Final Archive Definition Committee Reports

The IUE Final Archive Definition Committee (FADC) has met regularly since November, 1987 to provide specific technical recommendations and general guidance to the NASA IUE Project for the creation of the IUE Final Archive. This committee is composed of 19 members of the US astronomical community who have shown particular interest in improving the quality of the IUE archive. The members of the committee are:

Jeffrey Linsky, chairman, JILA, University of Colorado
Saul Adelman, The Citadel
Tom Ayres, CASA, University of Colorado
Ralph Bohlin, Space Telescope Science Institute
Ed Brugel, CASA, University of Colorado
Fred Bruhweiler, Catholic University
Reginald Dufour, Rice University
Rick Edelson, GSFC
Nancy Remage Evans, York University
Richard Hackney, Western Kentucky University
Keith Horne, Space Telescope Science Institute
Ed Jenkins, Princeton University*
Charles Joseph, University of Wisconsin
Anne Kinney, Space Telescope Science Institute
David Leckrone, GSFC
John Mathis, University of Wisconsin*
Don Neill, Space Telescope Science Institute
Richard Shaw, Space Telescope Science Institute
Meg Urry, Space Telescope Science Institute
Michael Van Steenberg, GSFC
Dan Welty, University of Chicago
Lee Anne Willson, Iowa State University*

* Previous member

The members of this committee have made significant contributions to the success of the IUE Final Archive effort. They have supplied technical guidance at every step of the development process, supplied software for use in the reprocessing effort, and individually tested the system to insure the scientific integrity of the developed algorithms. The members of this committee have worked very hard for nearly five years as representatives of the US astronomical community to specify the attributes of the IUE Final Archive that will best satisfy the needs of future researchers while being within the resource constraints of the IUE Project. Thus, the recommendations in the following reports are both scientifically ambitious and responsible. These committee members are to be commended for their efforts in the interest of the entire astronomical community and for the precedence of achievable excellence in consideration of available resources for space mission archives.

The report of the first meeting of the FADC was published in NASA IUE Newsletter #34. The report of the second meeting was published in NASA IUE Newsletter #36. The reports of the third and fourth meetings were published in NASA IUE Newsletter #38. In this issue we present the reports of the fifth through the twelfth meetings, held between April, 1989 and November, 1991.

Reprocessing of SWP low dispersion images for the Final Archive began in April, 1992. At the moment, images are only being processed up to the spectral extraction step, because the remaining functions of the code (extraction, absolute flux calibration and FITS conversion) are not completed. The images will not be archived until the processing steps are completed. The processing algorithms for low dispersion are essentially complete. The high dispersion algorithms are still under development. If members of the IUE community have comments or questions concerning the reprocessing of the data, especially the high dispersion development, they are urged to contact one of the members of the FADC so that their questions and ideas can be given attention by this committee. The next meeting of the FADC is planned for Oct. 26, 1992.

Joy Nichols-Bohlin

REPORT OF THE APRIL 27-28, 1989 MEETING OF THE IUE FINAL ARCHIVES DEFINITION COMMITTEE

1 Introduction

This report contains the recommendations of the IUE Final Archives Definition Committee (originally called the IUE Signal-to-Noise Enhancement Committee), which were developed at its fourth meeting held in Greenbelt, Maryland on April 27-28, 1989. These recommendations for the near-term study on how to create the Final Archives for the IUE mission are meant to modify and supplement those presented in the reports of the earlier meetings held on May 17-18, 1988, September 8-9, 1989, and January 26-27, 1989, and should be read in the context of the earlier reports. This report, like the preceding, addresses three main issues. The first part examines what requirements should govern the creation of the final archive, the second lists the near-term tasks that should be undertaken to learn how to reprocess the data properly and efficiently, and the third defines a sensible implementation plan in terms of the required number of people, computer resources, etc., in order to accomplish these tasks in a timely fashion. The near-time phase of this effort is rapidly coming to a close as definite decisions must be made this fall by NASA and the Three Agencies concerning the procedures for implementing the Final Archives.

2 Part I: REQUIREMENTS FOR THE FINAL IUE ARCHIVES

Previous reports have listed detailed requirements for the Final Archives. What follows are additions and modifications to these requirements.

2.1 The IUE Analysis and Retrieval Center (IUEARC)

The main objective in establishing the final IUE archives is to provide the best possible dataset in a form that is easily accessible and usable by the general astronomical community. We presume that the typical archival user desires reliable fluxes, wavelengths, etc. from the database, but future users typically will not have extensive knowlege of the IUE data or the desire to process the data to obtain usable data products.

Therefore, the Final Archives must contain the highest quality data products and there must be an efficient means to access the data and to perform preliminary quick-look analysis. Without this capability, many users, especially those at small institutions, will not be able easily to use this very important archive. Thus, an essential and necessary element of the IUE Final Archives will the IUE Analysis and Retrieval Center (IUEARC). This facility should be readily accessible to any potential user of IUE archival data, and the IUEARC will be similar to the currently operating IUE RDAFs. The IUEARC will become the IUE site of the Astrophysics Master Directory.

The IUEARC should include an extensive software library written in a language and in a form that can easily be transported to other computers by IUE archival users. It is expected that much of the current RDAF software will be incorporated into this library. If a language other than IDL is selected, extensive translation would be required and would be very costly. This is not being proposed at this time. The software should be well-documented, both internal and external to the programs. This is necessary to facilitate the use by remote users of the IUEARC.

The IUEARC should have the computing resources to support remote users, and it should have terminals or work stations available for guest users who might wish to visit the IUEARC in much the same manner as the current IUE RDAFs.

Because of the large volume of the IUE data, the variety of objects observed, the peculiarities of the SEC-VIDICON detector, several experts must be resident at the IUEARC to assist users for at least a five year period after the end of IUE flight operations. These experts will serve as consultants on the instrumentation, scientific operations, and data reduction and analysis procedures of the IUE.

2.2 Documentation

After the end of IUE flight operations, the IUE expertise will begin to disappear. Most future IUE archival users will have little direct experience with the IUE data and will therefore not know its peculiarities. It is necessary to provide these users with complete documentation describing the processing and use of IUE data. This documentation should cover at least five major areas:

i. Manuals containing a complete and detailed description of the processing of the IUE images.

ii. A comprehensive "Users Guide to the IUE", which should contain a very complete description of the accuracy and uncertainties of fluxes, wavelengths, spacecraft pointing, etc.

iii. Various reference materials, including special IUE data that are relevant to catalogues and calibration standards for fluxes and wavelengths. In addition, catalogues of IUE data should also be available.

iv. Special efforts should be made to provide documentation of IUE data analysis software to all interested astronomers. The IUE Newsletters should be continued as an important source of knowledge concerning the IUE data for archival users. Microfiche copies of all Newsletters should be included in the IUE archival documentation. In addition, a general description of the IUE data analysis software should be published in a refereed journal (e.g., *Publ. Astron. Soc. Pacific*) so that a wider audience would have ready access to this material.

v. The current on-line access to the merged IUE log should be continued so that archival researchers can locate quickly all relevant IUE images for a particular object, or class of objects, or by other selection criteria.

2.3 Accuracy

Preserving and improving the accuracy of the IUE database is a very important goal. An important concern is not to over-correct the data base by destroying the original GO comments or making unwarranted changes. Several suggested changes or improvements to the database are presented below:

i. The original GO comments must be preserved.

ii. Errors in the headers should be corrected. This effort should be started now, since many present users of archival IUE data rely heavy upon this information.

iii. Flag the blind-offsets. Obvious pointing errors are in the present datasets, especially for serendipity exposures where coordinates are entered for the other camera.

iv. Warning flags for possible problems in coordinates and other changes in the database should be flagged to alert the user.

v. Microfiche of all the scripts for images obtained both at GSFC and VILSPA should be available to the user. In cases where the VILSPA original scripts no longer exist, copies of the VILSPA IUE log must suffice. These records are often the final and ultimate source for answering questions about exposure time and intent of GO.

vi. The database should have extended comments to fully describe the reasons for any extraordinary changes made in the database.

A major question is how to present this information to users of the Final Archives. The FADC recommends that that the header information should be the "corrected" file. However, in this file flags should indicate that corrections have been made. If the user wishes to see the original uncorrected header information, the software could display it. This information should be available in the IUE database and in any FITS data tape provided to the user.

2.4 Uniformity

A single photometric and geometric scheme should be applied to all the data. The storage format selected for the final IUE archival data should be one that is best suited to maintain the integrity of the IUE data, and this format should be compatable with the Astrophysics Data System. Since FITS has been chosen by the IAU as the standard for transporting astronomical data, IUE data should be transported to users in this format.

2.5 Modern Media

The support and use of networking should be continued. This has proven to be a very important tool especially to small institutions which have limited computing facilities and support staff to handle IUE data. This is a basic requirement of the IUEARC as discussed above.

The decision as to which medium such as optical disc or another form of data distribution for achival users should be delayed as long as feasible. However, the utilization of the latest technology should be fully explored as a means to distribute large amounts of IUE data in a compact and easily accessible form.

2.6 Photometric Precision and Accuracy

The final IUE dataset should be processed with the most appropriate ITFs and absolute flux calibrations. These data should be of the highest achievable signal-to-noise ratio and have the best available wavelength scale.

2.7 Content of Data Files

The suggested contents of each data file in the Final Archives follows:

i. The raw image.

ii. A photometrically corrected but not geometrically corrected image plus the array of real coordinates for the geometric correction. This is the best possible unresampled image, and may be the one used for optimal extraction. This data product, except for the real position array, is already available from current IUESIPS processing.

iii. A photometrically and geometrically corrected image. This could be an image that is rotated such that the file is analagous to a line-by-line data file, the current ELBL file, for both the low dispersion and high dispersion images. Current tests indicate that rotated images can be created with little difficulty. However, to present the high dispersion data in an approximate rectilinear frame, an additional correction is necessary to compensate for the order splaying introduced by the echelle format, which produces an expansion or foreshortening in the spacing between orders as one moves along the orders from one side of the camera to the other.

iv. An extended line-by-line file for both low and high dispersion data. (If a rotated photometrically and geometrically corrected image can be used, then such a file might replace the conventional line-by-line file.)

v. One or two extracted spectral files. Generally, two extracted spectral files should be provided. One should be generated using the present rectangular extraction slit. The other should be a GEX or similar type extraction with its own calibration. Even though the GEX style extraction should yield a better signal-to-noise ratio, the rectangular slit extraction should be included to maintain continuity with the current database and with what has been presented in the literature.

   These extraction proceedures should be applied to low dispersion data, but it is unlikely that a satisfactory GEX-style procedure for extracting high dispersion data will be developed in time for use during the final processing of the IUE archival data. Therefore, the basic software should be available to do customized extraction of individual orders from rotated high dispersion line-by-line files. This software should be available to the IUEARC users as mentioned above.

   For extended sources, only a rectangular extraction slit should be applied. In very special cases, such as planetary nebulae and their central stars, it might be necessary to provide three extracted spectra; an extended source extraction as is currently done, and two point source extractions, one with a rectangular slit and one with a GEX-style slit.

vi. For high dispersion images, an extracted ripple-corrected (untrimmed) absolutely calibrated net spectrum should be included in the data files. The purpose of this file is to provide a fast quick-look capability to users of IUE high dispersion data without performing any time-consuming extraction procedures as is now the case to obtain calibrated net spectra. It is important to indicate splice points between the spectral orders. If the data remain untrimmed, the user can decide whether to use all the data in the overlap region.

vii. A file containing estimates of errors. This file should include a data quality index with some estimate of the internal r.m.s. error of the data and bad data flags.

3 Part III: RECOMMENDATIONS FOR NEAR-TERM STUDY

Since the last FADC meeting, the Final Archives project staff has made substantial progress in studying improvements to the IUE data processing scheme. Roughly three quarters of the projects outlined in the Report from the January 26-27, 1989 meeting are in progress or have already been completed. How best to process the IUE data for the final archive is now a well-defined and tractable problem, and there remain only a finite set of issues to be studied before the final recommendations are made by the FADC at its October 16-17, 1989 meeting. These issues and the associated tests are outlined below in our latest recommendations for the near-term study. Items flagged with an asterisk must be finished by October 1989; it is desirable that the rest also be completed by then, but we understand that this may not be possible given the limited resources of the IUE project.

The FADC notes that many of the artifacts in the IUE data were first described in the 1977 IUE Camera Users Manual, but the development of software corrections only began in earnest with the project to create a high quality Final Archives.

3.1 Geometric Correction*

A. Generalize the cross-correlation technique to science images.

The NASA IUE project has now demonstrated that cross-correlation techniques work well in aligning UV-flood images, and many specific details of the technique have been ironed out for such cases. The Lund Observatory developed a cross-correlation technique using LWR images, so in principle it should not be difficult to generalize this technique to science images. However, the IUE project must: (1) demonstrate that the technique will work for science images from all three cameras, (2) optimize the matching criteria for science images, (3) define the limits of usefulness (that is, the exposure levels for which cross-correlation will work), and (4) devise a back-up plan for the cases where cross-correlation will not work. As a first step, we suggest cross-correlating UV floods with sky-background exposures, since these will have increased camera structure (artifacts) and increased noise that may reduce the correlation.

B. Improved Reseau Positions

The reseaux are useful for approximate alignment before application of the cross-correlation algorithm, and will presumably be the only fiducials in cases where the cross-correlation technique fails. It is important, therefore, to determine the reseaux positions as accurately as possible. The current FINDRES technique uses a differencing method followed by some parabolic interpolation to the differenced values, and may be introducing errors as large as one or two pixels. It is important to increase this positional accuracy. First, the predicted positions will be more accurate when the model for reseaux motions (as a function of camera temperature and other external variables) is improved. Second, the found reseau positions can probably be improved by optimizing the assumed reseau shape and the fitting algorithm. Spline interpolation between the found resea positions is more accurate than the present interpolation scheme in IUESIPS.

C. Global Geometric Transformation

Other vector shifts can be added directly to those generated by the cross-correlation. We recommend a full rigid gross rotation of the spectrum to an approximately horizontal line-by-line format, followed by compression of the image (by roughly 4%, at most) to correct for splaying caused by the cross-disperser. For high-dispersion spectra this procedure will put the echelle orders into a parallel format. It may also be possible to compensate for the effects of beam-pulling, depending on the results of the beam-pulling tests (see Section II below). The full transformation is the convolution of the individual corrections, and the final result will be a vector field at a small number of fiducial points on a scale fine enough (i.e., finer than the reseaux) to make the alignment accurate.

The final, transformed coordinates of each pixel should be included in the Final Archive. In conjunction with the photometrically-corrected data image, these coordinates provide the best unsampled representation of the data, and are of great utility to the sophisticated user. (It may turn out that optimal spectral extraction routines are best done in the real-coordinate, un-resampled space.)

The Final Archive should also contain a photometrically and geometrically corrected image; i.e. one that has been resampled to integer coordinates. This should be done on $\sim$ 0.7 pixel centers, as is currently done for the low dispersion line-by-line file. High-dispersion images will now be treated in a manner analogous to the low-dispersion images.

D. Estimate of Processing Time

One of the requirements on the Final Archive is that it be produced in a timely manner. Therefore it is important for the IUE project to estimate the processing time required by the new schemes for geometric correction, even if only an upper limit is possible. (We anticipate that algorithms will be accelerated substantially when programmers give this task sufficient attention.)

3.2 Beam-Pulling Study*

The IUE Project had designed a beam-pulling test involving an image with striped background (generated by partial reads) and a superimposed calibration spectrum. This has now (at the time of this report) been done, and the image should be analyzed as soon as possible. In addition, there may be other images that are useful, such as high dispersion spectra of bright late-type stars (which have steep ultraviolet continua). If possible, these tests should be used to quantify the degree of beam-pulling. The questions that must be answered by October are: (1) can the degree of beam-pulling be quantified in a useful way, and (2) can corrections for it be incorporated in the geometric transformation?

3.3 Fourier-Filtering*

It is useful (and easy) to Fourier-filter the UV floods used to construct the ITFs. The IUE project has already demonstrated that 2-, 4-, and possibly 8-point noise can be removed using a two-dimensional Fourier transform. However, this noise may be introduced electronically in the data telemetry stream. Therefore, tests should be made to see if the noise can be removed from the reconstructed telemetry stream with a one-dimensional Fourier transform. The effectiveness of these two methods should be compared; in particular, is the 2-dimensional Fourier peak broader than the 1-dimensional peak, and does removing the noise the latter way produce a cleaner UV flood?

3.4 Wavelength Extraction*

Work on wavelength calibration has been done by the IUE Project staff and by Tom Ayres of the University of Colorado. Before the next meeting of the FADC, they should reach a consensus on the final scheme for wavelength calibration. Should the new functional form of the dispersion relations be used? Should these functions be fitted independently in different zones? (This depends on the identification of "fault lines" over the camera face due to the fiber optic bundles.) Even though some of this will depend on the new processing scheme, much of the calibration ideas can be tested with currently processed data.

3.5 Labelling and Annotation of Data

This is one of the most important, and most labor-intensive tasks in producing the Final Archive. The IUE Project has identified the necessary procedures and has estimated a 2.5-year completion time, assuming 2.75 FTE immediately for the development of the system and 3.25 FTE for the 2.5 year implementation phase. This is clearly a long lead-time item, and should be started/continued immediately.

3.6 Camera Properties

A. Artifacts

Over the years many people have looked at features that appear systematically in IUE images, particularly in long exposures. Such features appear in extracted spectra and can mimic emission lines. We think it is both useful and important to study these artifacts again. Existing sky-background images could be used to answer a few simple questions. How do the strengths of various features vary with exposure time? Do they also depend on the observation date, the camera temperature, or other parameters? A description of the results should be included in the final observer's manual/database, and one-dimensional (along spectrum) and two-dimensional (camera face) representations of the sky background exposures should be made available in the archive.

B. Background in High Dispersion

Spectral extraction in high dispersion is a big problem that is only made worse by our poor understanding of the background. The IUE project reported on the most recent attempt to study the background, which is related to the camera artifacts (but also other things, like scattered light) discussed in the previous section. It is important to continue this work and to be able to provide guidance for the user who wants to obtain reliable fluxes from high-dispersion data.

Chebychev polynomials produce a smoother background with less ripple and are faster to implement than the median filter algorithm currently used for smoothing the interorder background. The FADC recommends that a Chebychev polynomial scheme be implemented for the final archives.

C. The Point-Spread Function

All optimal extraction methods require a thorough understanding of the point-spread function (PSF) of the spectrograph. Previous studies have characterized the PSF as a Gaussian or a skewed Gaussian, but more recent work suggests that it is more complicated. In particular, there are broad, low-intensity wings that contain a few percent of the total flux. Moreover, the variation of Gaussian width along the dispersion direction is not a simple quadratic. With the many well-exposed images (especially calibration stars) now available, one could determine better the PSF and the parameters upon which it depends (e.g. temperature, focus, wavelength, camera, aperture, etc.). The eventual optimal extraction scheme should use this PSF.

D. Noise Model

A natural product of the camera studies outlined above is a noise model, that is the uncertainty (sigma) expected for a pixel based on its position and intensity. This noise model is vital to weighted-slit extraction schemes, and to any proper construction of an error vector for an IUE spectrum. Noise models have been determined by a few groups, but only from the smoothed, line-by-line files, and only for an arbitrary, restricted set of images. Sky background images and/or spectral regions in line-free standard-star images would be ideal. Whether or not the optimal extraction scheme(s) is/are used in producing the final archive, the noise model should be included in the final archive.

3.7 Weighted-Slit Extraction

In principle, the extraction of spectra using a weighted slit derived from the known PSF should improve the signal-to-noise ratio relative to the simple unweighted "boxcar" slit, because one is including information derived from a large number of spectra. In addition, GEX and optimal extraction schemes provide an estimate of the noise, remove cosmic ray events, and give the highest weight to the best exposed pixels. However, recent quantitative tests (reported by Anne Kinney at this meeting) suggest that there is little or no improvement compared to a narrow (5-line) slit. (There may be flux losses, and the centering of the slit is critical for narrow extraction slits, but these are issues that can be solved independently.)

So far, these S/N tests have been limited and fairly random (of necessity); comparable tests of the GEX method (which imposes a known PSF, unlike the Kinney/optimal method) suggest that the S/N can be improved, but general quantitative tests have not yet been done. While the magnitude of the S/N improvement (if any) will change with the new processing scheme (especially with the new ITFs), and with the new PSF information, the present data and software should be sufficient to demonstrate whether or not there is a real improvement in the S/N for extracted spectra. Furthermore, if the PSF includes the broad wings so that flux is properly conserved in the weighted-slit extraction, calibration of the extracted spectrum will not depend on the extraction method (boxcar or weighted-slit). This is highly desirable.

A consensus is emerging for the use of a GEX-like extraction scheme for all low dispersion data since this scheme works well on weakly-exposed spectra and all schemes work well on well-exposed spectra. Although the FADC has previously advocated the development of a GEX/optimal hybrid scheme, no progress was presented at this meeting. The IUE Project should consider developing such a scheme, but the priority for this effort is not high compared to other more pressing tasks.

Given the new proposed data product (the vector of real positions for the pixels in the photometrically-corrected but un-resampled image), it is possible that the optimal extraction should be done on the original image. If so, the PSF and the noise model should also be developed from this file. (Resampling smooths the data, and will affect primarily the noise model.) Centroiding of the spectrum is vital, and the routine must be able to follow [possibly] abrupt changes in the centroid position as the spectrum crosses fiber optic bundle boundaries.

3.8 End-to-End Test of the Prototype System*

As soon as feasible, there should be an end-to-end test of the prototype system. At least one (and preferably a variety of) science images should be processed with the proposed algorithms and with the current IUESIPS. Extracted spectra using both processing schemes should then be compared to answer several questions: (1) What is the quantitative improvement in S/N? (2) Is the spectral resolution improved and by how much? (3) Are the data less smoothed? (4)Is the fixed pattern noise in the extracted spectrum less prominent? (5) Can weak features that are at the limit of the IUE sensitivity using current IUESIPS processing be detected with the new processing?

Several specific tests for the improvement in sensitivity should be made: (1) One could introduce known [small] emission or absorption features into a science image, then measure the success with which the features are detected in the extracted spectra. (2) One could look for weak features in the IUE spectra that were detected in Copernicus data. (3) One could compare weak features in high- and low-dispersion IUE data for the same objects. (4) Spectra of the five IUE standard stars in low dispersion could be compared to the Bohlin supersums of all the data in the archive where the S/N is 50-100.

The tested system (known in the jargon as the "fast prototype") would represent the basic processing scheme. Because of the tight time constraints on production of the archive, there may not be time for major changes in the architecture or algorithms as the final system is coded and tested. Nevertheless, changes should be implemented when (a) they can be implemented with negligible impact on the schedule, or (b) the improvement in accuracy or signal-to-noise is dramatic.

4 PROPOSED IMPLEMENTATION PLAN FOR THE CREATION OF THE IUE FINAL ARCHIVES

The creation of the Final Archives naturally divides into 3 phases.

Phase I—This labor intensive phase should begin immediately, even though the procedures for implementing the Final Archives are not yet established. The tasks in this phase are to correct all headers, scan all scripts, and put all of the IUE images on line. The latter may be accomplished by placing all raw images onto a random access medium such as optical disks. Operator intensive tasks such as manual registrations should be started before the actual processing begins; the processing stage should be accomplished primarily in a "batch" mode with no or very little operator intervention—i.e., all operator tasks for a given image should be completed before processing. This pre-processing activity should be two-thirds complete (i.e., two-thirds of the archive data pre-processed) by the time Phase II begins. Programmers are needed now to design and implement this system, and a scanner should be acquired to digitize the scripts. Then two data techs are needed to scan the scripts and make the necessary modifications.

Phase II—This phase is for the 18 month period beginning after NASA and the Three Agencies decide on the procedures for creating the Final Archives (nominally November 1989 to April 1991). During this phase two RAs and two programmers are needed to recode IUESIPS and then to recalibrate the data. The FADC anticipates that the software environment (MIDAS/IUESIPS) will not change during this period. By the Oct 1989 meeting of the FADC, a complete flow diagram of the total end-to-end reprocessing system should be presented; this should include a status report on each component of the software system and a description of the interface between stages. An estimate of the programming effort (i.e., time) needed to convert the prototype software into a production system for each component is most desireable.

In addition, several tasks may not be complete by October 1989 and should be completed shortly thereafter:

1) Construction of the ITF for the LWP camera and earlier epoch ITFs for all cameras.

2) Characterization of the time, temperature, and exposure-level reseaux motions for the LWR and LWP cameras.

3) A solution to the background artifacts problem.

4) Implementation of the extended NIST line list for wavelength calibrations.

5) Investigation of hybrid extraction schemes and characterization of the point-spread function.

Phase III—This phase will begin nominally in May 1991 and continue for roughly 2 years. While it would be desirable to reprocess the IUE data with requested images being done first, there are the practical problems that the calibration for only one camera may be completed by April 1991 and that the reprocessing would proceed most quickly (and thereby producing the most science) by starting with the most recent images first. The decision as to which images to do first must therefore be revisited.

The FADC recommends that a distributed computer system be adopted with the purchase or lease of machines being done as late as possible so as to acquire the most computing power for the least cost. An evaluation of distributed tasking should be done—different aspects of the IUESIPS processing have different computing requirements; to the extent possible tasks should be isolated and operating on the most appropriate hardware.

The next meeting of the FADC will be October 16–17(+18?), 1989

REPORT OF THE OCTOBER 16-18, 1989 MEETING OF THE FINAL ARCHIVES DEFINITION COMMITTEE

1 Introduction

This Report contains the recommendations of the IUE Final Archives Definition Committee (formerly called the IUE Signal-to-Noise Enhancement Committee), which were developed at its fifth meeting held in Greenbelt, Maryland on October 16-18, 1989. Part I of this Report contains our summary recommendations to the NASA IUE Project, which we are also submitting as input to the meeting of Three Agencies to be held November 15-17, 1989. Part II summarizes the requirements for the IUE Final Archives which have been developed during the previous meetings. Part III describes our recommendations for the development program that should be completed before the reprocessing is started in January 1991.

2 PART I. RECOMMENDATIONS OF THE FINAL ARCHIVES DEFINITION COMMITTEE

The Final Archives Definition Committee RECOMMENDS that the development program described in this Report be completed in time to begin reprocessing of the IUE data in January 1991.

We are extremely pleased with the important work of the Final Archives Development Team, which has convinced us that the new processing scheme can find the fixed pattern reliably in the IUE images to within 0.2 pixels and can use this information to geometrically correct the raw images to match images used in creating the ITFs. Application of the present prototype software to representative IUE images has shown that the extracted spectra of nearly all images processed so far have better signal/noise properties than spectra extracted using IUESIPS, and that coaddition of extracted spectra using the new processing scheme have significantly better signal/noise properties than the coaddition of extracted spectra obtained using IUESIPS. We anticipate that significant additional improvements in extracted spectra will be present when corrections for beam pulling, better extrapolations of the ITFs at high DN values, the implementation of a GEX/Optimal hybrid extraction scheme, and other aspects of the development program are completed.

The timely completion of the development program and commencement of the reprocessing effort are highly desirable to enhance the scientific output of the IUE program and to support the HST program. Since this effort requires the expert personnel who are part of the ongoing IUE program, significant delays in the development effort would raise the possibility of the dissipation of this expertise should the IUE observing program end for any reason. Thus the reprocessing scheme should be completely developed and reprocessing begun while IUE is still an operating spacecraft.

From its inception IUE has been a Three Agency program with all aspects of the program coordinated among the Three Agencies. We look forward to each of the agencies contributing its appropriate share of the remaining development and reprocessing effort.

We understand that the recommended development program will require the timely assignment of a considerable number of FTEs, and urge that this assignment of valuable resources be made so that this program can be completed by January 1991. If, unfortunately, adequate resources are not available to complete the development program in a timely manner, then we RECOMMEND the following stretch out of the program:

1. First delay the development work necessary to reprocess the high resolution images by at most one year in order to begin reprocessing the low resolution images in January 1991. The reprocessing of the high resolution images should be melded into the program when ready.
2. If fewer resources are available, then delay the start of reprocessing of any images. In particular, the mass reprocessing effort should not begin until the absolute flux calibration of at least one camera is ready.

In addition, we do not believe that the scientific case for obtaining a new series of UV-flood images for another SWP ITF is sufficiently strong to divert resources that are needed for the development program.

We suggest that the astronomical community be appraised of the schedule of the reprocessing effort in a timely manner, so that they know when they can propose for reprocessed data under the ADP.

We are concerned that the effort to plan for correcting the headers is presently stalled and urge that manpower be assigned to this task, since correction of the headers is a major task that must be started before any images can be reprocessed.

We urge that the IUE Project begin writing a Project Data Management Plan as soon as possible to guide the Final Archives effort and to insure that the NSSDC will be able to support the program early and fully.

We support the present plans of the Development Team to reprocess 100-200 images within 12 months as a test sample that would be made available to the FADC to verify the new reprocessing scheme.

3 PART II. REQUIREMENTS FOR THE FINAL ARCHIVES

The objective in establishing the IUE Final Archives is to provide the best possible dataset in a form that is easily accessible and usable by the general astronomical community. One should not expect that the typical user in the future will want to or be able to perform extensive or even minimal processing of the data to obtain reliable fluxes, wavelengths, etc. from the database.

To satisfy these basic requirements we need the best available dataset, software to perform basic analysis of the IUE data (much of this software already exists in the current RDAFs), and an efficient means to access and perform preliminary quick-look analysis. Without this capability, many users, especially those at small institutions, will not be able to use this very important database easily. Thus, an essential and necessary element of the final archives is the IUE Analysis and Retrieval Center (IUEARC). This facility should be easily accessible to any potential user of IUE archival data. This system will be, in many ways, similar to the currently operating IUE RDAFs.

3.1 A. The IUE Analysis and Retrieval Center (IUEARC)

The IUEARC should include an extensive software library written in a language and in a form that can be easily adapted on other computers by IUE archival users. It is expected that much of the current RDAF software will be incorporated into this library. If a language other than IDL is chosen, an extensive amount of recoding will be necessary to translate the RDAF software. Software should also include the "building blocks" to do the equivalent of a GEX or optimal extraction of high dispersion data. The software, both internal and external to the programs, should be well-documented to facilitate use of the IUEARC by remote users.

A suitable computer system with the capability of supporting remote users is required to use the extensive software library. In addition, terminals or work stations should be available for guest users who might wish to visit the IUEARC, in much the same manner as the current IUE RDAFs.

Because of the large volume of the IUE data, the variety of objects observed, and the peculiarities of the SEC-VIDICON detector, it is extremely important to have expertise available to IUEARC users for at least a five year period after the end of IUE operations. This person or persons will serve as consultants on scientific operations and instrumentation of the IUE, as well as methods of data reduction.

3.2 B. The Data of the IUE Archives

The basic requirements for the IUE archives are briefly discussed in this section.

1. Completeness

   All data, both NASA and ESA acquired images, must be included in the dataset. Since most users will not care where the images were read down, and since not including all the images could greatly hinder any future study utililizing these data, anything less than a complete dataset would seriously compromise the usefulness of the archives.

2. Documentation

   After the last IUE image has been obtained, the IUE expertise will begin to disappear. Many IUE archival users will then have had little experience dealing with the complexities of the IUE data. Thus, it will be very important to provide these users with the most complete documentation describing the processing and use of IUE data. This documentation should cover at least five major areas.

   i. Manuals containing a complete and detailed description of the image processing of the data.

   ii. A comprehensive "Users Guide to the IUE". This should contain a very complete description of the accuracy and uncertianties of fluxes, wavelengths, spacecraft pointing, etc.

iii. Various reference materials. These should include special IUE data that are relevant to catalogues and calibration standards for fluxes and wavelengths. In addition, catalogues of IUE data should also be available to potential archival users.

iv. Results of studies crucial to understanding the S/N characteristics of the IUE. These include the best possible description of a noise model for data, a study of beam-pulling, and delineation of camera artifacts relevant to both low and high dispersion exposures in the three cameras used on the IUE. (Results of the beam-pulling study, especially if significant S/N improvement can be realized in optimally exposed images, should be incorporated in the adopted data reduction scheme. See Below.)

v. Special efforts should be made to provide timely documentation of software written by archival users to other interested astronomers. This would be an important role for the IUE Newsletter, which should be continued as an important source of knowledge for IUE data for archival users. Thus, microfiche copies should be available as part of the general IUE archival documentation.

vi. The current on-line access to the merged IUE log should be continued. The user,as now, should be able to find quickly all relevant IUE images for a particular object, or class of objects, or for several other selection criteria.

vii. A complete description of the improvements made to the image processing procedures for the IUE Final Archive should be published in a refereed journal.

3. Accuracy

Preserving and improving the accuracy of the IUE database is a very important goal. An important concern is not to "over-correct" the data base by destroying GO comments or make other changes that are not warranted. Several suggested changes or improvements to the database are presented below.

i. Whatever changes are made, the original GO comments are to be preserved.

ii. The headers must be modified to contain accurate information needed for image processing. In addition, the database should contain accurate information in key fields needed for data analysis. This correction effort should be begun before batch reprocessing, since many present users of archival IUE data rely heavily upon this information.

iii. Flag blind-offsets. Obvious pointing errors are in the present dataset. This is a particular problem for serendipity exposures where coordinates are entered for the other camera. There are many exposures involving blind-offsets in which the actual coordinates of the observed object are poorly known, making the observation useless for many archival investigations. Although time-consuming, efforts should be made to correct these coordinates. If this proves unfeasible or too time-consuming, the relevant data, scripts and printout of commands entered into the spacecraft, should be preserved for the final archives.

iv. Warning flags for possible problems in coordinates, etc. as well as other changes in the database should be flagged to alert the user.

v. Scripts for images obtained both at GSFC and VILSPA should be available to the user. They could be either in the form of microfiche or stored as bit-maps of the original scripts.

In cases where the VILSPA original scripts no longer exist, copies of the VILSPA IUE log will have to suffice. Often these records represent the final and ultimate source for answering questions about exposure time and intent of GO.

vi. The database should have extended comments to describe fully the reasons for any other than the most obvious changes in the database.

A major concern is how this information is to be presented to any user of the final IUE archives. From the discussions of the FAD committee meeting in April 1989, it was concluded that the header information initially presented to the user for any requested IUE image should be the "corrected file". However, in this corrected file flags will indicate that corrections have been made. If the user wishes to see the original uncorrected header information, the old values will be stored in the header, such that available software could display the original header information. There need not be two duplicate headers, one being a corrected and the other being the uncorrected version. The only requirement is that the user be able to display the uncorrected version. This information would be available in the IUE database and in any FITS data tape provided to the user.

4. Uniformity

A single photometric and geometric scheme should be applicable to all the data. Any format selected for the final IUE archival data should be one that is best suited to maintain the integrity of the IUE data. Furthermore, it should be, as much as possible, compatable with the Astrophysics Data System. Since the widely used FITS format has been chosen as the magnetic tape distribution standard of the Astrophysics Data System, IUE data will be made availabe to users in this format.

5. Modern Media

The support and use of networking should be continued and is a basic requirement of the IUEARC as discussed above. Networking has proven to be a very important tool especially to small institutions which have limited computing facilities and support staff to handle IUE data.

The Three Agencies should eventually select a modern high-density media such as optical disc for the distribution of data to achival users. The utilization of the latest technology should be explored as a means to distribute large amounts of IUE data in a compact and easily accessible form.

At the same time the IUE archives should be made accessible to institutions both in the U.S. and abroad that might desire data to be distributed in other forms such as floppy disks. This may well be the case for requests from small institutions.

6. Photometric Precision and Accuracy

In the final IUE dataset the most applicable ITF and absolute flux calibrations should be used for each image in a way that produces the highest feasible signal/noise. This will also include the application of the most accurate wavelength scale possible.

7. Content of Core Archive

The data included in the archive will be complete and include all possible images obtained with the IUE. These data will be supplemented with other datasets such as the final ITFs used in the new processing and other useful material.

8. Contents of Data Files

The suggested contents of each of the data files to be provided to the IUE archival user are as follows:

i. The raw image.

ii. A photometrically corrected image.

iii. A vector file representing the sum of the vectors (including rotation, desplaying, thermal shifts, geometrical shifts from cross-correlation, etc.) leading to the final rotated photometrically and geometrically corrected image. It is currently envisioned that each point in the photometrically corrected image (768x768) will have a x-y vector relating it to a point in a rotated geometrically and photometrically corrected image with real x and y values as opposed to integer values of x and y.

iv. A photometrically and geometrically corrected rotated image. This could be an image which is rotated such that the file will be equivalent to a line-by-line data file, the current ELBL file, except that it would be available for both low and high dispersion images.

v. Two extracted spectral files. One extracted spectral file should be generated using the present rectangular extraction slit. The other should be a GEX or GEX/Optimal hybrid extraction with its own absolute flux calibration. Even though the GEX-style extraction should produce much better S/N, the rectangular slit extraction should be included to maintain continuity with the current database and with what has been previously presented in the literature.

These extraction schemes should be applied to both high and low dispersion data. However, it is unlikely that a satisfactory procedure for optimally extracting high dispersion data will be developed in time for the initial implementation in the final processing of the IUE archival data. Also, during the October 1989 meeting of the FAD committee, possible problems with GEX-style extraction schemes surfaced. If at all possible a GEX-style extraction should be provided in a data file. If the method is not available in time, the procedure to perform this extraction should be provided in the software package of the IUE archives and available to IUEARC users.

It is probably desirable to develop a GEX-style extraction for high dispersion data. However, this is more complicated than for low dispersion. We strongly urge that a software package be developed to do customized extraction of individual rotated high dispersion line-by-line files. This software should be available to the IUEARC user as mentioned above.

In the case of extended sources, only a rectangular extraction should be applied.

vi. A file containing estimates of errors. This file should include a data quality index with some estimate of the r.m.s error of the data as well as bad data flags. This file is highly desirable, but may have limited usefulness if systematic errors such as improper background removal in high dispersion data and camera artifacts are not understood. (This is not essential to the archives.)

4 PART III. RECOMMENDATIONS FOR THE DEVELOPMENT PROGRAM

As time goes on, many of the questions raised at past FADC meetings have been answered, and the number of outstanding issues is steadily decreasing. For example, the cross-correlation technique of aligning raw science images with the ITF has been proven and is implementable. This section of the report details the few remaining questions that must be answered before the images can be processed for the final archive. It supersedes previous versions of this report; items were deleted because they were completed or because they were no longer deemed feasible and/or useful. The present list consists of four groups, each prioritized: (A) studies that must be completed before processing can begin, (B) studies that must be completed before processing can be finished, (C) tasks (no further studies needed) that should be implemented or begun immediately, and (D) tasks that must be completed before processing can begin, but that await final decisions on the processing algorithms. Because we believe a timely commencement of the processing is highly desirable, we assume that processing will begin on the low dispersion spectra first, since they require fewer calibrations, but that no spectra will be processed prior to completion of the necessary calibration. This is the principal distinction between categories (A) and (B).

A. Short Term Studies Which Must Be Done Immediately

1. The FASTDR system design.

   The system design for the software to modify the image headers and database must be initiated immediately if production of the Final Archive is to begin in January 1991 as planned.

2. Characterize the exposure-dependent geometric shifts (beam pulling), and explore possibile schemes for incorporating this into the global geometric transformation.

   We strongly urge that the effects of beam pulling be quantified and understood. While the new technique for photometric correction works very well on background data and weakly-exposed spectra, the added shifts due to beam pulling in the spectrum may well reduce the effectiveness of this technique for well-exposed spectra. Therefore, the Development Team should evaluate the beam-pulling test conducted last spring, as well as any other relevant data, to characterize the beam pulling effect. If possible, the shifts should be quantified as a function of intensity (and other possible factors) and incorporated into the general geometric correction.

3. Should the Geometric Correction be Explicit or Implicit?

   In general, the raw science images and the ITFs will be shifted with respect to one another. These shifts can now be identified with high accuracy, but is it preferable (in terms of signal/noise) to resample the ITF to the raw image space, or to resample the science image to the ITF space? This distinction, the question of using explicit versus implicit geometric correction, should be studied and a decision made soon concerning which approach is preferable.

4. Integer Representation of the Geometrically Corrected Data

   We have already recommended that the data products include (a) the raw image, (b) a photometrically-corrected image in raw space, and (c) the geometric transformation information in the form of an array of position vectors for each pixel. We also think it is important to have a representation of the geometrically-corrected, photometrically-corrected image, with integer coordinates. The scheme for converting the real (i.e., decimal) coordinates (of the vector array) to integer could be a resampling (perhaps oversampling) or a more sophisticated remapping, such as a topologic mapping. The latter scheme may have difficulty with high dispersion data, given that the geometric transformation will likely remove the splaying of orders. The possible schemes should be tested and compared.

5. Is The Improvement in the Signal/Noise Ratio due to Smoothing at the Expense of Spectral Resolution?

   One of the fundamental questions we have been asking since the beginning of our investigation into signal/noise is whether improvements in the signal/noise are due to real improvements in the processing or simply to smoothing of the data? The latter would be unacceptable. The Project should investigate, using narrow spectral lines, hits, or artificially introduced spectral features, the loss of spectral resolution caused by the prototype processing. It is imperative that the Project demonstrate that the prototype software is not artifically improving the signal/noise ratio simply by smoothing the data.

6. Removal of 2-, 4-, and 8-point Noise by Fourier Filtering.

   The Project has already demonstrated that the periodic noise (probably of electronic origin) can be removed effectively with a two-dimensional Fourier transform technique. It may be possible, and even more effective, to remove the noise with a one-dimensional FFT. If this is so, it may be feasible to apply this to all the data, science images and ITFs both. If not, and only the two-dimensional filtering is effective, we recommend that this technique be applied only to the ITFs unless the processing time is not severely impacted.

7. Dependence of the ITF on Time

   It is important to determine whether a single ITF can be used for all of the data collected from each camera, or whether both ITFs for each camera will be needed to accurately correct the data from both the early and late years of IUE. In particular, if the camera sensitivity has been changing significantly with time, then the signal/noise ratio of the data may be degraded by applying ITFs taken far away in time.

8. Enhanced Wavelength Calibration Scheme

   An enhanced wavelength calibration scheme is needed for accurate resampling prior to spectral extraction. The newest proposal for wavelength calibration (presented by Myron Smith at the FADC meeting) uses a smaller number of terms derived from a physical model for the wavelength dispersion, and incorporates an extended line list. (The newly proposed scheme may be used in conjunction with a linearized wavelength scale and desplayed orders; the latter effects may be incorporated into the geometric transformation vector.) This new scheme should be tested.

9. Characterization of the Noise, and Possible Modeling

   The noise characteristics of the IUE images, after the prototype processing with improved flat-fielding, should be measured, and if possible modeled. This information is a vital part of the archive, as well as being an important input to optimal extraction schemes.

   Artifacts: Over the years many people have looked at features that appear systematically in IUE images, particularly in long exposures. Such features appear in extracted spectra and can mimic emission lines. We think it is both useful and important to study these artifacts again. (Existing sky-background images could be used to study the dependence of the strengths of various features on exposure time, observation date, camera temperature, and perhaps other parameters.) A description of the results should be included in the final observer's manual/database, and one-dimensional (along spectrum) and two-dimensional (camera face) representations of the sky background exposures should be included in the Final Archive. (The one-dimensional study has already been completed.)

10. The Point Spread Function (PSF) and Optimized Extraction Schemes

    The PSF for each camera should be characterized as a function of wavelength, focus, time, temperature, etc. Previous studies have characterized the PSF as a Gaussian or a skewed Gaussian, but more recent work suggests that it is more complicated. In particular, there are broad, low-intensity wings that contain a few percent of the total flux. Moreover, the variation of Gaussian width along the dispersion direction is not a simple quadratic. With the many well-exposed images (especially calibration stars) now available, one could determine better the PSF and the parameters upon which it depends (e.g. temperature, focus, wavelength, camera, aperture, etc.). Its behavior will be an important piece of information for the archive, and if stable and well- defined, can be used to improve the extracted spectra greatly by use of optimal extraction techniques.

    The two schemes for optimal extraction of low-resolution IUE spectra, GEX and the Horne Optimal Method (both are described in detail in the previous report of this committee) should be combined into a hybrid code. If the PSF is well-behaved, the GEX method may be more effective; if not, then the Horne method should be used. In either case, the software to implement the best extraction method should be coded and tested, and compared to the IUESIPS broad and narrow slits (for signal/noise) on a variety of spectra. Note that both the optimal and GEX extractions may require rederivation of the absolute calibrations and high dispersion ripple corrections.

B. Short Term Studies Which May Be Postponed, If Necessary

1. Background in High Dispersion and the Negative Flux Problem

   Spectral extraction in high dispersion is a difficult problem that is only made worse by our poor understanding of the background. The IUE Project should continue to study the background, particularly scattered light and inter-order overlap. It is important to be able to provide guidance for the user who wants to obtain reliable fluxes from high-dispersion data. Chebychev polynomials appear promising as smoothing functions for the interorder background.

2. Low-dispersion Sensitivity Degradation

   All three cameras (but especially the LWR) have lost sensitivity over their lifetimes. In general, this degradation can probably be characterized by a simple multiplicative function of time and wavelength, and perhaps also temperature, and can thus be applied to the data post-processing. It may even be desirable to let the user decide whether and when to apply the correction. In either case, a study of the low dispersion camera sensitivity need not be started before processing, but should be completed before the processing is finished.

3. High-dipersion Sensitivity Degradation

   Absolute flux calibration of the high-dispersion data is more complicated than for the low-dispersion data. Nonetheless, since the archive should be the best and final version of the IUE data, it should include a measurement of the camera sensitivity (across the full image). As with low dispersion, this study can be postponed until after processing begins and some of the resources busy on part A are free.

C. Tasks To Implement Or Begin Immediately

1. FASTDR - the means for correcting the header labels - must be defined and started as soon as possible. (While complete accuracy and information is desirable, it may be too costly in terms of manpower to accomplish all that is desired. The Project should define a system that will not overwhelm the available resources while still providing a useful, effective, and timely correction of header information.)
2. Document scanning. The documents to be included in the archive should be scanned, so they will be available on-line. We encourage the IUE Project to request that the NSSDC do this task.
3. The IUE Project, in collaboration with the NSSDC staff, should prepare a Project Data Management Plan (PDMP). This is the document describing the content, format, and desired state of availability of the data products to be given by the IUE Project to the NSSDC. It is important that the PDMP be written in a timely manner and a preliminary draft be written in the next 3 months. Timely submission of the PDMP will likely bring in more NSSDC resources for preparing the Final Archive.
4. Construct an LWP ITF, finish the LWR ITF, and implement both in the prototype processing scheme.
5. Implement improved fits to ITF linearization curves for individual pixels (and extrapolations to high DN values), already studied by the Project.
6. Implement the cross-correlation technique for LWP and LWR cameras.

D. To Be Done Following Completion Of The Prototype Processing System And Before Processing Begins

1. Software - coding, testing, and documentation.
2. New absolute calibrations and high dispersion ripple corrections. We recommend that the IUE Project suspend current derivation of calibrations in the old processing scheme. The priority for calibration activities for the new processing system is: wavelength calibrations, absolute flux calibrations, ripple corrections, low dispersion sensitivity degradation, and high dispersion sensitivity degradation.

REPORT OF THE MARCH 26–27, 1990 MEETING OF THE IUE FINAL ARCHIVES DEFINITION COMMITTEE

1 RECOMMENDATIONS FOR GUIDELINES AND TESTS OF NEW IUESIPS SOFTWARE

Before implementing the new IUESIPS software to be used in generating the IUE Final Archives, it is important to establish guidelines or appropriate tests for the newly generated data products that are to be closely examined by the members of the Final Archive Definition Committee (FADC). In these recommendations, specific tests are proposed using the spectral images produced by the old and new IUESIPS processing. In each case, images resulting from both the old and new schemes are to be compared. In some cases, it will be useful to examine the degree of improvements from intermediate steps. These specific tests are outlined below. The list of tests should not be considered as complete, but only a representative example.

1.1 Recommended Tests for High Dispersion, High Signal-to-Noise Ratio Data

1. Short exposure, high S/N images from all three cameras (SWP, LWR, LWP) will be examined to determine whether the detection limit for weak interstellar features has been significantly improved. This will be tested by comparing new processing with old processing for the same images for objects that have multiple high dispersion exposures that can be co-added. Ideally, these multiple exposures should have been acquired using techniques to minimize effects of the so-called fixed pattern noise. One such technique uses multiple exposures obtained using more than one reference point. Examples include a recent series of exposures for Omicron Persei (SWP 37430–37438), which place the target in three different positions in the large aperture.

2. It is important to determine whether the spectral resolution is affected by the new software. A high dispersion resolution test can be provided by examining stars known to show multiple velocity components in interstellar lines both from visual and IUE wavelengths. An ideal test should be provided by the early high dispersion (SWP and LWP) images of SN 1987A, although other examples may be provided.

3. The continuum of largely featureless stellar objects, both with high and low S/N can be used to test the applied ripple corrections. The featureless spectra of hot white dwarfs such as G191-B2B, HZ 43, HD 149499 B, and WD 1620-39 as well as normal, fast rotating B

stars like Eta UMa are good stars to use in testing the ripple correction. In addition, low S/N, fainter white dwarfs can be used to test how good the background subtraction can be accomplished in long exposure, background dominated images. In these images the NET is much smaller than the BACKGROUND. Ideally, for the white dwarfs, no features should be seen, but in background dominated images, any pseudo-features in the background may produce false features in the net spectrum.

4. Stars with saturated interstellar features can be used to test the accuracy of the interorder correction in the high dispersion data. These features should go to zero intensity and not below zero as is the case shortward of 1400 Å in the present IUE processing. In addition, The equivalent widths of features in bright stars can be compared with those available from Copernicus data at wavelengths shortward of 1400 Å to also test the appropriateness of the correction (see Bianchi and Bohlin, 1984, *Astr. Ap.*, **134**, 31). If there is no significant error in subtracting the background, there should be no systematic differences in the equivalent width measurements.

5. The improved wavelength scale should be examined in high dispersion images exhibiting both sharp absorption and emission features. Such objects that might be appropriate are RR Tel, Capella, many planetary nebulae, and objects with many interstellar features. In each object, the radial velocities of the features and their repeatability will be compared with those from present IUESIPS processing.

6. An important new product in the new IUE archives will be the high dispersion line-by-line dataset. All FADC members interested in high dispersion data should carefully examine this product, furnish comments, apply existing RDAF software to remove radiation hits, and provide some analysis.

7. To determine how the single ITF applies to the entire lifetime of the IUE, spectra should be examined of objects that have been continually monitored over a range of epochs. Stars that might be best suited are those which sample a range of flux levels, presumably those with a rich absorption spectrum and which do not show spectral variations. Many IUE standard stars may serve well in such tests.

1.2 Recommended Low Dispersion Tests

The tests outlined for high dispersion images above (1 through 7) are also appropriate for low dispersion data.

Of special interest to be investigated are the anomalies described by Dave Finley in the low resolution data for hot white dwarfs and BL Lacertae objects as described at the 26–27 March 1990 FADC meeting. These objects should be essentially featureless and display a Rayleigh-Jeans tail as in the hot white dwarfs and a power law spectrum as in the BL Lacertae objects. However, Finley finds reproducible variations in a wide range of temperatures of the white dwarfs and the BL Lac objects. It remains a challenge to the new processing and calibration to explain and rectify the anomalies found in the Finley work. These two types of objects will play a special role in the final IUE calibration effort.

In recent years, a few investigators have begun to use the extended line-by-line data file to detect and delineate weak extended emission in a variety of objects including planetary nebulae, supernovae remnants, extragalactic jets, and extended nebular emission around AGNs. As a result it is extremely important to see whether the S/N enhancements of the new IUESIPS actually improve detection limits and enable the detection of new emission features. Objects that would be good examples to test these capabilities are the Cygnus Loop supernova remnant, the jet of NGC 4151, and the extended circumnuclear emission of NGC 1068.

As part of this test, one must ascertain whether the suggested modified line-by-line dataset is sufficient, and provides no loss in spatial and spectral resolution over the presently used ELBL file. These same datasets as well as others can be used in this test.

One of the new data products to be provided in the new IUESIPS should be a weighted extraction slit, that will yield better S/N characteristics over the standard rectangular extraction slit. Tests should be performed on a wide variety of low resolution images to test the range of applicability of this extraction. Present techniques show that the optimal extraction scheme works well for point sources. Can it or some modification be applied to multiple exposures or even some of the most pathological examples? Are the extracted fluxes always in agreement or better than those from the rectangular extraction slit? How does it compare in the new IUESIPS environment? What are its limitations? These are questions to be answered in any planned testing of the proposed optimized extraction scheme.

The effects of beam pulling must also be evaluated. It may be necessary to compare intermediate data products, those without and those including beam pulling, in order to determine its importance. Beam pulling is expected to be most important in images with the highest net DN level. Thus, short exposures of bright stellar objects are most appropriate for this testing.

2 A RESAMPLING TECHNIQUE FOR CREATION OF LOW AND HIGH DISPERSION LBL FILES

The Shepard method appears to do an effective job of resampling the photometrically-corrected image to produce a uniformly spaced line-by-line image. It is desirable to confirm that it preserves line contrast and resolution and also conserves flux. There is concern that the adoption of this algorithm will significantly increase CPU requirements for the reprocessing. Therefore, some effort should go into optimizing the code to reduce the running time.

3 ITF CONSTRUCTION

We commend the IUE Project for the excellent work already done and underway towards the construction of improved ITFs for use in creating the Final Archive. We urge the Project to proceed with this work as expeditiously as possible to complete in the very near future:

- The improved modern era ITFs,
- A noise model based on application of the improved ITF to individual images that were used in its construction,
- Tests of the applicability of the new ITFs to earlier epoch images.

One concern is the statistically unjustified procedure currently being contemplated to "fix" monotonicity violations, which appear to be due to statistical noise. We recommend fitting to every pixel a function such as:

$$DN = DN_0 + \frac{FN}{[1 + (\frac{FN}{FSAT})^A]^{1/A}},$$

which has the desired asymptotic behavior. The resulting ITF would then be available as images giving DN_0, FSAT, and A for the "pathological" pixels. The functional form can be validated by retaining an image of χ^2 values, examining residuals histograms, etc. This approach should result in lower noise in the final ITFs.

4 REVISED WAVELENGTH CALIBRATION

The FADC recommends that the Final Archives use only vacuum wavelengths instead of the present procedure of using air wavelengths above 2000 Å. This change is recommended because it will simplify the preparation of the Final Archives, it will remove the present confusion of many IUE users in the 2000 Å overlap region, and it will simplify the splicing together of SW and LW spectra. Also the adoption of vacuum wavelengths for the full IUE spectral range will be consistent with the convention adopted by HST.

5 MODELING THE IUE HIGH-DISPERSION BACKGROUND

[Previously discussed in Section 1.1, item 4.]

6 FINAL ARCHIVE DATA PRODUCTS

For each exposure the current IUE data archive includes: the raw image (RI), the photometrically corrected image (PI), a line-by-line file (LBL; low dispersion images only), and an extracted spectral data file (MELO/MEHI) containing gross, background, net flux, wavelength, and data quality flag arrays for each order.

- We recommend that the IUE Final Archive also include: a specification of the vector displacements used in creating the PI from the RI, a high-dispersion LBL file, and a data quality flag image corresponding to the PI and LBL files. The data quality flags should be bit-coded to indicate the presence and effects of reseaux, saturated pixels, camera artifacts, microphonics, missing data, etc., in any sensible combination.
- The wavelengths in the extracted spectra should be linearized, eliminating the need for a separate wavelength array; using a wavelength scale linear in log(wavelength) would facilitate the creation of a fully merged high dispersion spectrum without further resampling.
- We further recommend that an absolute net flux spectrum derived by the proposed optimal extraction procedure be included in the MELO file, in view of demonstrated improvements in signal-to-noise ratio and cosmic ray removal afforded by such procedures.

- Finally, each of the data products should be accompanied by a corresponding image or vector giving the error at each point.
- As all of these proposed data products are to be determined in the course of the proposed NEWSIPS processing, and as storage space for the final archive is apparently not a problem, all of these data products should be included in the IUE Final Archive in order to maximize the archive's utility.

7 QUANTITATIVE STUDY OF THE IUE NOISE CHARACTERISTICS

Calculations by Tom Ayres show that the fixed pattern noise for flat field images is roughly twice that expected from Poisson statistics and somewhat wavelength dependent. Tom's noise model appears to be a sensible approach, but it should be propagated through to the fluxes in the extracted spectra.

8 WEIGHTED-PROFILE EXTRACTION

Given that we have demonstrated that weighted extractions produce better signal-to-noise ratios over box-car extractions, and that such extractions succeed in finding and eliminating cosmic ray hits automatically, the FADC recommends that the IUE Project commit resources to test and implement a weighted-profile extraction for low dispersion that incorporates the following ideas:

1. a noise model for the new LBL file must be developed and applied to data points for rejection of cosmic rays and production of error spectra,
2. extraction must use weighted profiles and allow for cosmic ray rejection,
3. output must include extracted fluxes ($ergs/cm^2/s/\AA$), an error bar spectrum, and a goodness of fit statistic,
4. the algorithm must be able to run in the pipeline SIPS environment with no human interaction.

The FADC recommends that the IUE Project use the framework of the optimal extraction routine which is already in easily transportable FORTRAN, incorporates a noise model, rejects cosmic rays, runs in a pipeline mode and can accomodate extended sources. The Project should incorporate into this EXISTING CODE (available now from Don Neill) some of the very effective profile fitting capabilities of GEX, which uses our best knowledge of the shape of the PSF and the discontinuities of the profile center as a function of wavelength, and which uses variable binning to enhance the S/N, to form a weighted-profile extraction routine.

A variety of spectra must be tested to demonstrate that the weighted-profile extraction is applicable to most low dispersion spectra. All extracted spectra must pass tests based on a comparison with NEWSIPS boxcar extraction for overall success of the result, and on a statistical measure

of goodness of fit (χ^2) to evaluate whether the weighted-profile extraction worked better than the boxcar extraction.
The following cases should be tested:

- emission line source with no continuum
- absorbed source such as:

  quasar with a Lyman edge

  broad absorption line (BAL) quasar
- high background sources with cosmic rays
- faint sources
- extended sources including:

  LINER

  trailed spectrum

  double exposure
- standard star

In addition, several tasks must begin immediately:

1. We recommend that the optimal extraction routine be installed and tested in the off-line IUESIPS or in NEWSIPS by the time of the Three Agency meeting in May. This is CRITICAL to remove any doubts that the Three Agencies may have concerning the reliability and availability of the code for the Final Archives.
2. We recommend that several examples be tested (e.g. standard star, AGN, emission line star) and be presented at that meeting to demonstrate the improvement in signal-to-noise ratio realized with the weighted-profile extraction.

9 ABSOLUTE FLUX CALIBRATION

A thorough discussion of the absolute flux for the network of stars that IUE uses as flux standards can be found in the paper by Bohlin, Harris, Holm, and Gry, which will appear in the July 1990 *Ap.J Suppl.* and in the cited references. This material is also published in the *NASA IUE Newsletter.* The proposed plan for the absolute flux calibration of IUE should involve the following steps in sequence:

1. Correct each of the three independent spectrometers (L = large aperture, S = small aperture, T = time trailed) for changes in relative sensitivity with time. Five-Angstrom bins act as independent spectrometers, and sufficient SWP and LWR images exist when all available spectra of the five IUE standard stars are used.
2. Use the time-independent results from 1. to define the ratios T/L and S/L as functions of wavelength.

3. Correct all IUE spectra of the six OAO-2 standard stars for time changes of sensitivity and T/L (or S/L) to get one final FN/sec spectrum for each of the six stars.

4. Compute the raw calibration for each star: $S^{-1} = F/(FN/sec)$ and make a smooth fit to the S^{-1} ratios for the six stars. The IUE spectra should be smoothed to the OAO-2 resolution, and the Bohlin and Holm (1984) common flux scale for the OAO-2 data should be used.

5. The smooth analytic fit can be evaluated at five-Angstrom intervals to define a tabular IUE calibration. Linear interpolation over five-Angstrom intervals causes less than 1% error.

6. Apply the calibration to the available OAO-2 stars (including the six standards) and the (ratty) TD-1 stars, and compare the IUE and standard fluxes for checks.

The correction proposed by David Finley, which is based on the Rayleigh-Jeans-like spectra of hot white dwarfs, should be rederived on the basis of spectra obtained with the new processing scheme. The validity and accuracy should be assessed using AGN (power law) and other hot featureless spectra. Comments from experts (i. e. Wesemael, Shipman, etc.) concerning theoretical uncertainties in white dwarf models should be solicited. Then the Project should seriously consider applying the "Finley" correction to the above absolute flux calibration.

10 BEAM PULLING

Dave Giaretta provided evidence for a shift of one and a half pixels between high and low exposure levels and said that this beam pulling effect is the major source of noise in IUE data. He suggested that the proper way to account for beam pulling is to construct ITFs on the fly for each science image.

11 SOURCES OF INFORMATION FROM TELESCOPE OPERATIONS FOR THE FINAL ARCHIVE

1. Corrections to data for the Commissioning Period should be given lower priority than later data but should eventually be done.

2. The offset star positions and offsets should be put into the database and image header.

3. A general Quality Flag should be included in the database and image header.

4. The database for current observations should include more information (exposure time, fine pointing, offset information, etc.).

Note - The next meeting of the FADC is scheduled for Monday and Tuesday September 10–11, 1990.

REPORT OF THE SEPTEMBER 6-7, 1990 MEETING OF THE IUE FINAL ARCHIVES DEFINITION COMMITTEE

8 September 1990

1 HARDWARE REQUIREMENTS FOR PROCESSING THE FINAL ARCHIVES

The most important issue identified by the FADC at its meeting Thursday and Friday was the critical need for adequate computing hardware to process the Final Archives within a three year period beginning in January 1991. As best as we can tell, all technical issues are now solved or on a rapid track towards solution by the end of the year. Since the hardware issue is critical to the success of the Final Archives and **IT TAKES TIME TO ACQUIRE COMPUTING HARDWARE**, the FADC urges that the IUE Project assess the problem and alternative solutions this month (September 1990) and that it set a deadline of September 30 for deciding on the appropriate solution and then implementing it. **THIS ACTION CANNOT BE DELAYED.**

Before attempting an evaluation of the hardware requirements for the final archive reprocessing, it is necessary to state a few "ground rules" or assumptions.

1. Byte-by-byte compatibility is not scientifically required - i.e. there is no scientific necessity for requiring results to be identical to 1 part in 10^9. Requiring byte-by-byte compatibility significantly reduces the number of hardware options and may increase the hardware costs enormously.

2. All data will be on-line and thus available for batch processing. This is a much repeated statement but worth reiterating. Having the data on-line greatly reduces the need for human intervention.

3. The minimum set of header input parameters required to process a raw image should be defined. It may become necessary, although not desirable, to reprocess images faster than the rate at which all of the header information can be corrected and verified.

4. The NEWSIPS code has not yet been written, and the code will be written in FORTRAN for portable MIDAS, although some of the code will be reused from IUESIPS and that code has VMS extensions. Using standard FORTRAN and portable MIDAS means that there are several options for the operating system – VAX / VMS is not the only solution.

1.1 ESTIMATING THE EFFORT

- **There are approximately 30,000 high dispersion images and 45,000 low dispersion images in the total IUE database.**
- **The processing time per image is in the ratio of 5:1 for high to low dispersion data.**
- **THIS IMPLIES THAT THE TOTAL TIME FOR PROCESSING IS IN THE RATIO OF 10:3 FOR HIGH TO LOW DISPERSION.**

THUS: 25% of the time is needed to process the low dispersion data, and 75% of the time is needed to process the high dispersion data.

ASSUMING A 3 YEAR PROJECT TO COMPLETE THE ENTIRE REPROCESSING IMPLIES:

- **Processing 170 low dispersion images per day for 9 months.**
- **Then processing 40 high dispersion images per day for 27 months.**

The current processing times for NEWSIPS are about 1 hour per low dispersion image and 5 hours per high dispersion image. This is for a VAX 3500 class machine (i.e. PHOENIX). Thus the requirement for processing 170 low dispersion images per day implies 6 CPUs of the PHOENIX class; the requirement for processing 40 high dispersion images per day implies 7 CPUs. These estimates are based upon 24 hour a day operations and no down time. A more practical and conservative statement is that the current VAX 3500 machine is too slow by an order of magnitude. Assuming that VILSPA processes one-third of the images, NASA's hardware requirements are two-thirds of the above numbers.

1.2 OPTIONS THAT SHOULD BE EXPLORED BY SEPTEMBER 30, 1990

What methods are available to increase the processing speed by an order of magnitude? The following list is a set a options which are worthy of further study. Each option provides the necessary computing power, but it also presents a set of questions concerning costs, personnel, availability, installation, testing, etc. These questions must be addressed in the proposed September trade study.

OPTION 1. Use the GSFC CRAY YMP. Is this CPU actually available? What are the costs? What are the I/O requirements (i.e. how can the data be made available to the CRAY)? What are the actual processing times per image - this includes I/O since it is likely that the process will not be CPU bound? A test of the resampling procedure should be made on the CRAY. This should not be a major problem since the NAG library is available on the CRAY. Given the speed of the CRAY, the rate of reprocessing will be driven by the speed of correcting the database or the minimum input parameter set.

OPTION 2. Use faster UNIX machines: There are two possible solutions since portable MIDAS only runs on two UNIX platforms - SUN and DECstations;

(a) SUN Sparcserver 470 (also known as the SUN 4/470) - This machine does meet the required factor of 10 increase in speed. There are questions of training time needed for the operators to become familiar with a new environment, however the SUN Fortran compiler is very compatible with F77 and the MIDAS environment is essentially the same as on the present VAX/ VMS machine.

(b) DECstation 5000 - Similar statements apply as for the SUN, except that the Fortran compiler is not nearly as good or compatible with F77. (DEC is developing a new Fortran compiler for the DECstation series, but it is only in Beta release.)

OPTION 3. Use a faster VAX /VMS machine. The necessary CPU such as a VAX 9000 may be available at GSFC. This should be pursued. It is preferable to buy machine time, since purchasing the machine would be too expensive.

OPTION 4. Use multiple VMS workstations: Purchasing an additional 5-10 VAXstation 3100 class machines, which have essentially the same CPU speed as the PHOENIX, would provide the necessary CPU power. Each machine costs about 15-20K. Advantages of this approach are that these machines are familiar to the IUE Project and the machines can be purchased incrementally. Major disadvantages are the potential personnel and maintenance costs.

1.3 RECOMMENDATIONS

1. **Investigate the possibility of using a very fast CPU – the GSFC CRAY or even a VAX 9000. Study the costs and implementation requirements.** or
2. **Purchase a new machine - preferably a SUN 4/470.**

2 OPTIMAL EXTRACTION FOR LOW DISPERSION SPECTRA

Optimal extraction has been shown to process without difficulty and to give the most reliable and lowest noise result for a wide variety of low-dispersion IUE spectra, including all the pathological specimens we have been able to think of.

The following tests remain to be done:

- **Is the improvement in S/N due to smoothing?** To answer this question we suggest that fake features be added to a raw image to be processed with both the boxcar and optimal extraction algorithms. Another approach would be to examine the autocorrelation function of IUE spectra extracted via a 5-line boxcar (clearly unsmoothed) and the optimal method. If the latter has smoothed the spectrum, the correlation length should be greater, and the autocorrelation function will be broader.

This could be repeated for a number of spectra to avoid the random effects of noise on each autocorrelation function.

- **Check the ratio of extracted fluxes for the optimal and IUESIPS extractions of the same images.** It is especially important to check for flux conservation in the regions of emission and absorption features.

If there are no serious problems discovered during the above tests, then optimal should be installed in NEWSIPS and be made available now to users through the RDAFs. We note that optimal requires a new noise model. Finally, the optimal code must be verified in the NEWSIPS environment.

3 OPTIMAL EXTRACTION FOR HIGH DISPERSION DATA

The FADC recommends that the Final Archive contain a file for high dispersion data with the spectrum extracted using a simple boxcar technique. The Final Archive for high dispersion data should also contain an intermediate file with data geometrically corrected, photometrically corrected, rotated, de-splayed, and wavelength linearized (but not ripple-corrected) so that sophisticated users may apply their own extraction techniques and ripple corrections if they choose. The RDAFs and the Final Archive should contain software to permit users to apply a weighted slit extraction containing point spread function information for high dispersion data if they wish.

4 NOISE MODEL

Given that the noise for each pixel for each level of the ITFs is known only approximately, and given that the processing of science images through resampling involves at least two non-linear processes (i.e. photometric correction, resampling, and possibly Fourier filtering), the FADC recommends the following with regard to generating a noise model for IUE data:

- **The IUE Project should adopt the method for creating the noise model as presented by D. Neill for use with the optimal extraction algorithm.** The FADC notes that the production of a "variance" or "sigma" vector to describe the uncertainties at each extracted wavelength interval is an integral part of this algorithm.

- **Since the above noise model appears to be readily generalizable, and since a sigma vector is also very important for high dispersion extractions, a weighted slit extraction algorithm should be developed for high dispersion data.**

- **The Noise Model for each camera should be placed in the Final Archive.**

- **Data Quality Files or Bad Pixel Lists should still be provided for each archived image.** These are crucial for the extraction algorithms to function optimally, and would include such items as: missing data, saturated pixels, microphonic noise, reseau marks, bright spots, various problems with photometric correction (including extrapolation), and (possibly, for low dispersion) cosmic-ray hits.

5 WAVELENGTH CALIBRATION

Recommendations for wavelength calibration:

- **The use of the new NIST line library should enable increased accuracy in the IUE wavelength scale.** Although for many science images the wavelength accuracy will be limited by uncertainties in the placement of the object within the aperture, it is still desirable to determine the wavelength calibration for well-centered objects to within the limits set by the identification of lines in the calibration spectra (a few tenths of a pixel?).

- **The non-linearities seemingly present at the long wavelength ends of both the SWP and LWP cameras in low dispersion should be verified.** The centroiding routines should be tested (perhaps on simulated spectra generated using the NIST wavelengths) to determine how they handle slightly blended lines. Are there corresponding features in similarly processed high dispersion spectra (e.g., shifts in order center along the dispersion)? If the non-linearities are verified, can they be understood as resulting from unremoved geometric distortion or from some kind of discontinuity? (The proper correction could depend on that distinction.) Calibration exposures of different lengths should be used to more reliably extend the calibration to both longer and shorter wavelengths; comparisons should also be made with high dispersion spectra.

- **The re-parameterization of the high dispersion wavelength calibration outlined by Myron Smith should be tested.** The dispersion relations for adjacent groups of orders should be checked for consistency, particularly at the ends of orders where the relations have been extrapolated due to lack of lines in the calibration spectra. Is a linear dispersion relation sufficient for the new high dispersion "LBL" file, or are higher order terms required? Do the anomalies noted by Tom Ayres remain? If so, and if they cannot be removed, they should at least be mapped for inclusion in the documentation of the data set. Sharp-lined stellar spectra could be examined to verify wavelength calibration where there are few calibration lines.

- **The small aperture to large aperture offset should be checked, as there is some evidence that the current value may lead to errors of about 1 A near 1215 A for low dispersion SWP spectra obtained through the large aperture (Bohlin and Deutsch).**

6 REMOVAL OF PERIODIC NOISE IN THE SCIENCE DATA

Based upon the analysis presented by the IUE Project at this meeting, we recognize that periodic noise (the nature of which was discussed in previous FADC reports) in ITF images may approach eight percent of the signal, at least at certain frequencies. Since the magnitude of this noise is larger than previously thought, and may be comparable to other sources of systematic noise in IUE images, we recommend that the IUE Project investigate whether filtering the periodic noise from science images would enhance the signal-to-noise ratio (SNR) in extracted spectra. Specifically, we recommend:

- **Fourier-filter several low- and high-dispersion images, but only at some or all of the frequencies that were filtered in the ITF levels, and quantify any improvement in the SNR.** We suspect that the most appropriate images for this study would be those of well exposed standard star spectra—i.e., those with relatively few spectral features—so that spatial frequencies in the data are not confused with periodic noise.

- **Examine FFTs of extracted spectra (or means of many such spectra) for improvements in SNR, especially at particular frequencies.** Also examine two-dimensional FFTs in sections of the resampled images for improvements to the SNR in both the background and the spectrum.

- **Implement Fourier filtering in the processing software only if an increase in SNR is demonstrated, and if the filtering can be done accurately and reliably on virtually all IUE images.**

7 BEAM PULLING / RESEAU MOTION

The most recent tests described to the FADC appear to indicate that beam pulling is not a problem, but that the reseaux move with exposure level. To better understand what is really happening, the FADC recommends that the following tests be done soon:

1. Examine "sky flats" with different background levels.

2. Look at cross correlation fiducials and reseaux on and off a trailed "flat" continuum source.

3. Compare reseaux motions in T–flood and UV–flood images.

4. Determine reseaux and fixed pattern positions near geocoronal Lα through the full range of intensity (low noise down to no spectra).

8 LABEL MODIFICATION

The FADC recommends that more manpower be directed towards implementation of the system for image header checking and database development, as outlined by the IUE Project at the 1990 September meeting and contained in the "IUE Final Archive Reprocessing Reference Document". Since correct image headers are a necessary first step in the "critical path" for reprocessing of spectra, database and label checking-updating software should be in place approximately two months (1990 November) before the prototype NEWSIPS is installed for the processing of the scientific evaluation spectra (projected to begin in 1991 January).

Current projections (see Part 1 of this Report) for the reprocessing of the low dispersion spectra in the first 9-month timeframe require that approximately 170 headers per DAY to be checked and installed in the IUE database. This is more than twice previous estimates, and will require a proportionate increase in the originally projected manpower (6-8 FTE's compared to the original 4 FTE's). The division of effort between GSFC and VILSPA may be about 3:1; thus the Goddard header checking and correcting effort will be approximately 130 per day or 900 per week.

Some specific recommendations and target dates are as follows:

- **by November 1990.** Add 1 additional FTE to the header correction and verification effort to complete the prototype software development and to investigate the quality control of header parameters crucial in the data reprocessing.
- **by December 1990.** Add 2 additional FTE's to the header correction and verification effort (1) to complete header checks and modifications for science evaluation and NEWSIPS tests and calibration spectra, (2) to evaluate the manpower required for a 900 per week header checking effort, and (3) to evaluate potential problems with "early epoch" (1978-1981) headers.
- **by January 1991.** Add additional FTE's (perhaps 4) to the header correction effort as necessary to processes 900 images per week. This effort should include a part-time Resident Astronomer to correct those header parameters requiring scientific expertise.
- **by February 1991.** Complete the training of personnel and begin header inspection and database development effort with the goal of staying approximately one month ahead of the NEWSIPS processing.

9 RIPPLE CORRECTION

The FADC recommends that a physically realistic model of the ripple correction be investigated for high dispersion. Such a model should be able to account for the possibility that major optical elements are not quite on-axis. A desirable property of such a model would be coefficients which are almost the same for all images taken with the same camera.

10 VACUUM WAVELENGTHS

The FADC reaffirms its recommendation made at the March 26-27, 1990 meeting that the Final Archives use vacuum wavelengths for all data, not just the data below 2000 Å.

11 RECOMMENDATION FOR ADOPTING AND TESTING THE BACKGROUND ALGORITHM FOR HIGH DISPERSION

One of the most important enhancements in the IUE Final Archives for the high dispersion data will be the implementation, for the first time, of a means to properly subtract a realistic background from the data. Currently, IUE processing blindly subtracts interorder signal from the extracted spectrum **without** making any allowance for overlap of neighboring orders. As a result this method severely overestimates the background at shorter wavelengths.

The Chebyshev polynomial method appears to provide a reasonable background subtraction for high dispersion data on the examples tested. It also should be more adaptable than the Bianchi and Bohlin method for correcting the background in the SWP camera.

The FADC recommends the following:

- **The Chebyshev method should be extended to span the entire sensitivity range of both cameras.** In particular, it should be extended down to at least 1170 Å in the SWP camera. Currently, it has been applied to wavelengths only longward of Lyman -α. Also, it has not been tested in the long wavelengths corresponding to the LWR and LWP cameras.

- **It is important to test both the Chebyshev and the Bianchi and Bohlin methods thoroughly using comparisons of IUE and Copernicus data, and HST data acquired with the Goddard High Resolution Spectrograph.** Since data acquired with Copernicus and the GHRS do not suffer from interorder overlap, the equivalent widths derived from these instruments should be reliable. Thus, direct comparisons of equivalent widths among data from all three instruments will be very important in determining the validity of the two correction methods for IUE data. Of course, the Bianchi and Bohlin scheme has only been developed for SWP data and cannot work for saturated images. However, any test should include comparisons with this method, since many investigators, now incorporate it in their custom reduction of high dispersion IUE data.

- **The IUE Observatory should ensure that the necessary data are available for performing tests of the background subtraction algorithm.** The contents of this data set is dictated by the available high S/N data acquired at high dispersion from Copernicus and the GHRS. In some cases saturated interstellar features may be used in early-type stars. The IUE Observatory should ensure that it acquires use of the GHRS observations for these same objects. Indeed, they have been working closely with members of the GHRS team to accomplish this goal. Since a detailed plan already exists for obtaining these data, it will not be reiterated here.

12 RECOMMENDATIONS FOR THE CONTENTS OF HIGH DISPERSION FILES

The FADC recommends that the high dispersion data files in the IUE final archives contain the following data:

- **File 1.** This file should contain the unprocessed raw data image. This is the same dataset as is currently provided by the IUESIPS.
- **File 2.** This file should contain the photometrically corrected image constructing using the best available ITFs, properly aligned with the high dispersion spectral image.
- **File 3.** This file should contain the variance image, which provides the flux uncertainties for each data point in the photometrically corrected image.
- **File 4.** This file should contain the information needed to go from File 2 to File 5, which contains the rotated, de-splayed, and interpolated image with constant wavelength spacing in each order. File 4 may either be in the form of an image of vector displacements or coefficients for use in an algorithm.
- **File 5.** This file should contain the equivalent of the line-by-line file for low dispersion data. This image is rotated such that all of the orders are horizontal. The orders are de-splayed, and the the data points are interpolated to achieve constant wavelength spacing between points in an individual spectral order. The wavelength assignment for each point in each order must be easily accessed, either from header information in this file, or, if necessary, an additional file. The computational procedures used in creating this file must not compromise the suitability of this file for use by extraction schemes for high dispersion data similar to GEX and OPTIMAL for low resolution data.
- **File 6.** This file should contain a set of coefficients that can be used in an algorithm to generate the surface denoting the background used in the final archival processing. Most likely, this will be the Chebychev method. By using this file, it should be possible to generate a background corresponding to each data point in File 5.
- **File 7.** This file should contain the gross, net and background spectra for each individual order extracted using a simple boxcar. The fluxes, uncorrected for the echelle ripple, are given with constant wavelength spacing identical to that in File 5. This data set is comparable to the extracted data file now produced by IUESIPS, except for the constant wavelength spacing requirement.

- **File 8.** This file should contain the linear flux versus wavelength array with constant wavelength spacing throughout and spanning the entire sensitivity range of each of the respective cameras. The fluxes are given as ripple corrected absolute fluxes. Splice points between orders as well as bad data or positions of reseaux are flaged. This file also contains the errors in the derived flux at each wavelength.

13 PROCEDURE FOR CHANGING PLANS FOR THE FINAL ARCHIVE

The FADC requests that the NASA IUE Project consult with the FADC before agreeing to significant changes in plans for implementing the Final Archives, in particular, before changing such fundamental documents as the Final Archives Definition Document.

14 NEXT MEETINGS

The preferred date for the next meeting of the FADC is immediately before the next Three Agency meeting. If the Three Agency meeting date is November 28-30, as is tentatively scheduled, then the FADC will meet November 26+27. Otherwize the FADC will meet December 17+18. One agenda item for this meeting should be a discussion of how to disseminate IUE data - the proper medium, and the nature of data center(s).

The FADC requests that the NASA IUE Project approach the ESA IUE Project to encourage European participation in the scientific verification of the Final Archive reprocessing procedures. The evaluation should occur in early March 1991. A good opportunity for this evaluation would be at the subsequent meeting of the FADC, which is tentatively scheduled for March 7+8, 1991.

Jeffrey L. Linsky

Chair, FADC

FINAL REPORT OF THE NOVEMBER 27, 1990 MEETING OF THE IUE FINAL ARCHIVES DEFINITION COMMITTEE

7 December 1990

1 Removal of periodic noise

Low dispersion continuum source images were chosen as a testbed for investigating the possibility of Fourier-filtering raw science images. There were no obvious differences in either the photometrically corrected data or the extracted spectrum when the raw images were processed through the NEWSIPS system with or without the Fourier-filtering. On this basis the FADC recommends that the Final Archive reprocessing **not** Fourier-filter science images, but that flat field images used in the creation of the ITFs continue to be Fourier-filtered.

2 Status of the development work

Aside from combining the two suggested saturation conditions (one denoting DN $\geq$ 250 and the other denoting saturation of pixels at DN $\leq$ 250, where this latter condition is known from analysis of the ITF images) into one general saturation flag, the FADC concurs with the proposed NEWSIPS ν flags.

3 Reseaux motion studies

The FADC notes two important facts:

- The accurate registration of science images with the ITF images is crucial to optimizing the S/N ratio of the LI (Linearized Image).
- Several lines of evidence (including both reseaux and fixed pattern shifts with DN) suggest that the apparent shifts between the ITF levels are real and apply to the science images.

We therefore recommend that the IUE Project should attempt to account for these shifts in the photometric correction step. We suggest a test program along the following lines:

- Perform cross-correlations between all adjacent ITF levels for one camera at the same positions as for the science images.
- Express the shifts as a function of DN number and store in a library.
- Keep track of the DN levels of the ITF sections used in the cross-correlation stage.
- During processing, calculate and store the differences between pixel and the ITF level used in the cross-correlation.

- The shift appropriate for each ITF level should be used during the photometric correction procedure.

We also recommend that the S/N ratio between the LI files produced with NEWSIPS be compared to that using the above scheme in regions where the inter-level ITF shifts are large. If the S/N is improved, this enhancement should be adopted for the Final Archives processing. The Project should also consider whether the adopted scheme will provide extracted spectra that closely approach the highest possible S/N.

We are proposing this test program, which may impact the schedule for beginning the Final Archives by 2–4 weeks, because we believe that that the possible major enhancement in the S/N in well-exposed spectra must be pursued. **This is the last major unanswered question in the Final Archives development effort.**

4 Status of Optimal Extraction and the noise model

The FADC commends Kinney, Bohlin and Neill for their work in writing their manuscript "Weighted slit extraction of low dispersion IUE spectral data", which they are about to submit to *PASP*. This manuscript describes the Optimal extraction scheme and applies it to a wide range of IUE low dispersion images including many pathological cases. They show that the Optimal scheme enhances S/N over boxcar schemes with no apparent decrease in spectral resolution. Optimal is already implemented in prototype code and the SWP noise model will be developed in early December.

Mike Van Steenberg said that he and colleagues intend to generalize the Optimal extraction scheme to high dispersion data as a software package that archive users could apply to the Extracted High Dispersion Spectra files. The FADC encouraged them to pursue this vitally important effort and to report on their progress at the next meeting.

5 Progress in ripple correction

The FADC notes that the Barker interactive differential correction method for estimating the value of **k** by requiring that overlaping ends of echelle orders have the same flux looks like a good ripple correction procedure, but a number of problems must be addressed **before** the Project can decide upon a robust ripple correction scheme for the Final Archives. These problems are all related to the reliability of the net high resolution spectra. The ripple correction cannot remove faults in spectrum extraction:

- There still is no inter-order flux correction scheme which is accurate at the short wavelength regions of the cameras.

- There is also no accurate order tracking scheme that works reliably for poorly-exposed images. A centroid tracking algorithm should be used where feasible, otherwise the default should be standard dispersion relation constants.

- Well-exposed low resolution spectra of standard stars reproduce typically at the 2 percent level. The reproducibility of high resolution spectra for standard stars should be investigated as a test of the extraction procedure.

- The time and temperature dependance of sensitivity across the camera image should be studied. As the Barker algorithm compares data taken at widely spaced locations across the image, proper allowance for sensitivity variations as a function of position and not just wavelength (as for the low resolution absolute calibration) must be performed before the ripple correction. Removal of sensitivity dependencies may reduce, or even remove, the observed variations of the ripple correction with time and temperature.

These questions must be answered **before** the Project can adopt a ripple correction scheme. The FADC recommends:

- The high dispersion data for η UMa and other IUE standards should be used to explore the sensitivity degredation over the full camera formats.

- It is not clear at this time how the camera sensitivities over the full image format may best be determined. One possible scheme is to obtain very well exposed spectra of IUE standards with few absorption features. Another is to cross-calibrate with medium resolution GHRS data.

- Use longer exposure images, which may require new data, to determine the location of spectra at the ends of echelle orders, especially at the short wavelength ends of the cameras.

- Are there any viable alternatives to the Barker scheme for determining the value of **k**? If there are none, then the Project should test which of the following schemes works best on the widest range of data:

  1. use a Project-provided standard ripple correction for all spectra, including temperature and time dependencies,
  2. use the Barker method for each spectrum (where feasible), or
  3. use the Barker method to determine the mean k value for many orders and scale to all orders using Project-defined scale factors.

6 Hardware selection for the Final Archive

The FADC commends the IUE Project for its rapid response to our previous request for a trade study of hardware options to support the Final Archive production. We concur with the Project's decision to procure two DECstation 5000 model 200 machines to be used for the Final Archive processing. This choice provides sufficient computer resources to process the entire NASA acquired data set within the three year timetable. This architecture also allows for the possible purchase of additional hardware in the future, without the need for any code revision. This is important because many changes in computer costs will occur during the next 3 years and it should be possible to acquire additional resources at very modest costs. (For example, the DECstation 3100 has decreased in cost by 30% in the past month.)

The Project recognizes that the timely delivery of this equipment before the end of January 1991 is critical to the schedule of the Archive production.

The Project has been informed of potential problems with the FORTRAN compiler on the DECstation and a contingency plans exists should the DEC provided compiler not be available by early 1991. (The DEC compiler designated FORT is in Field Test version 4 and should be available within 3-4 months.) Specifically, code development will proceed using the MIPS FORTRAN compiler (F77). Furthermore, software development will begin in December prior to delivery of the DECstations, on a VAX / VMS machine with a requirement that VMS specific FORTRAN extensions be excluded from the code.

7 Core item verification – data verification

- The FADC commends the Project for its foresight in cross-checking items on scripts for accuracy to avoid overloading the header verification effort when production begins.
- The FADC suggests that the Project publish an appropriate schedule for the completion of reprocessing for the low dispersion data for each camera. This will help potential archive researchers to plan their future work and ADP proposals.
- Because of the short time required for reprocessing the low dispersion data for each camera, we recommend that the Project not support reprocessing of low dispersion data out of sequence.
- The Project should make sure that there are no hardware limitations that would preclude adding extra people to the header correction/verification effort should this work proceed slowly in the beginning.

8 Final Archive schedule

The FADC concurs in the proposed schedule leading to the commencement of the Final Archive System Commissioning Phase on April 1, 1991, except that there may be a 2–4 week delay for the tests described in the section on Reseaux Motion Studies.

9 Final Archive file contents

The FADC recommends that the Final Archives contain the data files listed below, which are somewhat modified versions of the list presented at the meeting:

- Raw image
- Vector Displacement file (consideration should be given to possibly replacing this file with analytic formulae)
- Cross-correlation coefficients, positional information, and associated specifics
- Linearized Image
- replace the proposed Linearized Variance Image file with a file of error flags
- Resampled Image

- replace the proposed Resampled Variance Image with a noise model prescription
- Extracted Low Dispersion Spectra (optimal extraction including the error vector)
- Extracted High Dispersion Spectra (including an error vector if this can be computed)
- Concatenated High Dispersion Spectrum

The Final Archive should also contain a description (probably empirical) of uncertainties in the ITFs which could be a noise model for the ITFs. We also recommend that the archives contain a disk with only the extract spectra files as many users will only wish to access these files.

10 Large aperture tilt correction

The FADC recommends the adoption of Option 1 from the list presented by Joy Nichols-Bohlin. The Project should decide on a procedure for determining which images to correct for the large aperture tilt. In particular, the Project must make every effort to ensure that trailed and Goddard's multiply-exposed images are properly flagged in the database, or are recognized correctly by the software during processing, so that the tilt correction is not applied in these cases.

11 Vacuum wavelengths

The FADC continues to recommend that only vacuum wavelengths be used in the Final Archives.

12 Reprocessing strategy

The FADC recommends that the Project implement its already agreed upon strategy of each observatory reprocessing its own images. The main reasons for supporting this strategy are:

1. Each observatory knows best how to reprocess its own data.
2. This procedure best utilizes available hardware and is most likely to lead to completion of reprocessing within 3 years of its commencement.
3. Byte-by-byte compatibility is not scientifically required. A procedure of cross-processing a representative sample of images and testing for flux agreement within prespecified error tolerances is an adequate quality assurance procedure.

13 Wavelength calibration and dispersion relations

The FADC recommends that:

- The set of 5 large aperture wavelength calibrations should be processed through NEWSIPS to verify successful removal of fixed pattern noise at wavelengths far removed from the 2500 Å ITFs.

- A set of five $\approx$10 minute exposure small aperture wavecals (with no superimposed TFLOODs) should be obtained by the Project to establish the dispersion relations at short wavelengths ($\lambda \leq 1400$ Å). (Five images are required for proper statistics.) Such images will be overexposed at NeII 1916 Å by a factor of 500, not a serious threat to the health and safety of the SWP camera.

14 Next FADC meeting

The next meeting of the FADC was originally scheduled for March 7+8, 1991. However, these dates conflict with the IUE proposal review at NASA, and the Project would like additional time to make the requested tests of image motion with DN number. The next meeting of the FADC is now tentatively scheduled for Monday and Tuesday March 18+19, 1990. An important agenda item will be the assessment of the Science Verification of the reprocessing procedures. The FADC requests that the NASA IUE Project invite representatives from the ESA and SERC to participate in this science assessment.

A second major agenda item for this meeting will be a discussion of plans for reprocessing the high dispersion data including ripple correction, background subtraction, absolute flux and wavelength calibration, and optimal extraction. Project people, O'Brien, Smith, Van Steenberg, and others should prepare presentations.

15 Distribution of Reports of the Three Agency and DCG meetings

The FADC requests that copies of Reports of recent Three Agency and DCG meetings that deal with aspects of the Final Archive preparation be distributed to FADC members by e-mail for their information.

DRAFT REPORT OF THE MARCH 18-19, 1991 MEETING OF THE IUE FINAL ARCHIVES DEFINITION COMMITTEE

April 3, 1991

1 Should the ITFs and the science images be Fourier Filtered?

The presentation by M. De La Peña on studies of periodic noise in IUE images, led the FADC to conclude that Fourier filtering this noise from the ITFs and/or science images:

- does not noticeably reduce the noise in extracted spectra;
- introduces noise artifacts at the 1–2% level into two-dimensional images (and possibly extracted spectra) that are processed using the Prototype software;
- complicates the task of recognizing saturated pixels in the ITFs; and
- precludes preforming an accurate photometric correction near the edges of reseaux.

Since the FADC has not seen evidence that removing periodic noise from either the ITFs or the science images will enhance the signal-to-noise ratio (SNR) of extracted spectra, and indeed creates some undesireable side effects, **we recommend that the IUE Project reprocess the IUE images without Fourier filtering either the ITFs or the science images.**

The IUE Project expressed an interest in extending the study of periodic noise to include an analysis on a wider range of science images, particularly those that do not align well with the ITFs. **The FADC endorses this plan so long as this issue is resolved within a few weeks of this meeting**, owing to the tight time constraints of the Final Archive production schedule. However, we reiterate that Fourier filtering of the periodic noise should not be done for the Final Archive unless convincing evidence is found very soon that it substantially enhances the SNR of extracted spectra.

1.1 Alignment of the ITF levels

The IUE Project was unable to provide evidence that aligning the ITF levels (during the Photometric Correction) made any significant difference to the SNR of processed science images. In addition, the presentation by M. De La Peña suggested that implementing this correction on full IUE images during Final Archive processing would require additional time and effort to optimize the software. Unless the Project can, within a few weeks from this meeting, provide evidence that the SNR of science images would be enhanced, **the FADC recommends that no attempt be made to align the ITF levels in Final Archive processing.**

2 ν Error flags in NEWSIPS

The proposed data quality (ν) flag system for NEWSIPS represents a significant improvement over the old IUESIPS (ϵ) flags by virtue of the new cumulative binary format allowing multiple pixel errors to be labeled in resampled and extracted spectra.

The FADC supports the full use of ALL ν flags in the OPTIMAL extraction. The implementation should be such that the user will be aware of any and all anomalous data errors and/or problems in the final extracted spectrum products (possibly including use of summed flags and/or weighted errors in the processing). In the documentation of the Final Archives products and their proper use, "up front" detailed descriptions of the ν flags and their significance and importance in science interpretation of the NEWSIPS SILO-MELO results should be emphasized.

The FADC recommends that the IUE Project explore the feasibility of developing graphics software packages for use in the OPTIMAL and for displaying the ν flag errors in the SILO and MELO data (perhaps as overlays) in a standard manner convenient to users in the IDL-RDAF, MIDAS, and IRAF environments (including possibly the incorporation into the X-windows–SAOIMAGE system now becoming widely used in the community because it is machine-independent).

3 Aperture alignment and de-tilting

Howard Bushouse reported on the "SILO GEOMETRY: APERTURE ALIGNMENT, DETILTING, AND WAVELENGTH LINEARIZATION." The new points of his presentation are:

- There will be only one line-by-line file in the final low dispersion archive that covers the region of both the large and small aperture. This proposal introduces a fault line discontinuity of 1–3 pixels between the apertures in extended source reductions. The cases of point sources, multiple and trailed exposures are not detilted and required no slipage along the fault line, because the line joining the center of the large aperture and the small aperture is sufficiently close to perpendicular to the dispersion direction. No one could find any fault with this scheme, but the orders in high dispersion should not be slipped along fault lines, because the orders are close enough together that scattered light features may extend more than half way to the adjacent orders.

- A non-linearity of 2–3 pixels in the wavelength scale was discovered, so that NEWSIPS should have more accurate wavelengths than the present IUESIPS.

- The claim was made that detilting point source spectra will "significantly" degrade the resolution. However, no quantitative measures of the degradation were presented. If the operational impact of separating the point and extended sources with .999 reliability is important, the question of whether or not to detilt the point spectra (as is now done in IUESIPS) should be re-examined.

4 Implementation of Optimal Extraction in the prototype

FADC Recommendations for Optimal Extraction

1. Documentation. The OPTIMAL algorithm, as delivered to the Project, is fully documented in the paper "Weighted Slit Extraction of Low Dispersion IUE Spectral Data" (Kinney, Bohlin, and Neill, 1991, *PASP*, in press). Any changes made by the Project for incorporating the algorithm into the pipeline processing must be documented, perhaps in the form of *IUENewsletters*. For example, the flagging of bad pixels in the output spectrum appears to have been changed so that the description of flags in the *PASP* article would not be correct for the final output spectrum of NEWSIPS. It is important that users have access to complete documentation.

2. The polynomials determined in the cross–dispersion profile should be saved in the headers. These polynomials can be used to reconstruct the profile to determine if the spectrum is a point source, extended, trailed, or multiple.

3. We recommend that the Project make the following small tests:
   - Would increasing the size of the region used to determine the background decrease the noise in the background without in any way compromising the background?
   - The discontinuity in the LWP at 3100 Å should perhaps be incorporated into the default profile for this camera. If possible, the discontinuity should be taken into account in the fits to the cross–dispersion profile also.

4. A few additional cases should be run to test the limits of OPTIMAL extraction and especially to check the results when the point spread function is varying rapidly along the spectrum. Herbig-Haro objects (see Ed Brugel for camera numbers) and Jupiter aurora (see Cathy Imhoff for camera numbers) are two of the toughest examples.

5 Science Verification tests

The following types of IUE spectra with the new processing (including optimal extraction) were investigated: coadded spectra, weak point sources, well-exposed point sources, weak trails, well-exposed trails, high radiation background (all by Nichols-Bohlin), coadded spectra (Shaw), long exposure "semi extended source" (Dufour), a heavy overexposure (Bohlin), well-exposed spectra (Welty), and an extended continuum with superimposed point source emission lines (Brugel). Nearly all showed an improvement in the S/N, with the most improvement in the weakest spectra. In the case of the heavy overexposure, the new processing was more accurate in recognizing which pixels are saturated. The notable exception is that the point source emission lines in the extended source Herbig-Haro object spectrum were completely removed, presumably because the optimal extraction mistakes them for cosmic ray hits.

In addition, the ratio of spectra with a 20% exposure and a 100% exposure showed a 10% difference in flux, indicating a significant linearity error (Shaw). Linearity problems were confirmed by a study of spectra with a range of exposure times (Cassatella), a difference in color in a color index derived from LWP and LWR spectra (Evans), and previous experience (Bohlin). The importance of investigating this nonlinearity problem was stressed by the committee. (See next section).

Ayres presented a study using the large aperture patches on an SWP wavecal to show that the SWP can be satisfactorily flat-fielded, even though the UVflood used in constructing the ITF's is at a wavelength of 2500 Å.

The FADC recommends that the definition of the -128 ν flag be reconsidered and perhaps eliminated. This flag indicates data extrapolated below the ITF level 1. Bohlin suggested that perhaps only data more than 10 DN below the first ITF level be flagged. Evans suggested that this flag be eliminated, because the best exposures with the best background should be those with no measurable background–which is physically perfectly correct.

So far there has been no test of the resolution of spectra with new processing. One possibility is to use high-dispersion spectra with weak and very weak features. A comparison between the visibility and width of the features with the new and old processing should tell whether the improvement in the S/N seen in the new processing could be the result of some additional unexpected smoothing in the process. Nichols-Bohlin has the data in hand for the test.

6 Nonlinearity of the Present Absolute Flux Calibration Scheme

The FADC was most troubled by three presentations that showed substantial nonlinearities in the absolute flux calibration, particularly for the SWP camera. Two experiments were suggested to investigate the possibility that incorrect effective exposure times of the ITF levels are responsible for these nonlinearities. One experiment involves taking a set of graded TFLOOD exposures that match the DN levels of each of the ITF levels and then comparing the relative exposure times. The other involves mapping out the nonlinearities using existing standard star data and adjusting the effective exposure times iteratively until the nonlinearities disappear in processed spectra. **The FADC recommends that these and other lines of inquiry be given the highest priority, so that this problem can be resolved quickly (or at the very least, documented).** We do not wish to see the determination of the absolute flux calibration and the start of the Final Archive processing delayed by more than one month.

7 Final Archive absolute calibration plans - Reported by Dick Shaw

The FADC was most impressed with the accomplishments of those participating in the effort to derive an absolute flux calibration for IUE. **We endorse the plan to use White Dwarf stars, in particular G 191B2B and CD−38°10980, as the basis of the IUE relative flux calibration.** We were convinced that the intrinsic flux distribution of these stars is known from model atmosphere calculations to better than 2%, and thus will provide a far more accurate relative calibration than would be possible using the previous OAO and TD1 standards. We recognize, however, that the traditional OAO and TD1 standards must be used to determine the variation of sensitivity with time and temperature for the three IUE cameras. For this purpose, we believe it best to use the

1984–85 calibration observations as the zero-point epoch. Testing and evaluation of the relative flux calibration should extend beyond objects with spectra similar to the stars used in the calibration itself and should include, for example, power-law spectra such as those from active galaxies.

The FADC also recommends that work continue through the first part of June 1991 to determine whether the new white dwarf standard stars can provide a more accurate absolute flux scale as well. The viability of this approach should be evaluated, in part, on the basis of consistency with the rocket observations of the OAO and TD1 standard stars, as well as more recent rocket observations (if applicable). In the event that the white dwarf models are not used to set the absolute scale, then that scale should be set using the OAO/TD1 standards in the approximate wavelength interval 1900–2300 ÅÅ, where the two experiments show the greatest agreement.

8 Final Archive absolute calibration plans - Reported by Tom Ayres

The historical calibration of the IUE spectrometers has been based on a comparison between the apparent signal levels of a group of "standard stars" – principally the early-B main-sequence star η UMa – and absolute radiometry of those same stars by a variety of satellite and sounding rocket experiments. Unfortunately, significant disagreements exist between the fundamental calibrations in the region longward of Lyman α and C IV 1550 Å: in effect, the IUE scale is tied there by a Johns Hopkins rocket flight in the late seventies by Brune and collaborators. Recently, a significant systematic error in the IUE calibration scale in that interval has been reported based on interpretations of DA white-dwarf spectra (which are belived to be intrinsically featureless) by D. Finley and collaborators at Berkeley. Systematic errors of up to 15% should not be considered surprising owing to the extreme difficulty of performing reliable absolute flux instrumental calibrations in the far-UV, particularly for satellites like OAO-2 and TD1 which can be calibrated only pre-launch. Indeed, the fundamental reference standards, NIST photodiodes, probably cannot be trusted to better than ± 10% below 2000 Å.

Concern over possible systematic errors in the IUE flux scale, and a desire to obtain the most reliable absolute calibration for the Final Archive, led to a meeting on the subject at VILSPA in December 1990. The concensus of the participants was to adopt the DA white dwarfs as the new radiometric standard for the IUE flux scales, based on the simplicity of the Planckian energy distributions and the confidence of the modelers in their ability to predict the spectral slopes to an accuracy far better than can be attained in a laboratory calibration of a far-UV spectrophotometer. In practice, the white dwarfs would be utilized as transfer standards to establish the relative wavelength response of the IUE spectrometer sensitivities, while the absolute level of the calibration would be determined at a particular wavelength (probably longward of 2000 Å, and conceivably even in the visible) where independent absolute calibrations of, say, η UMa agreed among themselves and were deemed to be sufficiently reliable (preferably to ± 5%, or better). To that end, the IUE Project is conducting a major observational effort – the CALathon – this spring (1991) to obtain an "optimum" series of large-aperture point-source low-dispersion spectra of two DA white dwarfs (including well-exposed and 2-3X overexposed images) as well as the historical standard stars. In addition, a series of high-dispersion spectra of the WD's are contemplated for use in a modern-epoch refinement of the high-dispersion absolute calibration.

The change in the basis of the IUE absolute calibration is one of the most far-reaching enhancements envisioned for the Final Archive, in part because it affects other missions like HST which rely upon IUE for their calibrations. Implementation of the new primary standard has been agreed at least in principle by the Three Agencies, but a number of practical questions remain to be resolved:

1. Should the new calibration be defined as a "correction factor" to the old calibration which would be applied ex post facto, for example at an RDAF? The concensus of the FADC was that if the historical calibration of the IUE is systematically in error, then it should be abandoned in favor of a more modern version. The new calibration should be applied as THE calibration, rather than as correction factors.

2. Should the white dwarfs be used to define not only the relative response of the spectrometers, but also the absolute level? The FADC agreed that while the cited error of the model-derived absolute scale (about $\pm$ 7%) is superior to the precision of any laboratory-calibrated radiometry shortward of 2000 Å, that is not necessarily the case longward of 2000 Å. Thus, the calibration team should endeavor to identify an appropriate "peg-point" to tie the WD relative calibration to the satellite/rocket scales. Further, in applying the "peg-point", the predictions of the WD absolute scale should be considered as well, perhaps on an equal basis to the laboratory-calibrated radiometric experiments.

3. How does one treat the interval around Lyman alpha in a WD-based flux calibration? The model predictions for the Lyman alpha region are uncertain, and there is the additional uncertainty concerning the ISM absorption. The hot DA WD G191B2B displays only a relatively weak Lyman alpha absorption in its low-dispersion spectrum, it probably would be sufficiently accurate to simply interpolate the derived calibration over the about 40 Å interval affected by the broad Lyman α damping wings.

4. How to calibrate the LWR camera which is no-longer functioning normally? The IUE Project has recommended deriving a correction to the IUESIPS calibration of LWP based on the new WD-based flux scale, before applying the correction factors to the historical LWR calibration. The FADC endorses this sensible strategy, because new calibration observations with the LWR camera would be of questionable value given its present operation at reduced high voltage and concerns about the stability of the camera now that it is no longer used regularly.

5. What should be the zero epoch of the absolute flux calibration? The FADC favors a zero epoch of 1984-85, which corresponds to the epoch of the new ITFs and to a period of extensive observations of the standard calibration stars. It also is a more appropriate epoch for measuring the sensitivity degradation of the cameras, since it lies halfway between the original calibration epoch (1978-79) and the present. The existing sensitivity-degradation monitoring of the standard stars provides an accurate mechanism for transfering a current-epoch calibration of the WDs back to the zero epoch of the new ITFs.

6. A final issue concerns the high-dispersion calibration, although it was not specifically discussed at this meeting of the FADC. At the previous FADC meeting it was suggested that a high-dispersion calibration must be derived simultaneously with the echelle blaze correction. Furthermore, the interorder flux problem at the short wavelength ends of the formats must

be solved before either the absolute calibration or ripple-correction can be derived. Thus, the development of a reliable absolute calibration for high-dispersion spectra – based, say, on the echelle observations of the DA WDs – must be deferred until a specific strategy for extracting the echellograms has been decided and implemented. However, high-dispersion observations of the DA WD calibration stars should be obtained soon to speed up the implementation of and WD-based calibration strategy once the strategy is accepted by the Three Agencies.

9 Using white dwarfs for the IUE calibration

Koester and Finley summarised the status of the work performed to determine the relative and absolute IUE flux scale from spectra of white dwarfs. The FADC commends the IUE Project for performing a rapid and comprehensive study of this vital problem, including the scheduling of many new observations on a short timescale.

Regarding the relative flux scale (i.e. the slope of the spectra within the IUE wavelength range), the accuracy of the model atmosphere calculations is dependant on the type of white dwarf under consideration, but is a few percent for DA types with T_{eff} between 20,000 K and 70,000 K. This uncertainty includes estimates of the technical and physical approximations used. The main astronomical uncertainties come from determining the effective temperature, gravity and helium and metal abundances. Finley showed optical spectra of sufficient quality to accurately determine these parameters for three white dwarfs proposed as possible flux calibrators for IUE. Some of the physical parameters used in the models can also be cross-checked using Exosat data and by fitting the Lyα line. Using data for G131−B2B, CD−38° 10380 and 0549+148, Finley derived IUE calibration curves (S^{-1} type curves) which agree to within 2% in 10 Å bins. These curves differ by up to 20% from the current standard IUE calibration curves. The differences are similar to those seen when comparing BL Lac object spectra with constant spectral index powerlaws. Therefore the relative flux scale of IUE determined from white dwarfs seems well established, and in the opinion of the FADC should be adopted.

It is not yet clear whether the absolute flux scale (i.e. the zero point of the flux calibration) should also be adopted from White Dwarf spectra. The models can be used to set the ultraviolet flux scale using the optical/ultraviolet flux ratio given by the models and an accurate optical flux measurement. The current accuracy of this process is estimated at better than 8%, and will probably be reduced to 5% or less, particularly if more white dwarfs are included in the calibration dataset. If this process is not completed by the summer to the satisfaction of the IUE project, the FADC recommends that the current set of standard stars be used to set the absolute flux scale, using the wavelength range (around 1900 - 2300 Å) within which the fluxes of the standards determined from several experiments agree.

10 Preparations for Running the Final Archive System

10.1 Core Data Item Verification

The FADC observed that a workable verification system is essentially developed and in place. The recommendations address some concerns expressed by the committee, and the likely need for evolutionary refinement as experience is gained with the system.

Continuing attention should be given to improvements in ergonomics and user friendliness of the verification process, including such factors as menu access, consistent control key functions, data screen organization in relation to observing scripts, and computer checking for data items in typical ranges and for likely consistency among related entries. Database field entries that are taken directly from the header should be highlighted for special checking in the database section of the menu.

Ongoing effort will probably be required to refine procedures in order to minimize oversights, mistakes, and effects of operator boredom or fatigue. Tests should be performed initially and periodically to assess the rate of error inclusion in the database. Current estimates are that the average time required to verify core data items is about 6 minutes per image.

As previously agreed, all corrected descriptive data, along with the unmodified original header, are to be included in the archived database. Additional descriptions, such as the specification of the reference point in use, should be included as comments in the database. Graphic image scans of the actual observing scripts will speed the verification process and should be included in the archives.

10.2 Commissioning and Running the New Processing System

It is evident that Project personnel have given a great deal of careful attention to the implementation of the new processing system, specifically planning for automation (including error checking), streamlined operator interfaces, and staffing arrangements to utilize available expertise.

A very important provision for assessing the quality of the output products from the automated reprocessing system will be the visual screening of each processed image by personnel with experience equivalent to that of resident astronomers. The integrity of the final products depends strongly on this step, and it is here that careful testing should determine the appropriateness of adjustable parameters used in the automated processing. Continuing as an integral part of the process, this screening should also serve to identify anomalies in the processing or specification of individual images. One suggestion is that the routine display of histogram diagnostics could instantly reveal many types of anomalies in the processed images.

Apparently, the nominal timeline of 3 years for reprocessing the entire archives can be maintained using the computing facilities recently acquired by the Project, with the anticipated addition of 4 to 6 more terminals.

11 FADC Recommendations for the Final Archive Schedule

1. The Three Agencies should create a proceedure for deciding when to begin pipeline processing for the Final Archive.

2. We encourage GSFC and VILSPA to coordinate their schedules for processing the Final Archive.

12 High Resolution Extraction

The centroids of the orders in high-dispersion spectra wander perpendicular to the dispersion direction from the positions predicted from the dispersion relations. As the slits used to extract the one-dimensional spectra follow the centroids predicted for each order, the extracted spectra may be in error by a few percent over wavelength intervals of several Angstroms. High-dispersion resampled images obtained with NEWSIPS with a different geometric correction technique, should be examined to determine whether this order centroid wandering is still present. A variety of images, including those obtained at extremes of time and temperature and at different stellar offsets perpendicular to the dispersion in the large aperture, should be examined. If any remaining displacements are smooth, predictable functions of time, temperature, and location, it may be possible to account for them in the resampling step so that the positions of the order centroids in the resampled image would be constant functions of wavelength. If not (or alternatively), the orders should be accurately tracked in the extraction process in order to minimize errors in the extracted fluxes.

13 High Dispersion OPTIMAL Extraction

As a minimum, the extraction slit must follow the spatial "wiggles" along the spectral orders - ie track the centroid for the flux or possibly use templates which represent the "fixed"" displacements. This minimal extraction can be a box car with appropriate noise model, thus an error vector is also produced. The background subtraction approach developed by Myron Smith should be investigated and included in the final archives IF this approach is shown to be an improvement.

Development of an OPTIMAL extraction algoritm is encouraged and the Project should supply whatever data are required. This work is being done by M. VanSteenberg et al. This algorithm should not be used for the Final Archive, unless it is proven to be effective.

REPORT OF THE JULY 15-16, 1991 MEETING OF THE IUE FINAL ARCHIVES DEFINITION COMMITTEE

August 29, 1991

The FADC discussed the ongoing development effort that is approaching the point where development should be completed and processing of the first data set should begin. To guide the NASA IUE Project into the Final Archive production phase, our Report consists of specific recommendations and the rationales for these recommendations.

1 Recommendations concerning Final Archive Deliverable Products

1. The NASA IUE Project should demonstrate a working prototype NEWSIPS that can process acceptable SWP low dispersion images by the time of the Three Agencies meeting in November 1991.

2. As a goal, the NASA IUE Project should also attempt to demonstrate a working prototype NEWSIPS that can process acceptable LWP and LWR low dispersion images by the time of the Three Agencies meeting in November 1991. If this development effort identifies enhancements which would also improve the results of the SWP images, they should also be implemented for that camera.

3. We urge that the IUE Project set a goal of completing the reprocessing of the whole SWP low dispersion data set (without the absolute flux calibration if it is not then available) by the time of the NASA Senior Review now planned for the Spring of 1992.

Rationale. The continued operation of IUE and the proper funding of the Guest Investigator program will require a high level of support by the Science Operations Branch at NASA HQ. Enthusiastic support by the upcoming Senior Review is probably required for this to occur. The Senior Review will almost certainly respond favorably with a strong endorsement of IUE if the spacecraft remains healthy, the scientific output remains high, and the Final Archive is clearly far along in its implementation. This latter point will likely be important to the Senior Review Panel, since its predecessor strongly endorsed the initial development work for the Final Archive. Three Agency endorsement of NEWSIPS in November 1991 at least for the SWP low dispersion data is required for the timely beginning of reprocessing of this data set, leading to its completion by the time of the Senior Review.

2 Recommendations concerning the Best Default Processing Scheme for Noisy Regions of the LWP Camera

1. The IUE Project should continue studies to determine whether improved techniques in constructing the LWP ITF will yield improved cross-correlation strengths and improved signal/noise in the extracted spectra.

2. If the present procedure for applying the ITFs in NEWSIPS does not provide significant improvement in the signal/noise of extracted spectra for the noisy regions of the LWP camera or other cameras, then the default algorithm in NEWSIPS may be to smooth the ITFs in these regions.

3. To align the data image with the ITFs in regions of low cross-correlation strengths, smooth interpolations/extrapolations of the shifts from the surrounding regions may prove necessary.

4. The criterion for determining whether to smooth the ITFs in noisy portions of the LWP or LWR cameras should be defined. One promising possibility is to cross-correlate the ITF with the PI images, since if the fixed pattern noise persists, or gives an anti-correlation, then the ITF is not appropriate in its new form to the science images. When this proves to be true, the ITF should be smoothed.

Rationale. The LWP camera contains a noisy patch (corresponding to the wavelength region below 2500 Å) where the new processing scheme yields low cross-correlation strengths and often decreased signal/noise in the extracted spectra relative to IUESIPS. Since the fixed pattern may be weak or not present in this region of the image, then nothing is accomplished by using an ITF with large pixel to pixel variations.

3 Recommendations concerning the Development of an Improved Cross-Correlation Technique

Although the adopted cross-correlation technique has produced noticeable improvements in S/N over current IUESIPS for many images, there are cases for which the cross-correlation is poorly defined and the resulting S/N seems degraded (e.g. the short wavelength region of LWP).

In order to improve the quality of spectra processed by the prototype NEWSIPS to be delivered by the Three Agencies meeting in November 1991, we recommend that a series of questions be answered to the best extent possible within the limited time available. These questions address the critical need to understand and characterize the shifts that occur between the science images and the ITFs, to determine why the existing cross-correlation technique fares poorly in some cases, and how to make the cross-correlation technique more robust and reliable.

1. Is it sufficient to search for translational shifts between small patches in the images and the ITFs, or should other possible distortions such as stretching, rotation, and shearing also be considered?

2. Do either the shifts revealed by the cross correlations or the performance of the cross-correlation technique itself show any systematic behavior with time, temperature, DN, or position in the cameras?

3. Could some parameters (e.g. window size), which had been optimized initially in experiments with SWP images, be adjusted to give better results for LWP and LWR?

4. Is there a systematic relationship between the strength of the cross correlation and the magnitude of the detected relative shift?

5. Do the poor results for the short wavelength region of LWP camera result from the fixed pattern being overwhelmed by random residual charge left in that region after the camera is readout, and are the apparently poorer results thus more realistic?

Any systematic behavior determined in investigating such questions could provide assistance in accurately registering the science images with the ITFs when the cross correlations are weak; if such additional information is used in particular cases, it should be noted in the processing history for those images.

When the IUE Project begins to work on the high-dispersion data, we recommend an investigation into the availability of cross-correlation alignments for high-dispersion spectra at the short-wavelength end of the cameras, especially the SWP. There the order overlap may cause difficulty in routinely providing sufficient alignment points.

Rationale. Proper flat fielding to remove the fixed-pattern noise in IUE images depends on accurate registration between the science images and the ITFs. This is accomplished in NEWSIPS via a cross-correlation routine which attempts to match the fixed pattern in the background of the science image with that in the relevant ITF level. This registration step is crucial to all subsequent processing, as:

- the ITFs are no longer smoothed,
- the reseau positions (which are used in IUESIPS implicitly to align the science images with the ITFs) apparently do not track the fixed pattern in detail,
- and there seems to be some correspondence between the "strength" of the cross correlation and the signal-to-noise ratio in the resulting photometrically corrected image and extracted spectrum.

4 Specific Recommendations Concerning the List of Proposed Analyses for NEWSIPS Enhancement

The FADC recognizes that the amount of time and resources to address the remaining problems with the NEWSIPS prototype system are limited, so that the list of recommendations for further study are also necessarily restricted to the most important analyses, presented in order of decreasing priority.

1. Study the images. This rather obvious recommendation is also the most important, in that one's intuition about the most useful studies or techniques to pursue ought to be guided by blink-comparing the raw images with the ITFs and processed images. Linde and Dravins demonstrated this point for IUE data over 10 years ago, and the subsequent successes of NEWSIPS can be traced to the exploitation of these techniques.

2. Look for potential causes of a change in the fixed-pattern, beyond THDA. It may be that the fixed pattern is affected by the state of the camera after the immediately

previous exposure, or that the fixed pattern changes slowly with camera age, or with some other as-yet unidentified state of the instrument.

3. Determine the THDA dependency of fixed pattern shifts. It is important to determine the magnitude of the maximum shifts that can be expected in order to adjust the search radius of the cross-correlation routine. The current limits were based upon the shifts found in a limited number of SWP images, but this should be determined separately for each camera, and upon several images with the most extreme THDA deviations from that of the ITFs.

4. Optimize the cross-correlation algorithms and parameters (cf. Section 3). Once the maximum expected shifts (based upon the THDA study above) have been determined, the other parameters of the cross-correlation code can be optimized. It may be, for example, that the size of the template must be decreased in order to avoid erroneous shifts and/or diminished cross correlation strengths that would be caused by image rotation, shear, etc. of the raw image relative to the ITFs. It may be beneficial in this case to allow for a template size that varies with position on the image: larger sizes in the center where the shifts are usually small, and smaller at the edges where the shifts and shear are greatest.

5. Reexamine the viability of the LWP and LWR ITFs—i.e., should any contitutent images be rejected? The cross-correlations among all the images that compose each level of each ITF may reveal images should not have been co-added, owing to large relative shifts, at least without first resampling them. If such inappropriate images were included, the resulting cross-correlations with and photometric corrections of the science images would be degraded.

6. Cross-correlate several LWP and LWR PIs with their corresponding ITFs. If the nature of the fixed pattern has changed or if its amplitude has decreased relative to other sources of noise (owing to changes in the camera that are not well understood), then the fixed pattern in the ITF may anti-correlate with the background in photometrically corrected images. If a residual fixed pattern (or its inverse) remains, then the Project should investigate whether smoothing the ITFs is appropriate (cf. Section 2).

7. Compare the gain in signal-to-noise ratio (SNR) of co-added spectra from NEWSIPS to that from IUESIPS, and to that expected from a noise model. Also compare the FFTs of these coadded spectra to determine the nature and magnitude of the noise as a function of the number of spectra coadded. This study will help identify the nature of the remaining noise (i.e., it is systematic or random?), and therefore will set upper limits on the magnitude of further enhancements that might be expected from the NEWSIPS algorithms. Since time is so limited, we recommend that the IUE Project provide the FADC with the LWP and LWR images and spectra that were specified in earlier Project reports for scientific verification of the prototype processing system. These spectra will permit this study of the noise properties to proceed with minimal effort by the Enhancements task.

8. Build an improved noisemodel, and determine whether it (or some other parameter adjustments) will eliminate the linearity problems created by the SWET extraction (cf. Section 7).

9. Determine the intensity dependency of fixed pattern shifts (cf. Section 5). This study is particularly important for the LW cameras, in that the inter-level shifts in the ITFs have never been studied for these cameras. These shifts could be partly responsible for the lower SNR in processed images, as compared to the SWP camera.

10. Process and examine camera baseline and sensitivity monitoring images, and study their cross-correlations with the ITFs. These images may be the best candidates for revealing any time-dependent changes in the fixed pattern. This study is also crucial to determining whether a new ITF should be taken for one or both of the functional cameras before the end of IUE operations.

11. Create an LWR ITF in raw space from UV-Flood images taken in 1978 and process several science and camera baseline images with that ITF. If the cross correlations are stronger between this ITF and some (presumably earier epoch) science images, and the resulting SNR of processed images is higher, then a two-epoch calibration for LWR may need to be implemented. The emphasis of this lower-priority study should be to determine whether the applicability of the ITFs is time-dependent, and not to implement a two-epoch calibration.

Rationale. Since the SNR is greatly improved for most all SWP images, and only *some* LWP and LWR images, it is important to take this last opportunity to investigate the root cause(s) in order to enhance the scientific utility of the entire archive. But since time and resources are extremely limited, the questions to investigate must be limited to those which have the best chance of solving the remaining problems. We encourage the Enhancements task members to reexamine the ideas and methodologies used in the prototype processing software and to use their intuition to guide their investigation. While we also recommend that the prototype code and parameters be optimized for each camera, it is not at all clear that this approach alone will ultimately solve the problem of lower SNR in the LWP and LWR images.

5 Recommendation Concerning Systematic Shifts that Depend on DN Level in the Spectra

We recommend the following test for the existence of spectrum shifts with DN. Select 3 trailed spectra at each of 3 exposure levels (say 50%, 100%, and 200%) for the SWP, LWP and LWR cameras. Then for each camera cross-correlate with the appropriate DN level on and off the spectrum in several boxes (perhaps 10 x 20 pixels each), and display the vector errors. The vector differences should be the same as the differences between the alignment of the ITF levels.

Rationale. This is our last chance to confirm and perhaps understand the shifts with DN that are apparently seen in the flat fields that comprise each ITF. If these shifts also occur in well-exposed spectra relative to the background, then we know why the present cross-correlation scheme (which only uses the background) inproves the S/N of the background but not the spectrum.

6 Recommendations concerning the Low Dispersion Extraction File

1. We recommend that the IUE Final Archive include an extraction record in the MELO file that contains a flux calibrated spectrum derived using the "Signal Weighted Extraction Technique" (SWET) formerly called "Optimal".

2. In addition to other records in the extraction file that include: wavelength, ν flag records, FN Background, FN NET, FLUX (ABSOLUTE), and SIGMA (output from the SWET extraction), this file should also contain a "Difference" record. This record is obtained by differencing the SWET-extracted spectrum with an simple Boxcar-extracted spectrum. We note that this assumes that the flux calibration would be the same or at least similiar for both extractions. There is only one flux calibration, however, and that is derived using the SWET extraction.

3. Both the difference and error records should include data in units of erg cm^{-2} s^{-1} $Å^{-1}$.

Rationale. The Difference record will afford users a means of comparing results obtained by two different extraction methods. This insures that spectral features that are possibly corrupted or distorted in either the SWET or a simple Boxcar extraction method can be identified at the data analysis stage. Since there is only one extracted spectrum, novice users of the Final Archive data will not be confused.

Our recommendation that "Optimal" be renamed SWET is in response to Yoji Kondo's request for a new name for the extraction algorithm.

7 Recommendations concerning the Extraction Algorithm

We recommend that the SWET (previously called "Optimal") algorithm be changed to properly treat spectra in which a significant portion, such as the short wavelength regions of the LWP and LWR images, have negligiable flux. When this happens the extraction algorithm should assume that the profile in the negligiable flux region is the same as that in the adjacent region where there is sufficient flux to compute the profile, and that the centroid of the spectrum where there is negligiable flux is an extrapolation of that in the region of significant flux. There should be a ν flag indicating these regions of the spectrum

Rationale. At present SWET often computes the flux in regions of low level flux to be much lower than the flux computed using a boxcar extraction algorithm. This problem has been used as an argument against using SWET. Extrapolating the profile instead of a 15 parameter fit to the profile into the low flux region may solve the problem.

8 Recommendation concerning Absolute Flux Calibration

We recommend that the earlier UV observations of standard stars should be used as a consistency check, but that the absolute IUE flux calibration should be established using optical observations of hot DA white dwarfs. This approach should result in an absolute flux calibration whose accuracy is better than ±5%.

Rationale. The Three Agencies have adopted the earlier FADC recommendation that white dwarfs be used to determine the relative calibration of the IUE cameras. That approach is justified, because the accuracy of hot DA white dwarf temperature determinations is such that the spectral slope in the IUE range can typically be predicted to ±0.3%/1000 Å.

It is also possible to use white dwarfs to set the absolute level of the calibration by scaling the model fluxes using visible photometry or spectrophotometry. Measured V magnitudes can be used to establish the stellar flux at 5490 Å to a precision of 2–3% (or better), while spectrophotometric measurements have quoted uncertainties of ±3% to wavelengths as short as 3400 Å. Models may be used to splice IUE fluxes to ground-based spectrophotometry with negligible errors due to temperature uncertainties ($\leq$ 0.1%, and typically 0.05% from 3100 to 3400 Å). V magnitudes may also be used to predict UV fluxes with comparable accuracy: temperature uncertainties are such that fluxes at 3100 Å relative to 5490 Å can be predicted to within ±1% (and typically ±0.5%). Therefore, errors in UV flux predictions for hot DA white dwarfs using visible measurements are dominated by the uncertainties in those measurements, which are typically 3% or less for an individual object.

The effect of the random measurement errors on the absolute flux level determination will be further reduced by using an ensemble of WDs for the calibration. Since the absolute fluxes are tied to ground-based measurements, no assumptions are needed concerning the angular diameters of the WDs.

Alternatively, the absolute flux determination could be based on earlier rocket and satellite measurements in the UV. However, those measurements are subject to external errors of ±15% or greater.

[Subsequent to the FADC meeting, Dave Finley sent a message saying that initial indications from Mario Perez's comparison of η UMa and the white dwarfs are that the absolute flux calibrations using the two classes of stars agree to better than 1% when fluxes are averaged between 2400 and 3000 Å.]

9 Next FADC Meeting

The next meeting of the FADC is tentatively scheduled for Monday November 18 at GSFC to preceed the IUE Three Agencies meeting tentatively scheduled for November 19–21.

REPORT OF THE NOVEMBER 18, 1991 MEETING OF THE IUE FINAL ARCHIVES DEFINITION COMMITTEE

December 5, 1991

The Report of the July 15-16, 1991 meeting of the FADC contained a set of specific recommendations to guide the development effort as it was approaching the time for the coding of NEWSIPS before commencement of reprocessing of the first data set. The FADC is very pleased that the the NASA development team has followed all of these recommendations and has found solutions to most of the outstanding problems. Our report for the November 18, 1991 meeting will, therefore, be very short. Since nearly all of the problems that have characterized the Final Archive development effort for low dispersion images are behind us, we believe that processing of the low dispersion data set should begin quickly. The remaining development effort should be concentrated increasingly on the high dispersion images.

1 Recommendation concerning a new ITF for the LWP Camera

The FADC recommends that an investigation of possible variations in the null level of the LWP camera be performed as a first step towards obtaining a new ITF. A final decision to proceed with a new ITF for the LWP camera should be made following an analysis of the effects that changes in the null level (if any) introduce into the cross-correlations.

Rationale. The abrupt change in the LWP camera characteristics soon after the last ITF in 1984 implies that the fixed pattern has evolved and therefore the cross correlations are less confident for LWP data obtained since that time. Consequently, the photometric correction for these images will not be the most appropriate or of the best quality. It is critical to solve this problem either by corrections for changes in the null level since 1984 or by the use of a new ITF.

2 Recommendation concerning Absolute Flux Calibration

The FADC reaffirms its previous recommendation that the absolute flux calibration of IUE data should be established using IUE observations of hot DA white dwarf stars and model atmospheres. The absolute flux level should be set using absolute photometry/spectrophotometry. We recommend that this calibration be subject to an independent scientific verification using the relative fluxes of BL Lac objects (and/or other simple hot continuum sources like subdwarfs) as checks on calibration errors.

Rationale. We described the rationale for the use of hot DA white dwarf spectra as the absolute flux standards for IUE in the Report of the July 15-16 meeting of the FADC. No new information has come to our attention to change this conclusion.

3 Recommendation concerning the Development and Reprocessing Schedule

The FADC recommends the following schedule for development and the start of processing for the Final Archive:

1. Begin processing low dispersion SWP images in January 1992. We agree with the plans presented to us that the initial effort will be partial processing through the geometric rectification/resampling step which produces the LI file. We are pleased that the development effort for processing SWP-LO images is now complete, except for coding and testing in the P-Midas environment. It is desirable that partial processing of nearly the entire SWP-LO data set be completed by the time of the NASA Senior Review in the Spring of 1992, and that the extraction of the SWP spectra and their final absolute flux calibration be completed by July 1992. We note that this stage of the processing is contingent upon the receipt of the absolute flux calibration files, which is the responsibility of VILSPA.

2. Complete the remaining development work for the LWR camera, such that complete or partial procesing of the low dispersion LWR images can begin immediately following the completion of processing of the SWP-LO images.

3. Complete the development work for processing the LWP low dispersion images, including construction of a new LWP ITF should this be required. We recommend that processing (or partial procesing) of the LWP-LO images begin immediately after the completion of processing of the LWR-LO images.

4. Begin the development work for the SWP high dispersion images after the completion of the development work for the low dispersion images. We request a presentation by the Final Archive development team of the preparations for processing of the SWP-HI images at the next FADC meeting, which will occur shortly before the next Three Agencies meeting (probably in May 1992).

Rationale. The FADC believes that processing the low dispersion images should preceed the high dispersion images, because the development work for the low dispersion images is more mature and less risky. Also, the scientific benefit of providing the astronomical community with the complete high quality low-dispersion data set in a timely manner far exceeds the benefit of providing a mixture of low and high dispersion data in a piecemeal manner. Finally, the processing of the complete low dispersion archive before any high dispersion images will provide the development team with the maximum time to develop technical approaches to processing the more difficult high dispersion images.

4 Recommendation concerning SWET Extraction

The FADC is pleased by the solution of the missing flux problem at low DN levels and other improvements in spectral extraction that have resulted from the use of bicubic splines and other modifications to the SWET code. We recommend that these changes in the code be adopted for use in producing the Final Archive.

5 Recommendation concerning trend analysis

The FADC recommends that the Final Archive development team evaluate the smoothing inherent in IUESIPS by using trend analysis and Fourier transform techniques.

6 Next Meeting

The next meeting of the FADC should be scheduled for shortly before the next Three Agency meeting (presumably in May 1992). A major agenda item for this meeting will be a review of the development effort to prepare for the processing of high dispersion images.