A Brief Description of the FES

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Several of our IUE Guest Observers have expressed interest in the characteristics of the Fine Error Sensor (FES) which IUE uses for target acquisition. In this brief article, some of the salient features of the two FESs are summarized.

There are two FESs, of which #2 has been used almost exclusively since launch. Both FESs can view the aperture plate through a beam splitter, which sends 70 percent of the light to FES #2 and 30 percent to FES #1. FES #1 is normally turned off, but in principle could be used at the same time as FES #2. Currently the primary function of FES #1 is as a backup to #2, but both FESs may be needed for target acquisition with the one-gyro backup attitude control system.

The FES sensor consists of an ITT image dissector tube with an S-20 photocathode. FES counts, which are essentially photon counts, are recorded for the light passing through the FES aperture. This aperture, which is 12.57 arcsec by 12.57 arcsec square, can be deflected around in the field of view either in a raster-scan pattern or in a center-of-light tracking pattern.

The FES is normally used in three different modes.

o For the first mode, known as camera mode, the FES raster scans a field of view to permit the construction of a visual image of a star field. For each step in the raster scan the aperture is displaced by 8.64 arcsec, producing an image with roughly 9 arcsec resolution.

The nominal FES image size is 11 arcmin by 11 arcmin, but images as large as 15 arcmin by 15 arcmin or images as small as 1 arcmin by 1 arcmin are sometimes obtained. If the telemetry rate is reduced, the FES will dwell longer at each location resulting in a "deeper" image. Small, deep images known as "postage stamps" can be used to assist in identifying faint targets but the images have only the crude 9 arcsec resolution.

o In the second mode, known as primary mode, the FES tracks on the center of light of an object. This mode is frequently used for target acquisition and offset guiding.

FES tracking can be performed in several variations according to the brightness of the object to be tracked. In the overlap mode, the FES aperture is deflected in a plus-sign pattern in which the center of the aperture is displaced 5.4 arcsec from the origin. The aperture positions overlap at the origin, nominally the center of light, thus the name "overlap mode". To track fainter stars, the dwell time at each point can be increased by a factor of 4 from 48 msec ("fast track") at each point in the plus-sign pattern to 192 msec ("slow track") per point. Bright stars (brighter than about 4.5 mag) cause the FES to saturate in fast track, overlap mode. Thus a different mode, known as "underlap mode", is used. In underlap mode, the FES aperture is deflected in a plus-sign pattern which is displaced by 15.66 arcsec from the origin. In this instance the FES tracks not on the image of the star but on the halo of scattered light around the star. In recent years, it was found that the scattered light is asymmetric. Because of this the FES finds a center of light in underlap mode which is as much as 1 arcsec displaced from the actual center of light. This effect is important and must be corrected for if very accurate centering is required. This offset is generally not taken into account for routine exposures of bright stars taken through the large aperture.

The underlap and overlap tracking modes are depicted in Figure 1. This figure is taken from an internal IUE document, "IUE Fine Error Sensor Operations Manual" (IUE-670-76-97).

o In the third mode, known as search and track, the FES scans until it picks up sufficient light, then tracks on the object. This mode is often used to acquire bright stars for which the identification does not require inspection of an FES image.

The wavelength sensitivity curves of the two FESs were measured by Ball Brothers Research Corporation (now Ball Aerospace) during the acceptance testing of the devices. These results are given below (previously published in an early FES article by Holm and Crabb, 1979) and are plotted in Figure 2.

Table 1
FES Sensitivity Curves

	FES #2		FES #1	
Wavelength	Sens.	Rel. Sens.	Sens.	Rel. Sens.
4080 A	43.15	0.76	48.80	0.67
4550	56.74	1.00	66.20	0.91
5130	48.63	0.86	72.45	1.00
5530	40.14	0.71	71.06	0.98
6130	31.26	0.55	55.57	0.77
6530	26.10	0.46	43.88	0.61
6940	22.67	0.40	36.22	0.50
7190	19.88	0.35	30.73	0.42
7920	12.00	0.21	18.48	0.26
8880	1.64	0.03	1.34	0.02

The sensitivity figures given here are in units of microamps/watt. According to these test results FES #1 was apparently more sensitive than FES #2 by 27 percent. (FES #2 is known to have lost some sensitivity over the years; changes to the sensitivity of FES #1 over time are unknown at this time.) FES #1 also has a redder response than FES #2.

The broad bandpass of each FES means that the effective wavelength of the FES varies greatly depending on the color of the source. A simple calculation based on black-body curves indicates that the effective wavelength of the FES can vary from 5100 A for a 20,000 K black body, 5300 A for 9,000 K, 5500 A for 6,000 K, to 6400 A for 3000 K. This is the basis of the complex correction term for color between FES magnitudes to V magnitudes (Imhoff and Wasatonic, 1986).

References:

A. Holm and W. Crabb, 1979, NASA IUE Newsletter No. 7, pg. 40.

C. L. Imhoff and R. Wasatonic, 1986, NASA IUE Newsletter No. 29, pg. 45.

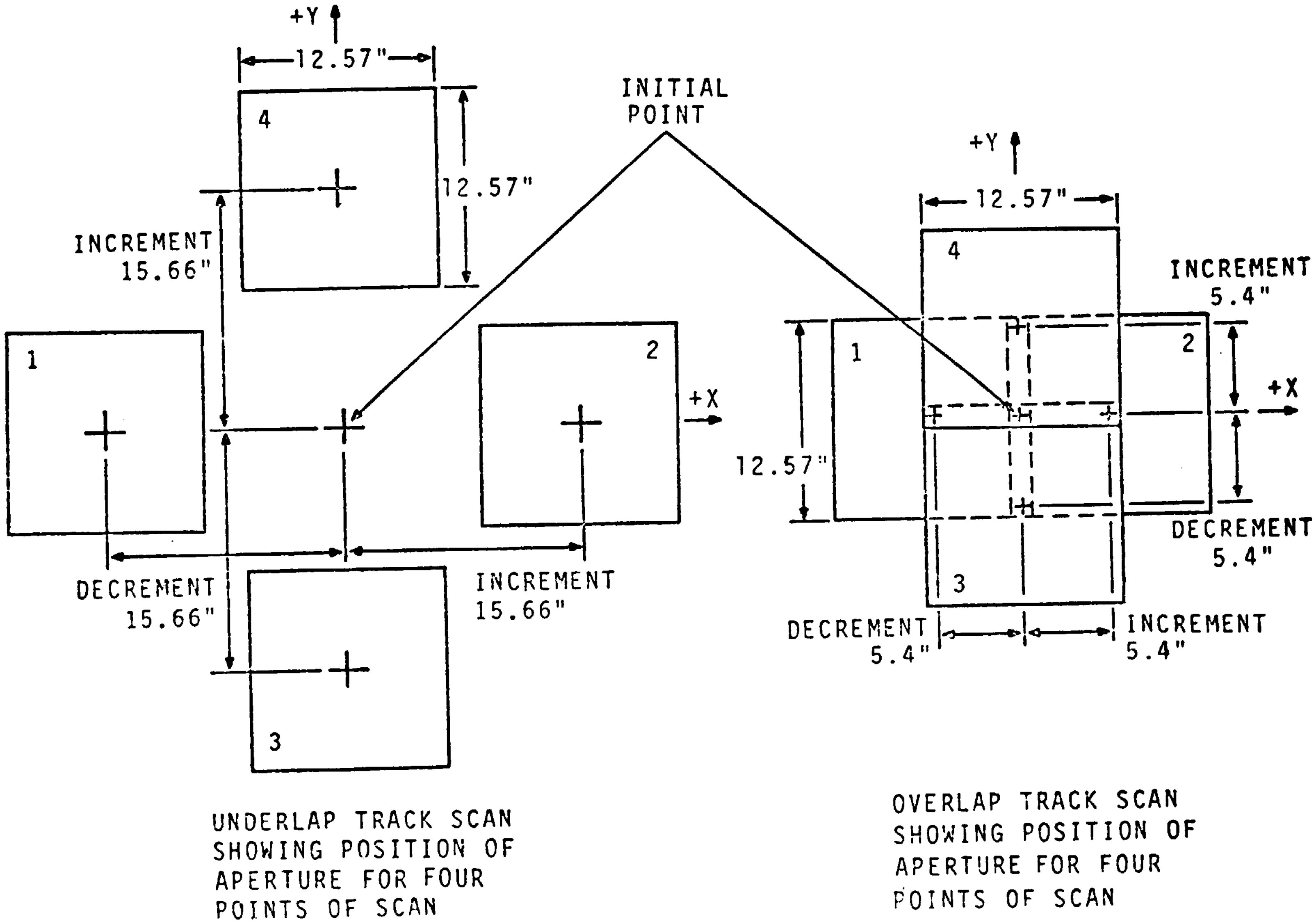

Figure 1. FES tracking patterns. Both the underlap and overlap tracking modes are depicted.

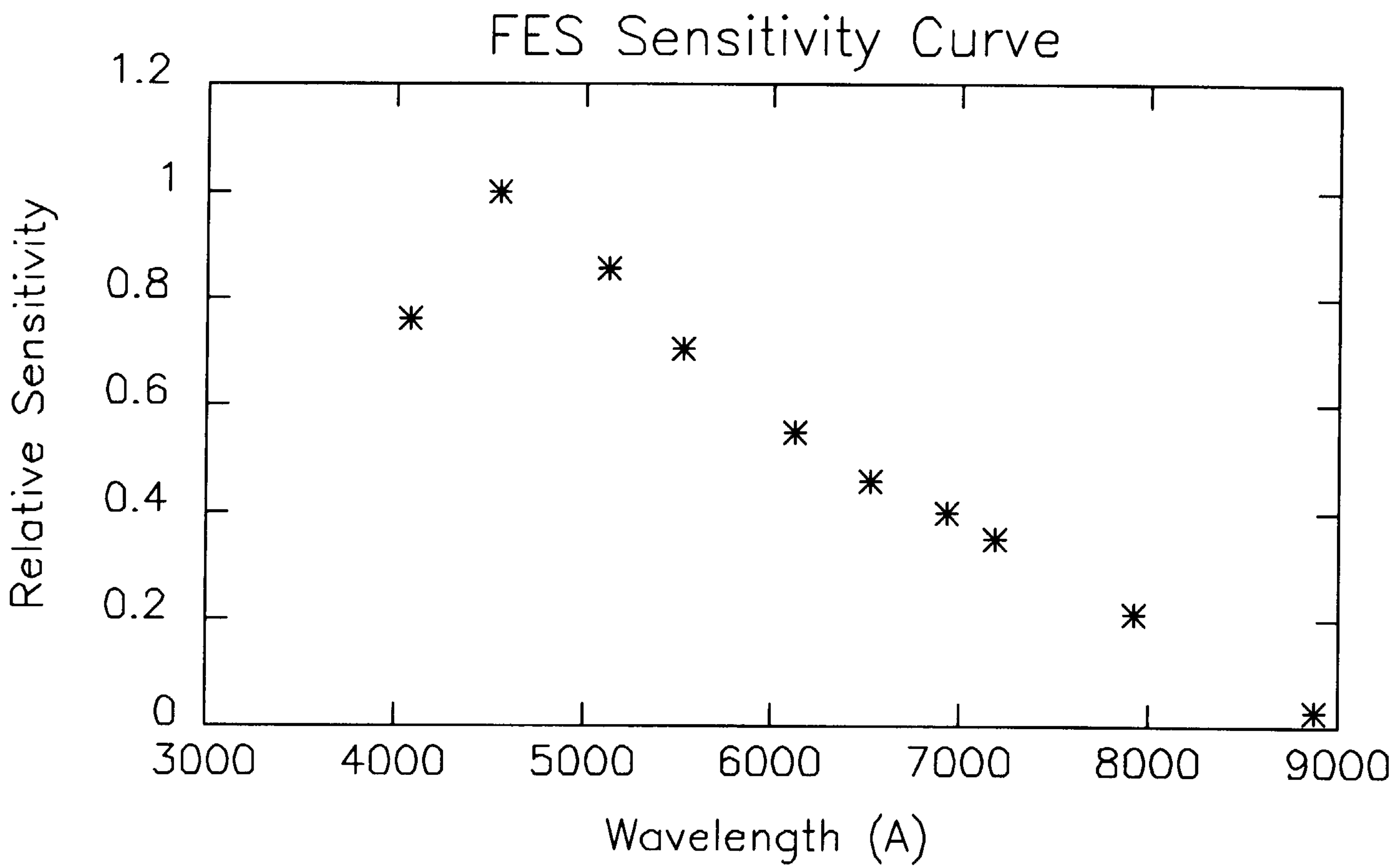

Figure 2. Relative sensitivity curve for FES #2.