AXAF
Science Center

MEMORANDUM

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To: Distribution

From: M. Juda

Subject: HRC Time Tagging

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1 Introduction

This memo addresses how to time tag the different types of HRC data that appear in AXAF telemetry. The HRC data format is fairly simple when compared to ACIS data formats but it still consists of data sampled both synchronously and asynchronously and at a variety of different rates. Some of the HRC data, instrument health and status, will appear in "Engineering" portions of the telemetry. AXAF telemetry format 1 is the HRC observing mode telemetry in which the HRC places event data, rate data, and housekeeping data in the 24-kbps "Science" portions of the telemetry; each type of data goes in a well defined location within the telemetry major frame. AXAF telemetry format 2 has the HRC operating in net-in-line (NIL) telemetry format. In this format the HRC science telemetry appears in the "Engineering" portion at a reduced rate of 0.5-kbps. Each of the the data items will receive a time tag based on its location within the telemetry and, for the event data, additional time-tagging information supplied by the HRC.

2 "Engineering" Data

There are several HRC instrument health and status data items that appear in the "Engineering" portion of the telemetry. Sampling frequencies vary depending on the type of data. Primary bus voltage and current values and analog versions of the event and shield rates are sampled four times per major frame. Secondary supply voltages and instrument configuration status bits are sampled twice per major frame. Temperatures are sampled once per major frame. The location of these data within the telemetry major frame are determined by TRW and should be obtained from the AXAF IP&CL.

All samples of a given item appear evenly spaced within the telemetry. In other words, since the duration of a major frame, $\tau_{\rm MF}$, is 32.8 s, items sampled once per major frame appear every 32.8 s, those sampled twice appear every 16.4 s, and those sampled four times per major frame appear every 8.2 s. However, the samples are distributed through the major frame so that the corresponding sample times between two items sampled at the same rate are not identical. We will adopt the convention for time tagging the HRC instrument health and status items of using the time of the start of the major frame (or fraction thereof) as the time tag for all of these items. If $T_{\rm MF}$ is the time of the start of the major frame, v_i is the i-th sample of a given datum within the major frame from a total of N $(0 \le i \le N-1)$, then the time tag for the sample, T_{v_i}, is given by:

$$T_{v_i} = T_{\rm MF} + i\frac{\tau_{\rm MF}}{N}.$$

3 "Science" Data

When the HRC has the observing mode telemetry allocation, telemetry format 1, the 24-kbps "Science" portion of the telemetry contains the HRC's serial digital telemetry. The repeat cycle for the serial digital telemetry is faster than the major frame rate; I will refer to these sub-frames as science frames. There are 16 science frames per major frame. This telemetry consists of three different types of data: event, rate, and housekeeping. Below are the conventions for time tagging each of these data types.

3.1 Housekeeping Data

All housekeeping data is sampled once per science frame (16 times per major frame). These samples all appear within a contiguous set of words within the telemetry. The same algorithm for time tagging these items will be used as described above for time tagging the instrument health and status data; we will time tag all housekeeping data with the time of the start of the science frame. The time tag, T_{h_i}, for the i-th occurrence of a housekeeping item within a major frame is given by:

$$T_{h_i} = T_{\rm MF} + i\frac{\tau_{\rm MF}}{16},$$

where $T_{\rm MF}$ is the time of the start of the major frame and i is the science frame number $(0 \le i \le 15)$.

3.2 Rate Data

There are two samples of the rate data in every science frame; they correspond to the rates from the first and second half of the previous science frame. If $T_{r_{ij}}$ is the j-th sample ($j = 0$ or 1) from the i-th science frame within a major frame and $T_{\rm MF}$ is the time of the start of the major frame, then the time tag is given by:

$$T_{r_{ij}} = T_{\rm MF} + i\frac{\tau_{\rm MF}}{16} + (j-2)\frac{\frac{\tau_{\rm MF}}{16}}{2}.$$

3.3 Event Data

The times of individual events are asynchronous with telemetry, so the HRC supplies a hardware generated event time tag. This time tagging information is generated with respect to the start of the science frame in which the event occurred (note that this is not necessarily the same science frame in which the event data appears). The hardware generated tag consists of the number of "clock ticks" since the start of the science frame until the event occurred and the three least significant bits of the number of the science frame in which the event occurred (sub-frame tag). Having only three bits for the sub-frame tag cannot by itself unambiguously label the science frame in which the event occurred; however, this can be achieved by also using the number of the science frame in which the event was telemetered.

If $N_{\rm ticks}$ is the number of clock ticks between the start of the science frame and the event trigger, $\tau_{\rm tick}$ is the size of a clock tick ($\tau_{\rm tick} = 15.625\mu s$), $N_{\rm tag}$ is the sub-frame tag of the event, and i is the number of the science frame in which the event was telemetered, then the event time tag, $T_{\rm evt}$ is given by:

$$T_{\rm evt} = T_{\rm MF} + i_{\rm sf}\frac{\tau_{\rm MF}}{16} + N_{\rm ticks}\tau_{\rm tick}.$$

In this expression, the quantity $i_{\rm sf}$ is determined from $N_{\rm tag}$ and i by defining a new variable, n, that is equal to the three least significant bits of i, then

$$i_{\rm sf} = \begin{cases} i - (n - N_{\rm tag}) & \text{for } N_{\rm tag} \le n \\ i - ((n+8) - N_{\rm tag}) & \text{for } N_{\rm tag} > n \end{cases}$$

Note that the quantity $i_{\rm sf}$ can be negative as is necessary to cover the case when the event occurs in the major frame prior to the one in which it is telemetered.

4 Next-In-Line Data (NIL)

When the HRC is in NIL-mode, the serial digital data that appeared in the 24-kbps "Science" portion during observing mode telemetry is put into a special section of the "Engineering" portion of telemetry with sampling at a reduced rate. The repeat rate of the serial digital data is changed from the science frame rate to the major frame rate.

4.1 NIL Housekeeping Data

Housekeeping data will be sampled once per major frame and can be time tagged with the time of the start of the major frame in which they appear. Using the symbols from the housekeeping data section above:

$$T_{h_i} = T_{\rm MF}.$$

4.2 NIL Rate Data

The two samples of rate data correspond to the rates within the first and second half of the previous major frame. Expressed in the terms from the rate data section above, we have

$$T_{r_{ij}} = T_{\mathrm{MF}} + (j-2)\frac{\tau_{\mathrm{MF}}}{2}.$$

4.3 NIL Event Data

The actual time tag that is supplied by the HRC for each event is identical in both the observing and NIL modes. The event clock tick counter is reset at the start of each new science frame and the sub-frame counter is reset at the start of each new major frame. Unfortunately, there will be an ambiguity in the time tag because the sub-frame counter rolls over within the major frame and the HRC's FIFO buffer can hold enough events to span more than one major frame's capacity to telemeter events. We currently should implement the same algorithm for both observing and NIL mode event time tagging. More sophisticated means will have to be developed if we wish to attempt to recover better time tags for the event data in NIL mode.