XVIII. Implementation of New Low Dispersion Software: Summary of Output Format Changes

The new low dispersion IUESIPS software (PHOTOM, SPECLO, POSTLO) which has been described in general in previous memos of this series (IUE DATA REDUCTION VI, VIII, IX, X) has been evaluated in testing and is scheduled to be implemented in standard production at the same time both at GSFC and by the Europeans. (The high dispersion reduction is unchanged at this time). Details of the low dispersion evaluation will be presented in a subsequent memo; here we provide a brief summary of the changes in the format of the output products associated with the new software. Particular attention should be paid to the increased record lengths of extracted-spectrum files on Guest Observer tapes (item 5 below). This expanded record size accommodates the increased number of spectrum samples produced by the new software in order to realize the full resolution capabilities of the instrument.

1. There is no geometrically corrected image produced with the new software. Instead, a photometrically corrected image is produced in the original distorted readout frame of reference. The geometric distortion in the detectors is accounted for implicitly by using the reseau grid to locate the position in the raw (distorted) image for photometric correction or extraction. This procedure avoids the smoothing of the non-linear raw images in the GEOM step of the old software. However, the fluxes in the line-by-line file still define a geometrically corrected image in the region of low dispersion spectra. The second frame of the reduced Photowrite film sheets showing the superposed dispersion overlay after spectral registration is a raw image.

2. The photometric correction is performed on a pixel in the raw image by spatially interpolating within the existing Intensity Transfer Function (ITF) at the appropriate point. The low dispersion correction is done only within a band parallel to the dispersion, centered between the large and small aperture. In both SWP and LWR, this band is 160 pixels wide.

Pixels outside of this band are left unchanged (raw DN), as is evident on the third frame of the reduced Photowrite film sheets. The new adopted nomenclature for the photometrically corrected image is PI (old nomenclature was GPI).

3. The coding of the halfword pixel values in the photometrically corrected image file (PI) has been changed to accommodate a more extensive flagging system for exceptional pixels. The price paid for this additional flagging is a more complex relationship between true pixel flux number FN and the coded value in the PI file, F_{image}. This relationship is defined by Table 1. The notation [x] means the largest integer less than or equal to x.

Table 1 - Coding of Pixel Values F_{image} in PI File

Range of F_{image}	Condition	Functional Relationship	Inverse Relationship
$-32767 \leq F_{image} \leq -2049$	Saturation (DN=255) or excessive extrapolation of ITF	$F_{image} = -[FN/2+0.5]$	$FN = -2xF_{image}$
$-2048 \leq F_{image} < 0$	Extrapolation of upper end of ITF up to FN=65536	$F_{image} = -[FN/32+0.5]$	$FN = -32xF_{image}$
$0 \leq F_{image} \leq 255$	No photometric correction (Raw DN outside of band)	$F_{image} = DN$	$DN = F_{image}$
$256 \leq F_{image} < 32767$	Normal Interpolation of ITF Up to FN = 61534 or Extrapolation to negative FN Down to FN=-3488	$F_{image} = [FN/2+2000+0.5]$	$FN = 2x(F_{image}-2000)$

The coding system used is such that the range of F_{image} values is itself used to flag the special cases of extrapolation, saturation, and no photometric correction. FN values are recovered from the coded F_{image} values by the inverse relationships listed in the last column of Table 1. The ITF extrapolation procedure employed is the same as that discussed in IUE DATA REDUCTION XIII, with the following exceptions:

a) Saturated pixels (DN=255) are no longer set to 32767, but rather an FN is obtained by extrapolation, up to the limit of 65534, in the same way as extrapolated values for other DN are computed.

b) Extrapolated FN are no longer limited to 32767 as under the old software. FN extrapolated up to 65536 are flagged as normal extrapolations. FN extrapolated beyond this chosen cutoff (corresponding to $F_{image} = -2048$) are flagged in the same way as saturated pixels with FN = 65534 ($F_{image} = -32767$).

4. There is no longer an image segment file (old name: GPIS) written to the Guest Observer tape. This information was redundant with the flux values in the line-by-line spectrum and hence is omitted.

5. The extracted spectrum files (line-by-line and merged spectra) have an increased data record length of 2048 bytes, accommodating a total of 1022 points per order. Otherwise, the spectral data records are in the same format as before. The scale-factor (record zero) has an expanded format defined by Table 2. Neither the location nor the meaning of any of the old quantities has been changed.

6. The merged spectrum file denoted MELO (old name: ESLO) is now derived directly from a summation at the correct omega angle of fluxes in the line-by-line spectrum LBLS (old name: ESSR). The angle omega is defined in the document "International Ultarviolet Explorer Image Processing Information Manual, Version 1.0," CSC/TM-79/6301, section 6.2.2, and has the values given in Table 3 for the new software.

Table 3 - Omega Angles (Low Dispersion)

	Small Aperture	Large Aperture		
		Point Source	Extended Source	Trailed Source
SWP	92°.5	81°	81°	90°
LWR	83°	97°	97°	90°

Under the old software, all omega angles were 90°. Note that in the new software a distinction is made (in terms of omega angle) between a large aperture extended source reduction and a trailed source reduction. For extended source, omega is along the major axis of the large aperture; for trailed source, omega is along the trailing axis (perpendicular to dispersion). Small aperture omegas are not affected by the choice of large aperture reduction mode.

7. The background is processed by a median filter of width 63 before a double mean filter of width 31 is applied. This effectively removes small-scale artifacts from the background (see IUE DATA REDUCTION X). Reseaux presence is the background spectrum is no longer carried through to the net spectrum (i.e. there is no $\varepsilon = -400$ any more; see below) because of the median filtering and also because the background is not extracted at reseau positions at all. The new data quality flags (epsilons) are defined in Table 4. Note that epsilon is no longer the sum of a positive term, and a negative term for special conditions, as in the old software. Also, note that if more than one of the negative-epsilon conditions occurs, the most negative flag is used.

Table 4 - Data Quality Flags (Epsilons)

Epsilon	Condition
100	No special conditions
-200	Extrapolated ITF
-300	Bright Spot*
-800	Reseau in spectral extraction region
-1600	Saturated pixel or maximum ITF extrapolation
-3200	Pixel outside target ring (line-by-line file only)

*Feature to be implemented in the future, to flag the bright-pixel artifacts of radiation hits.

9. For double-aperture spectra, the order of small and large aperture extractions has been interchanged to put large aperture first. The double-aperture file structure is now

1. RI
2. PI
3. LBLS (large aperture)
4. MELO (" ")
5. LBLS (small aperture)
6. MELO (" ")

All of the information contained herein, along with further details of the new extraction procedure, will be incorporated into an updated version of the IUE Image Processing Information Manual. The present summary is designed simply to flag changes in the number or format of output products.

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TABLE 2

FORMAT OF RECORD ZERO
(scale factor record)

HALFWORD	(Integer*2)	QUANTITY
1	*	Zero (for Record #0)
2	*	Number of points in Record (1022)
3	*	Minimum Wavelength (nearest Å)
4	*	Maximum Wavelength
5	*	Number of orders present
6	*	Camera Number
7	*	Image Number
8	*	Number of records per group (i.e. per order)
9		Year
10		Day Number } - of Midpoint of
11		Hour } Observation (GMT)
12		Min
13-16		Date as above for Time of Image Processing (GMT)
17		Target Aperture (1-large, 2-small)
18		Line shift (pixels x 1000)
19		Sample shift (pixels x 1000)
20		THDA X10 (°C)
21	*	Minimum FN for Gross
22	*	Maximum FN for Gross
23	*	J for gross } where actual $FN_{\bar{\bar{K}}}$ data
24	*	K for gross } on Tape x J x 2^{-K}
25-28	*	as in 21-24 for Background
29-32	*	as in 21-24 for Net
33-36	*	as in 21-24 for Absolute Net
37-41	*	Spares
42-44		Min, Sec, ms of exp in Target Aperture (not implemented)
45		Hours } - Right Ascension
46		Minutes } of Target
47		Seconds x 10
48		Degrees }
49		Arc Minute } - Declination of Target
50		Arc Second
51-53	**	$VX_{sun}, VY_{sun}, VZ_{sun}$ - Velocity of earth in celestial coordinates (km/s x 10)
54-56	**	$VX_{sat}, VY_{sat}, VZ_{sat}$ - same as 51-53 for IUE at Mid-point of Exposure
57	**	Net velocity toward target (km/s x 10)

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* Existing Quantity

** High Dispersion Only

TABLE 2

FORMAT OF RECORD ZERO
(continued)

HALFWORD (Integer*2)	QUANTITY
58	Omega angle (degrees x 10)-(zero in High-Dispersion)
59	Wavelength Scaling Factor (= 5 for Low Dispersion, = 500 for High Dispersion) where actual λ = (λ on tape)/(Scale Factor)+ λ_0
60	Background Slit Height } - Low Dispersion only in units of pixels x 100
61	Background distance from dispersion line } - Low Dispersion only in units of pixels x 100
62	0 = No shift of dispersion constants, 1 = auto shift, 2 = manual shift
63-102*	Spares
103-202*	λ_0, offset wavelengths for each order
203-302*	m, order number for each order
303-402*	Number of extracted data points in each order
403-502*	Slit height for each extracted order (pixels*100)
503	Sign + First 4 digits after decimal of Dispersion constant A1
504	Sign + Second set of 4 digits after Decimal of Dispersion constant A1
505	Sign + Third 4 digits after decimal of Dispersion constant A1
506	Exponent (including Sign) of Dispersion constant A1 where: A1 = [word(503)x10^{-4} + word(504)x10^{-8} + word(505)x10^{-12}]x10** (word(506))
507-510	As above, for dispersion constant A2
511-538	As above, for dispersion constants A3 through A9
539-574	As above, for dispersion constants B1 through B9
575-1024	Spares