINV of 1. In the A&V testing for which these blocks were developed, closing the port was not desired. For YTAINV equal to 0, or target acquisition, the ion gauges should be turned off and the entrance port should be opened. The block shown in Appendix 1 has been modified to meet flight criteria.

The block YS28TA has three parts; parameter setting, control flow, and error recovery. Section [YS28TA,A] sets the software parameters to be used by the AP. A summary of the parameters given in Table 3.

The parameter section of YS28TA is followed by the commands that actually control the execution of the algorithm. First, all event flags and event timeout flags are cleared in section [YS28TA, B]. These flags will be used to control further branching within the RTCS. Then section [YS28TA,C] actually starts AP 28. Since it is a synchronous AP, enabling it for execution will cause the NSSC-1 scheduler to execute it at the proper times. Note that the timing on the command to enable AP 28 is critical, and must be at least 61.0 seconds from the last command to the FOS. Section [YS28TA,D] is the command to the FOS microprocessor which causes the firmware to execute its internal TA routines on the data in its memory. When this internal TA is complete, the values passed to the engineering data stream will cause the AP to take appropriate action.

Finally, section [YS28TA,E] was designed to accomodate the multiple test cases required during A&V testing. The function of this section is to provide for the paths necessary to deal with the success or failure of this TA mode. It also has built into it the logic necessary to perform a dump of filtered data if that is desired. Note that there are global variables used in this section as allowed by SATS. This section may need editing if global variables are not allowed in SOGS as they are in SATS.

d) Binary Search Command Blocks

In Binary Search (BS) the Application Processor uses the FOS microprocessor to acquire data one line at a time. The AP then analyses the line, sets a new Y-Base and acquires another line of data. When the target has been located on the edge of the diode array, a SAM is issued to the Support Systems Module (SSM). If the AP does not place the target on the edge in eight binary search steps, an error path is taken.

The first step in BS, as with Firmware TA, is to set the CU/SDF and FOS data acquisition parameters. In the setup to acquire data, we always specify only one Y-Step, and all data must be transmitted to the NSSC-1 in one line of data per frame. This single line of data must include the science data plus the 64 words of engineering header which precede the science data memory in the FOS microprocessor.

Once all of the data acquisition parameters are specified, an RTCS of the type shown in Appendix 2 (BSRTCS) must be invoked to perform BS TA. The blocks required in BSRTCS are YS32TA, YTDFC and YRSEW. These blocks must all be included and must occur in the order specified.

In block YS32TA all of the necessary parameters are set. Section [YS32TA,A] does the memory loads required by BS. One parameter is not included in Table 2; YSCALE. YSCALE scales the counts by its value to avoid overflow problems. The loading of the value for YSCALE is not currently parameterized since it is believed that we will operate with a fixed value for it. The logic of the block allows defaults to be established by setting parameters equal to 999. However, a value must be supplied for every variable. A summary of the parameters is given in Table 4.

Section [YS32TA,B] loads the parameters for the Peak Up, Peak Down mode of testing (see Section II e). The rest of the block is common to both BS and Peak Up test modes. Section [YS32TA,C] clears all possible event flags required by AP 32 and enables AP 32 for commanding. AP 31 is started up to wait for the first line of science data.

The purpose of YTDFC is threefold; to manipulate the LED's and the entrance port, to set the Take-Data-Flag interlock, and to start the first frame of science data.

For an aperture acquisition, the TA LED's are turned on, and are otherwise turned off. As with YTDFC28, this block has only been used in test situations so it does not ever open the FOS entrance port. Control of the port should probably happen as a complement of the TA LED's. When TA LED's are on for an aperture acquisition, the door should be closed and when the TA LED's are off for target acquisition, the door should be opened. The sample block included in Appendix 2 has been modified to control the FOS entrance port.

The Take-Data-Flag interlock is then set to 0 so that the Housekeeping AP will not set FOS event flag 11. This is very important for recognizing the Take-Data-Flag. The final purpose of block YTDFC is to start the first frame of science data. When the data comes through, AP 31 is activated. AP 31 in turn activates AP 32, which then proceeds as intended.

The last RTCS, YRSEW, is an attempt to provide a structure for error processing. As it stands, the error branch doesn't do anything, but it provides a place where error RTCS blocks could be inserted.

e) Peak Up Command Blocks

The Peak Up works as follows: 1) The parameters are set for the FOS to acquire the data for each dwell point. The data must follow the guidelines for sending data to AP 32; 64 words of engineering data with the remainder of the data fitting with the engineering data in one line of transmitted science data. 2) The software parameters are set for AP 32, including the number of dwell points and the option of Peak Up or Peak Down. 3) The block YPKUP is invoked to perform Peak Up.

The five steps of the actual Peak Up are: 1) Preload the DF-224 with dwell scan parameters. Generally this will consist of two sets of parameters, one for the Peak Up and one for the Peak Down. 2) The block YPKUP checks that the ST is stable and if so, proceeds with the first data acquisition. 3) If the first acquisition is successful, the dwell scan is invoked. A difficulty that arises at this point is that the absolute sequence which called the TA RTCS has to change the DF 224 dwell scan parameter pointer to the dwell scan parameters before a Peak Down is performed. 4) The RTCS then loops in YPKUP while taking each set of new data to be summed. 5) When AP 32 has counted the number of dwell points that had been previously set, it issues a Peak Up request to the appropriate point. The parameters for AP 32 are then reset for the Peak Down and YPKUP is reinvoked using the second set of dwell scan parameters.

Table 1

Firmware Event Flag Settings

EF	4	6	12	Meaning
	0	0	0	TA failed, no moves allowed
	0	0	1	Cannot occur
	0	1	0	Cannot occur
	0	1	1	TA failed, take pre-planned branch
	1	0	0	TA succeeded, no PPB or RS taken
	1	0	1	Cannot occur
	1	1	0	TA failed, RS moves initiated
	1	1	1	Cannot occur

0 means event flag is not set, 1 means event flag is set.

Table 2
Binary Search Event Flag Settings

EF	4	6	12	Meaning
	0	0	0	TA failed, no moves allowed
	0	0	1	Cannot occur
	0	1	0	Raster scan in progress, or RS called but failed to locate target
	0	1	1	TA failed, take pre-planned branch
	1	0	0	TA succeeded, no PPB or RS taken
	1	0	1	Cannot occur
	1	1	0	TA failed, RS initiated with success along the way
	1	1	1	Cannot occur

Table 3

Parameters for Commanding Firmware TA

Parameter	Function
YOFST	Y offset added to computed slew before SAM
YXOFS	X offset added to computed slew before SAM
YTALM*	Number of windowing changes allowed by AP
YPB	Pre-Planned branch flag.
YRSNV	Raster scan permission flag.
YRSMVS	Number of raster scan moves if raster scan permitted. Must be 0 < YRSMVS < 9.
YXMV0-YXMV7	X positions for raster scan moves.
YYMV0-YYMV7	Y positions for raster scan moves.
YTAINV*	TA slew inversion flag. 0 = target accquisition, 1 = aperture acquisition.
YTAMD*	TA mode. See description of Firmware TA algorithm.
YXFW	X filter width.
YYFW	Y filter width.
YNMAX*	Target window upper limit to counts.
YNMIN*	Target window lower limit to counts.
YSKYB*	Sky background count value.
YCASE*	Case number used to construct unique memory labels within the TA RTCS.
YFDDA	Secondary dump address (see YTDFD) used by YSCI DMP command.

Table 3 Continued

Parameter	Function
YTDFD	Dump delay time. Used to allow a secondary dump of Science Data (usually filtered data) to complete before continuing with observation.
YSADDO	Original SD dump address.
YWLO	CEA words per line.
YLFO	CEA lines per frame.

All of the parameters listed can be altered to suit different situations, but those marked with an asterisk are the most likely to require case by case adjustment. There are no defaults specified by the command blocks as the are presently written. Recommended values for the parameters are in FOS-CAL 027.

Table 4

Parameters for Commanding Binary Search TA

Parameter	Function	Default
YPRCD	SD processing code.	1
	1 = Binary Search, 2 = Peak Up, Down	
YMOBSN	Observation number. Word 11 in UDL, 14 in SHP.	0
YNMAX	Maximum peak counts.	65535
YNMIN	Minimum peak counts.	50
YSMTSV	Multiple of the sky variance.	2
YPEAK	Peak maping indicator.	2
	1 = stop after first peak is found,	
	2 = map entire aperture.	
YHWHM	Half width half max.	4
YBRT	Nth brightest star.	1
YPB	Preplanned branch indicator.	2
	1 = available, 2 = not available.	
YSTT	Percentage statistical tolerance.	200
YTLR	Percentage y tolerance.	3
YYBAS	Initial y-base value for FOS CEA.	N/A
YBASKP	Initial y-base value for ap 32 use.	N/A
YOFST	Y-offset value	0
YXOFS	X-offset value	0
YRSNV	Raster scan request status.	3
	2 = permitted, 3 = not permitted	
YRSMVS	Number of raster scan moves.	0
	Must be < 9.	

Table 4 Continued

Parameter	Function	Default
YXMV0-7*	X-move positions for raster scan.	0
YYMV0-7*	Y-move positions for raster scan.	0
YTAINV	Invert TA slew request.	0
	0 = target acquisition	
	1 = aperture acquisition	
YDWLS	Number of dwell points in dwell scan.	8
YUPDN	Direction of peakup.	1
	1 = Peak Up, 2 = Peak Down	

Any 16-bit two's-complement value is valid for the parameters marked with an asterisk.

Table 5

ATCS's Already Translated to SOGS

ATCS	Function
YAPER	Selects the FOS aperture desired.
YSSDFMT	Sets CU/SDF parameters including whether to
	route the data to the SSM or the NSSC-1.
	Also sets FOS internal (CEA) W/L and L/F.
YSPTRNS	Establishes the FOS internal parameters
	for data acquisition.
YSUDL	Invokes an RTCS to dump an FOS UDL and SHP.