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ESA IUE Newsletter No. 47 — January 1997

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OBSERVATORY CONTROLLER'S MESSAGE

Willem Wamsteker

ESA IUE Observatory

When this ESA IUE Newsletter reaches you, the rundown phase of the IUE Operations has been completed, and the project is now fully oriented towards a proper completion of the **IUE** **F**inal **A**rchive (**IUEFA**). The IUEFA is the legacy of 18.5 years of in-orbit operations of the International Ultraviolet Explorer (IUE) Satellite, which resulted in 104,470 spectral images. As such, this will represent the historical record of the observations made with the IUE Space Observatory, and we hope that, at completion, it will be worthy of the Operational IUE Project.

This Newsletter is to some extent a memorial issue for IUE Operations where we reproduce the words, spoken by various dignitaries, at the occasion of the end-of-operations ceremony in VILSPA on 30 September 1996. I see no reason to comment further on these, since they all speak for themselves and address the IUE Project from different angles.

To assure you that the remaining IUE staff has redirected its efforts to the preparation of the IUEFA, we have included some short contributions on the activities which are driving the IUEFA related work, also indicating in which directions we plan the final form of the IUE Archive. I would like to draw your attention to the experimental WWW[1]-driven ESA IUEFA data server (see this newsletter) which is currently implemented at VILSPA. We foresee to upgrade this throughout the year, as the development of the **INES** (**I**UE **N**ew **E**xtracted **S**pectra) system, will be gradually implemented and tested, in parallel with the data processing. INES will be the main support system for the final distributed IUE Archive which we intend to locate at the -currently 29- National Hosts, which have shown to be such an extremely effective, and economic, Archive data retrieval support system. An increase in the number of National Hosts is foreseen to assure full worldwide access for the future.

Rest me to wish all of you a good 1997 and again express my thanks, in the name of the full community of IUE Users, to all who have, through their efforts, contributed to the success of the operations of the IUE Project, which we can expect to be remembered as the first true World Space Observatory.

[1] World-Wide-Web

Personnel Changes

-.-

ESA IUE Observatory

Departures:

- **Alfredo Ruiz de Silva** (SC[2]) - Sep. 96
- **Antonio José Garcia Mandillo** (CO[3]) - Sep. 96
- **Armin Theissen** (RA[4]) - Sep. 96
- **Cristina Calderon Riaño** (SC) - Sep. 96
- **Cristina García Miró** (SC) - Sep. 96
- **Cristian Longhi-Bracaglia del Olmo** (CO) - Sep. 96
- **David Garcia Asensio** (SC) - Sep. 96
- **Domingo Hermoso Mariscal** (S/C Supervisor) - Sep. 96
- **Domitilla DeMartino** (RA) - May. 96
- **Francisco Javier Marcos Fernandez** (SC) - Sep. 96
- **Francisco Jose Manso Noguerales** (SC) - Sep. 96
- **Heinz Andernach** (RA) - Dec. 96
- **Herminio Perez Vela** (GS[5]) - Sep. 96
- **José Chamorro Valero** (CO) - Sep. 96
- **Jose Manuel Fernandez Cuena** (CO) - Sep. 96
- **Jose Ramon Martin Zaforas** (SC) - Sep. 96
- **Jose-Luis Casero Montes** (Photolab) - Sep. 96
- **Juan Carlos Martinez Salvador** (CO) - Sep. 96
- **Juan Piñeiro Garcia** (CO) - Sep. 96
- **Luis Suarez-Llanos** (CO) - Sep. 96
- **Maria Luisa Garcia Vargas** (RA) - Dec. 96

[2]Spacecraft Controller
[3]Computer Operator
[4]Resident Astronomer
[5]General Services

- **Maria del Carmen Rosales Alvarez** (Secretary) - Sep. 96
- **Pedro Elosegui Larrañeta** (RA) - Sep. 96
- **Pedro Gomez-Cambronero Alvarez** (IPS[6]) - Sep. 96
- **Santiago Pascual Calviño** (SC) - Sep. 96
- **Victoria Ester Moll** (SC) - Sep. 96

We wish them all the best for their future!

[6]Image Processing Specialist

Decommissioning Operations Summary Report (Day 267-274)

Ana Perez

IUE S/C engineer, INSA

1. Operations Summary

The spacecraft was under OBC control in hold/slew mode until the 30th of September at 15:30 U.T. At this time the spacecraft was placed into spin mode to carry out the N_2H_4 (hydrazine) venting and the discharge of the batteries. After the venting and discharge, the IUE was switched off at 18:44 U.T.

The observing programme has been carried out according to the 16 hours per day schedule until the 26th of September of 1996.

2. Spacecraft Anomalies

None.

3. Spacecraft Status until N_2H_4 Venting

- a. The status of the S/C was nominal.
- b. ACS[7]/OBC[8]
  1-gyro/FSS[9] control system loaded and enabled in OBC-1 (8 k memory) for attitude control.
- c. POWER.
  - Battery uv[10] detectors and 28V bus uv detector are disabled.
  - 28V oc[11] detector is enabled.
  - Both batteries 3rd electrode OFF.
  - Battery No. 1 main charger ON.
- d. HAPS[12].
  Heater group-2 ON.
  Hydrazine tank pressures:

[7] Attitude Control Subsystem
[8] On-Board Computer
[9] Fine Sun Sensor
[10] under voltage
[11] over charge
[12] Hydrazine Auxiliary Propulsion System

  - Tank D/H: 210.59 PSIA[13]
  - Tank F/B: n/a PSIA
  - Tank C/G: 272.00 PSIA

- e. DHS[14] Configuration:
  - OBC-1 ON
  - DMU[15]-1 ON
  - SBTX[16]-1 ON
  - SBPA[17]-2 ON
  - DECODER-2 Selected

- f. Thermal. The temperatures correspond to a Beta angle (SAA) of: 52.3°
  - Tank B/H: 60.9°C
  - Tank G/C: 52.3°C
  - Tank D/F: 46.2°C
  - OBC PR-1[18]: 49.1°C
  - BATT.1: 15.2°C
  - BATT.2: 10.8°C

4. Scientific Instrument (SI) until day 274

- a. The SI configuration remained unchanged.
- b. Cameras selected: LWP and SWP.
- c. Fine error sensor (FES) selected: FES-2.
- d. Spectrograph image collection during reporting period:

Camera	Nr.images
LWP	18
LWR	none
SWP	32
SWR	none
Total	50

[13]Pounds per Square Inches
[14]Data Handling Subsystem
[15]Data Multiplexer Unit
[16]S-Band Transmitter
[17]S-Band Antenna
[18]On-Board Computer Processor 1 Temperature

5. Final Spacecraft Status

- a. All equipment was switched off and both command decoder disabled.
- b. POWER.
  Both batteries were switched off after their voltages dropped under 17 volts.
- c. HAPS – Hydrazine tank pressures:
  - Tank D/H: 8.13 PSIA
  - Tank F/B: n/a PSIA
  - Tank C/G: 5.88 PSIA
- d. Scientific instrument, last image numbers:

  FES: 2794 LWP: 32696 LWR: 18765 SWP: 58388 SWR: 1181

  Total number of spectral images collected:

  Low resolution: 72,559 High resolution: 36,508 N/A[19]: 3,679

5. IUE End-Of-Life (EOL) Operations

During the last six months of IUE operations a number of special science observations (*Lasting Value programmes*) were conducted from VILSPA under single-gyro spacecraft control (in March 1996 another gyro failure left the IUE with only one functional gyro, out of the original six).

These last observations covered programmes related to planetary studies (Jupiter and its Galilean satellites), stellar winds in massive stars, and a coordinated campaign of X-ray, ultraviolet and optical observations of the Seyfert I Galaxy NGC 7469.

The **science programme** was terminated the 26th of September. The last IUE image was a high resolution spectrum of target "CAPELLA", as was the first IUE image on February 9,1978.

Transcript of the IUE Final Operations audio clip *"Turning off sequence of the science cameras* (see/hear also: `http://www.vilspa.esa.es/general_info/vt/history/iue_end.htm`):

```
VILSPA: ''IUE control - VILSPA''
GSFC:   ''IUE''
VILSPA: ''Ready to send ALL-OFF command''
GSFC:   ''Copied''
VILSPA: ''Mark - all cameras off
          - all low voltage switches for LWP,LWR,SWP off
          - low power supply off
          - all low voltage loaders off -
          - all MECS off''
GSFC:   ''VILSPA - IUE control''
VILSPA: ''Go ahead''
GSFC:   ''We see everything is turned off!''
VILSPA: ''We confirm.''
```

[19]resolution Not Applicable/Not Available

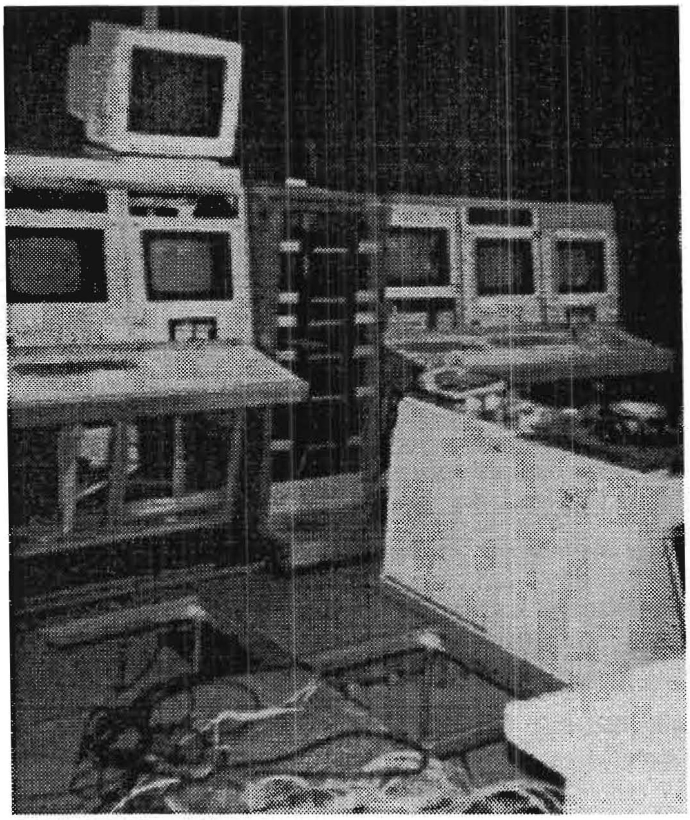
The last five mission days were dedicated to EOL (end-of-life) operations. These consisted of test of both the battery and solar arrays to determine their efficiencies after prolonged (over 18 years) exposure to the High Earth Orbit space environment.

Battery Characterization: although IUE represents old technology, important and unique innovations were applied to IUE's batteries, which will be very useful for future battery technology developments. The requested data were collected by discharging the batteries both on an individual basis and together. The minimum voltages reached were around 18 volts, which produced depths of discharge of approximately 70%. These tests also allowed very important comparative evaluations with currently operating spacecrafts.

Solar Array Characterization: since the solar array behaviour is strongly affected by the radiation environment and IUE has been in High Earth Orbit for nearly two solar cycles, the complete history of the solar panels give important information for the determination of valid radiation models for the space environment. The test consisted of collecting solar array currents at various beta angles while maneuvering the spacecraft from a low beta angle to a high beta angle. This is of critical importance for the design parameters of future missions.

The spacecraft remained under OBC control until 15:30 UT, Sep. 30, 1996. At that time, the OBC was switched off and IUE began to spin. In this mode the remaining hydrazine propellant was vented from the spacecraft, which was completed around 17:30 UT. The batteries were then discharged, and the spacecraft as a whole was switched off by disabling the telecommand receiver at 18:44 UT.

The IUE S/C operations ended on day 274 (30th of September 1996) at 18:44 U.T. after a project duration of 6,823 days.



Picture: Dismantling of the ESA IUE Observatory - December 1996
(S/C Controller Consoles)

Welcome to the End of IUE Operations

V. Claros Guerra

Villafranca Station Director

Ladies and Gentlemen,

On behalf of the European Space Agency and all staff of the Villafranca del Castillo Satellite Tracking Station, I wish to welcome you to this special event: the End of IUE Satellite Operations.

I would also like to thank all of you for accompanying us at this very singular moment and specially to our distinguished speakers who, I am sure, will tell us interesting and, may be, unknown features, discoveries and insights of the IUE Project in its eighteen and a half years of operations.

A few minutes ago a command named "ALLOFF" has been transmitted to the IUE S/C[20] and all its scientific instruments have been switched off. The remaining operation now is to vent the hydrazine from the tanks to avoid its possible explosion caused by micrometeorites and the creation of additional space debris and the command to make silent the transmitter so that the S/C will not cause any radio frequency interference in the future.

For many people here, including myself, both in my functions as Station Director and ESA IUE Mission Operations Manager, this is a very sad moment, especially because for some people, who have devoted over 20 years (nearly a complete professional life!) to this Project, there is no job continuity. As there is no replacement for IUE or a new workload for VILSPA, the exceptional support team we have formed in all these years has to be partially disbanded. I want to thank the whole team for the excellent job done and wish to all of those who leave VILSPA today the best in your future!!

I cannot miss this opportunity to emphasize in front of the Spanish delegation to ESA and the directors of the ESA Operations and the Scientific Programme, how uncertain our future is. It seems that, in spite of the difficult financial situation of the Agency, an effort should be made by all concerned and based upon the excellent support provided by VILSPA stafff to the Scientific Programs - to maintain this Centre as the Science Support Site it has been since its creation in 1976. I know that other ESA sites are also striving for their survival but the success of the IUE Project will always be linked to the exceptional support provided by all VILSPA staff. The achievements we are reaching in the ISO Project and in the creation and distribution of the IUE Final Archive, deserve that VILSPA continues in the ISO Post Operational Phase and as the XMM Science Operations Centre (SOC).

I know some studies are being currently made on the rationalization of ESA's Ground Station Network which will probably lead to the reduction in facilities. I can only hope that their conclusion will take into account not only the economical factors but also the know-how available at each site and the efficiency shown in the past years. I believe that in this area, VILSPA can hold a strong position.

Thank you again for sharing with us our concern for our future and our joy and satisfaction for the work we have done for IUE. Thank you for being here today.

[20]Space Craft

END OF IUE OPERATIONS

F. García-Castañer

ESOC Director of Operations

Dear Prof. Wilson, Distinguished Guests, Dear Colleagues, Ladies and Gentlemen,

An event like today's is always characterized by mixed feelings: a brilliant phase is finishing which is in a way sad, but brilliant results can be presented which, after all, was the objective of the project. Therefore, this get-together here today is not to concentrate on the termination of the IUE spacecraft orbital operations but to look back and summarize the achievements of one of the most successful astrophysics projects in space science.

I am sure the various speakers in the course of this event will explain the major contribution of IUE to science, so let me address the aspects concerning the IUE spacecraft and its mission.

I will start with some historical background.

Precursors

Following the start of UV[21] astronomy with sounding rockets after the World War II, the first major ultraviolet satellite was the Orbiting Astronomical Observatory-2 (OAO-2) launched in 1968 which provided photometric measurements of sources within our Galaxy and measured the brightest nearby galaxies.

Two experiments were mounted on board of the ESRO[22] TD-1 satellite, which was launched in March 1972 into a circular solar-synchronous orbit. The two telescopes provided an UV sky-survey in the range 1.350-3.000 A.

The Astronomical Netherlands Satellite (ANS), which operated between September 1974 and April 1978, observed a few thousands of stars in five UV photometric bands.

The next major UV satellite was Copernicus, which also carried X-ray instrumentation. Its observations revealed the existence of a hot, thin phase of the interstellar medium in the galactic plane and let to the determination of the isotopic abundance of deuterium along many paths through the Galaxy.

IUE

The initial studies on the IUE project date back to 1968-69, when it was known first as SAS-D (Small Astronomical Satellite) and somewhat later as UVAS (Ultraviolet Astronomical Satellite). The project eventually took shape in 1974 when the three partners Space Agencies, NASA for the United States, ESA for Europe and SERC (Scientific and Engineering Research Council), now PPARC (Particle Physics and Astronomy Research Council) for the United Kingdom, signed an agreement to jointly build and exploit a 45 cm UV telescope which was then renamed International Ultraviolet Explorer, IUE.

[21] Ultra-Violet

[22] European Space Research Organization

It was agreed that NASA would build the telescope, the spectrographs, the spacecraft and would provide one tracking station in the USA. SERC provided the four spectrograph detectors, SEC vidicons, including part of the relevant software. ESA built the solar panels and set up a second tracking station, VILSPA (VILlafranca del Castillo SPAin), for the European observers. IUE was expected to be launched in 1976 but some problems encountered during its development delayed the launch until January 26th, 1978, when IUE was finally lifted up in a clear and rather windy morning. The mission duration was estimated at 5 years.

The IUE satellite was conceived as a very flexible machine as it was able to point anywhere on the celestial sphere within 45° of the Sun, with an accuracy of 1 arcsec. The attitude control system could re-point the satellite to a new target star over wide angles with a slew rate of 5.5 per minute and per axis and guarantee that the desired target star fell, at maneuver termination, into the 16 arcmin. field of view of the fine guidance system. The control system was able to hold a 1 arcsec diameter target within the 3 arcsec entrance aperture to permit an integrated exposure of 1 hour duration by the spectrograph camera, when the spacecraft was using a minimum of three gyroscopes.

With this excellent tool in orbit the operational phase of the IUE mission was ready to start. Let me now put the operational activities in perspective.

IUE mission operations

All projects go through four important phases from their conception till their completion. The significance of each phase is:

1. The establishment of scientific objectives is at the root. It is the 'raison d'être' of a scientific project.
2. The development of all elements, i.e. spacecraft with its scientific payload and the ground infrastructure provides the tools and is a technical challenge.
3. The placing of the S/C into space is a critical phase of a very short duration (only a few minutes), but it is a "GO/NO GO" pre-requisite.
4. The exploitation of the S/C capabilities in orbit to satisfy the scientific objectives is the mission operations phase. It is the moment of truth: science will be depending on "data", or, as we call it, on "mission products" delivered to the scientists.

The provision of these mission products is the objective of operations. These products must be maximized in terms of quantity, quality and continuity by managing together the capabilities of the S/C in orbit, of the facilities on ground and the operational expertise. The mission plans and procedures are designed to make all these elements operate in an integrated optimal fashion. It is the entire system which is put at work.

Whenever any part of the space segment or the ground segment fails the system must be restored and performance again maximized.

Both elements, space and ground segment, have presented many challenges for the engineers and scientists involved in the course of the long IUE mission. The S/C subsystems have worked remarkably well although, over their lifetime, problems have occurred as had to be expected in a mission originally conceived for 5 years.

The clever design of IUE and mainly the use of a programmable on-board computer has allowed to solve many of the problems which have been encountered during the mission: IUE has been working almost continuously over 18.5 years (6.860 revolutions) and during this period the solution of failures has led to new operational aspects in order to cope with them and continue to provide service to the Astronomical Community. To mention the most relevant:

Failure of 5 gyroscopes: from the six gyroscopes at the beginning of the mission to 1 gyroscope at the end of the mission, the control system of the spacecraft had to be reviewed first to a "two gyro system" and then to a "one gyro system". Integrating an exposure could only be achieved when a bright star fell within the field of view of the fine error sensor. Track on the bright star had to be performed through a small fine slew in order to place the target light within the aperture.

The work-around solutions to on-board problems allowed to continue scientific operations at a very high level.

Financial constraints at NASA - the major partner in the IUE Project - led to its decision to terminate the IUE Science operations in September 1995. At this time, ESA was able to convince NASA that the Agency could extend its support to include full responsibility for the scientific operations under the "hybrid science operations". This posed one of the challenges for the ground segment engineers at VILSPA, who developed a method to remotely control the GSFC IUE Control Centre and the Wallops Tracking Station via an intelligent and simple system called ISLU (Interface and Logic Unit). This configuration allowed the extension of the real time operations for one additional year, being the target two years.

Unfortunately, ESA financial constraints also led to the decision made by the Science Programme Committee (SPC) of the European Space Agency in February this year to terminate IUE orbital operations in September 1996. However, this is not the end of the IUE Project as VILSPA will continue the data re-processing with a newly designed software to complete the Final Archive by the end of 1997.

At this point it is fair to say that the mission could not have been prolonged until today without the ingenuity and professionalism of all those who have managed to squeeze-out the last drops of science data from the system when it started to dry out.

In 18.5 years (or 6.860 revolutions) of operations this small, but undoubtedly successful telescope, has collected more than 100.000 ultraviolet images containing over 110.000 spectra of all classes of astronomical objects, originating an impressive number of articles and conferences based on their scientific interpretation. The last observation programmes, associated with planetary studies (Jupiter and its Galilean satellites in co-ordination with the GALILEO spacecraft in-situ mission) has demonstrated the added value of the instrument whose mission comes to an end today.

All these achievements have been possible thanks to the dedication of the scientists, engineers and staff at VILSPA. The end of a project like IUE implies that some of you are terminating your assignment here today while others will continue in the archival activities. For those who depart, I hope that the experience you have gained will contribute to your success in your new endeavours. To you all, many thanks for a job well done and good luck!

The End of the Explorer Era

L. Woltjer

President of the International Astronomical Union

Even though said many times before, it bears repeating that IUE has been an unqualified success: a thousand weeks of operation, a thousand European scientists as users, producing more than a thousand papers. IUE represents the first real exploration of the UV with important discoveries in the solar system, in stellar atmospheres, in the interstellar gas, in galaxies and in quasars. The first exploration of a scientific area always has a particular charm and excitement: little is known and much awaits to be discovered. It is a phase in the development of research to which one always thinks back with a certain nostalgia. The current generation of space astronomers in Europe is fortunate to have experienced such an exploration phase first in the UV and now again in the IR[23] with ISO. The IUE archive, still under development, will provide a lasting foundation for much future research.

However, IUE is a very small telescope. On the ground 8-10 meter class telescopes are being built with a collecting area some 500 times larger than IUE. Such telescopes are needed because most objects in the Universe are faint and only large telescopes can collect enough light to allow a detailed analysis. The nostalgia for the exploration phase cannot obscure the fact that we now are entering into a phase of more detailed and precise studies of objects way beyond the reach of IUE. Some will be studied by HST[24], others may have to wait for its successors. We certainly do not seek bigness for its own sake, but faint objects are accessible only with large collecting areas. Large telescopes in space are expensive and can only be built at an acceptable cost on the basis of the development of new technologies. It is important that such technologies are also developed in Europe.

Today, as we are pursuing new areas of research, we should realize that many of the programmes which we will undertake in the future will be based on the results of the exploration with IUE. We should pay tribute to the pioneers who conceived, built and developed the space-craft and its instrumentation and who operated it with competence, creativity and professionalism. The astronomical community in Europe and elsewhere owes them much.

[23]Infra-Red

[24]Hubble Space Telescope

Reminiscences of IUE

Prof. R. Wilson

University College London, UK

I remember being here twenty years ago for the official inauguration of this satellite tracking station which was built to operate a new observatory satellite called the International Ultraviolet Explorer (IUE). Like today, it was a perfect sunny afternoon, but we are gathered for a different and somewhat sadder purpose - to mark the demise of IUE. The project has been international in the full sense, not only in its building and operation, but even more so in its use, being available to astronomers from all countries depending only on the excellence of their proposals.

Although there is sadness in the air, I think we can look at IUE with pride in its achievements and the contributions that so many people gathered here have made to its success. In the solar system, it has observed every type of primary object with the exception of Mercury which is too close to the Sun, Pluto which is too faint, and the Sun which is too bright. In stellar astronomy, it has made a massive contribution to understanding the evolution of all types of stars. In particular, it has revealed the critical importance of dynamical effects. It has shown that all stars have winds including late-type stars like the Sun which are associated with chromospheres and coronae; in the more massive stars, the winds can be so heavy as to affect their whole evolution; dynamic effects are of particular importance in interacting binaries, that is, stars that are orbiting close enough to allow a significant transfer of material from one to the other. IUE observations conducted here in VILSPA led to the explanation of the classical nova as being a binary system comprised of a normal star and a white dwarf. The transfer of material builds up in an accretion disk around the compact white dwarf until it becomes unstable and falls onto the surface; the gravitational heating is sufficient to raise the temperature to a level where thermonuclear processes are ignited, as in stellar interiors or an H-bomb. Even greater energies are generated in the X-ray binaries where the companion is an even more compact neutron star and the gravitational energy far exceeds the thermonuclear energy. IUE has also made extensive contributions to the study of the interstellar medium and discovered that the Milky Way galaxy has an extensive, very hot (100,000° K) halo.

Despite having only a 45 cm telescope, the sensitivity of the IUE spectrometer has allowed extensive studies of extragalactic systems. I will select only one example - the double quasar. This is a single quasar which appears as two images formed by an intervening galaxy acting as a gravitational lens. It has immense cosmological significance because the time difference taken to traverse the different light paths is directly related to the Hubble constant (H_0), presenting the possibility of measuring it to a greater distance than any other method. (Remember that the measurement of H_0 is one of the prime aims of the Hubble Space Telescope). IUE measured that time delay as 1.8 years and deduced a value for H_0 as 68 $km.s^{-1}.Mpc^{-1}$.

Although we should today celebrate the great success of IUE, we should also recognize the sadness of its turn-off, not only for the astronomical community at large but, more poignantly, for the operating staff here at VILSPA, who have effectively to be disbanded. So I would like to end by addressing them directly and saying "thank-you!" for all you have done on behalf of the visiting user and astronomers, not only for the very professional way that you conducted the operations but also for the warm, friendly, welcoming and charming way that you did so.

Science with IUE at Villafranca

Willem Wamsteker

IUE Project Manager

Dear Guests, Colleagues and Friends,

Let me start with expressing my pleasure to see all of you here present. I have realized with gratitude that everybody here belongs to at least two of the above categories, and most belong actually to all three, I consider that a great privilege.

Although many of you feel that the present occasion is an unhappy one and to some extend it is, I would rather like to look at it under the concept of the fact that we have all been involved in a Project. As definitions go, a Project has to have a beginning and an end. The remarkable issue with IUE is, that beginning and end have been separated by a surprisingly long time. I am very pleased to say that we have the beginning here with us, in the person of Bob Wilson. I am still trying to figure out who of those present, would be equally representative of the end. However, this is not an important issue. The fact is that we all have been privileged to participate in a wonderful project: the International Ultraviolet Explorer IUE.

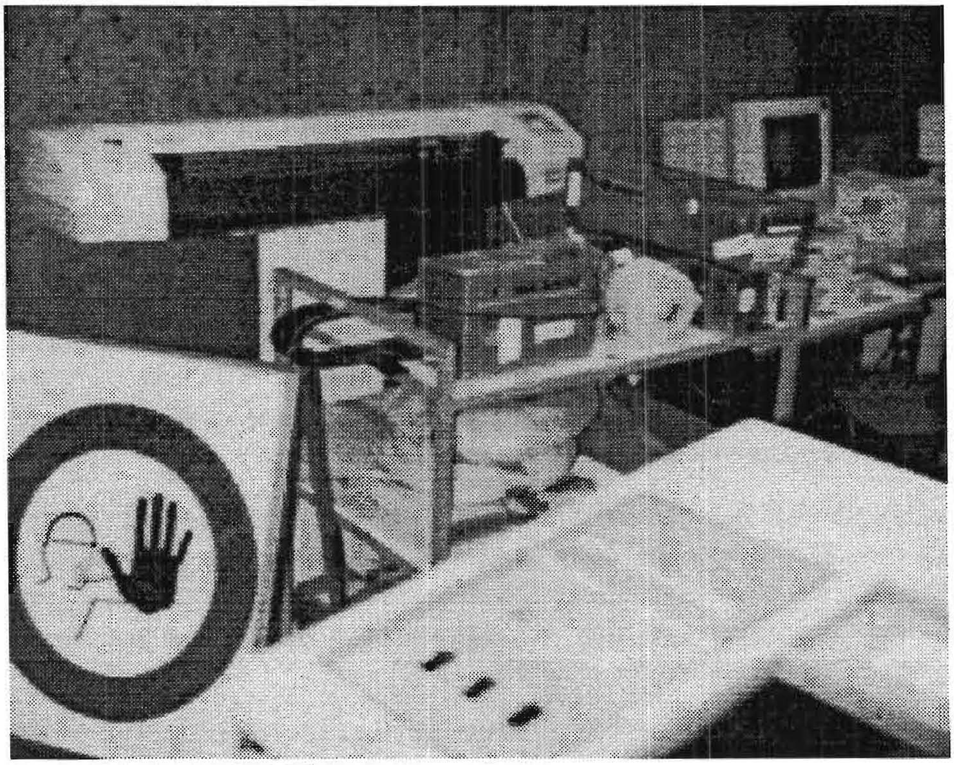
I think the two nicest things that have ever been said about the IUE Project are the words of a prominent space scientist: *"the IUE is a popular Project so that can not be serious"*. And the other one from an equally prominent astrophysicist: *"Perhaps it is no accident that the most successful projects are the least conspicuous........If this is so, then we should be careful and not talk too loud about IUE"*. In my opinion those two quotes illustrate exactly what has made the IUE project such a very special project: the whole astronomical community has felt that IUE was important for THEIR SCIENCE, be it planetary or cometary studies or the structure of the early phases of the Universe. All have felt that IUE was their instrument to clarify important scientific questions about interplanetary plasma interactions, stellar winds, conditions in the Interstellar medium, Nova outbursts, Supernovae, extragalactic star formation, the size determination of black holes in active galaxies, the mass of the neutrino and abundances in the intergalactic matter at high redshifts.

Others will tell more about the nature of the scientific accomplishments of the project and how they have experienced their interaction with the project, so I will not dwell on that too much. I would rather address for a few minutes the nature of the years that we at VILSPA and many others, not present here today, have had their interaction with the Science of IUE. Primarily I will direct myself to all those who have shared the many years we have worked together in the continued struggles to keep IUE up and running at the front lines of contemporary science, even though all its associated pieces of hardware in space and on the ground became older and older.

Before IUE was launched nobody in the scientific community, had ever heard of Villafranca. Now the whole astronomical community knows where Villafranca is and what it is. That this placing on the map has been so successful on such a relatively short time (18 years is not too long to establish the reputation of a scientific observatory!), has not in the least been the consequence of all of your efforts. You all have made it possible that the scientific activities

-only part of the work by the scientific staff at VILSPA-, and which have to a large extend been driven by the community of users, have been so successful.

I would like to use this opportunity to thank you all for the remarkable professionality, the exceptional originality and the dedication, which you have given to the IUE Project. Firstly, I do this in the name of the 2000 Astronomers who have passed through the IUE Observatories, secondly in the name of all of those who have benefited from the IUE results indirectly, and thirdly personally, since I feel an enormous gratitude towards all those who have made my years in the IUE Project an unforgettable experience through your willingness to respond, as the professionals you all are, to all my wishes which occurred to me and which at times were not so easy to accommodate, but have established firmly the dynamic evolution of the IUE Observatory over the past 18 years. *Thank you!*



Picture: Dismantling of the IUE R/T computer 'Telefile-85' - December 1996
(Front: line-printer; Middle: removed power-supply boxes of tape drives; Back: Calcomp plotter)

The Impact of IUE

Ian Howarth

University College London, UK

IUE has had an impact in many respects, but the most obvious is the impact which it has had on our science, astronomy. IUE was not the first experiment to give access to the ultraviolet spectral region, but the limited sensitivity and operational constraints of earlier missions had limited high-quality, high-dispersion spectroscopy to, essentially, no more than a handful of the brightest stars.

IUE changed that overnight. With its multiplexing ability to record a broad swathe of spectrum in a single observation, and its ability to integrate for long periods on faint sources, it quickly became a valuable – one might have said indispensable! – tool for investigations as diverse as planetary aeronomy and observational cosmology. There is scarcely any area of astronomy where IUE has failed to make an impact.

In our 'local patch', the solar system, IUE has, remarkably, observed over 100 different objects, including all the major planets except Mercury. IUE has even been used to study the Earth's atmosphere, through its geocoronal emission. This work is outside my personal expertise, and I will not comment on it further, but my ignorance should not lead one to suppose that IUE has not had a major impact, for example in the studies of comparative cometology and the photochemistry of planetary atmospheres. Indeed, the last science programme was a study of the Jovian system.

Although IUE has certainly made great contributions to solar-system science, it greatest impact has, in my opinion, been in the field of galactic astrophysics. The most important elements in the Universe –hydrogen, helium, carbon, nitrogen, and oxygen – all produce strong spectroscopic signatures in the UV; signatures which we can use to probe the physics and chemistry of an enormous range of objects.

Moreover, IUE's sensitivity and longevity has allowed not only detailed studies of individual objects, but also broad surveys of large samples. This has led, for example, to the discovery of an extensive gaseous halo around our Galaxy; to the identification of a dichotomy between cool stars which disperse energy through a chromosphere and corona, like our Sun's, and those with cooler outflows of matter, or 'stellar winds'; and to the realization of the key role of time-dependent dynamics in the winds of hotter stars.

The death of a star is pre-ordained at its birth, according to its mass. For stars similar in mass to our own Sun, that fate is to become a red giant, then a white dwarf, doomed to cool eternally. In the transition from gianthood to dwarfdom, the star sheds its outer layers, and IUE provided the first opportunity for us to study the abundances of that material in detail. The particular significance of this is that you and I are carbon-based life forms; carbon is the linchpin of *all* organic chemistry, and the most important source of carbon is dying red giants. IUE has given us the carbon chemistry of those objects for the first time.

Stars much more massive than the Sun live short, bright lives and end their days explosively. IUE has observed many such supernovae, most of them very distant, but the jewel in the crown of such studies must surely be its close monitoring of the LMC[25] supernova, 1987A. Here IUE's *flexibility* allowed it to observe the supernova just hours after its eruption, while the satellite's *durability* let us monitor the supernova for several years. In addition to detailed studies of the supernova's physics and chemistry, these IUE observations, supplemented by HST[26] imaging, have allowed a largely geometric determination of the distance to the LMC. This provides an important step in the cosmic distance scale, and one which is almost uniquely free of intermediate calibration steps normally necessary.

IUE has contributed to the study of more distant galaxies, too; indeed, it was the first satellite capable of obtaining UV spectra of objects beyond our Milky Way. Examples of work in this area include the 'weighing' of the super-massive black holes which lurk at the hearts of active galactic nuclei, and the demonstration that the famous 'double quasar' is indeed a gravitationally lensed single object, thereby laying a foundation for one of the most important fields in modern observational cosmology.

These are just a few, specific examples of the impact which IUE has had on the science of astronomy; I could easily give many, *many* more. If we were to try to identify a unifying theme, it would be that IUE has given us a perspective on the Universe as an unexpectedly dynamic environment. Not only planets and stars, but even whole galaxies vary across the range of time-scales accessible to IUE: from minutes to decades. As such, IUE has given us a whole new paradigm for viewing the Universe.

IUE has also had an impact on the way in which space science is conducted (or, at least, should be conducted). A generation of astronomers can now invest their efforts in understanding the science, rather than the hardware, of space missions. The 'observatory' concept pioneered by IUE has contributed enormously to its success, and the interaction of observers with their observations has been a key feature of that success. This has allowed IUE to take full advantage of transient events, of targets of opportunity, and of that friend to the astronomer, serendipity.

Unfortunately, this is a lesson not well learned in some more-recent missions; but the flexibility provided by IUE has meant that it has played a pivotal role in innumerable multi-wavelength campaigns, many involving other, more tightly constrained satellites. The model for such campaigns was established very early in the lifetime of IUE, by Robert Wilson's programme of observations of X-ray binaries, and more recently RIASS[27] has benefited a large numbers of astronomers investigating the relationship between the UV and X-ray behaviour of astrophysical sources.

These multi-wavelength campaigns also provide excellent examples of the unprecedented degree of international collaboration between astronomers which IUE has fostered. These collaborations are exemplified in some of the 'heroic' programmes driven by IUE's capabilities, such as the 'Lovers of Active Galaxies', led by the late Michael Penston, which evolved into the 'AGN[28] Watch', and, more recently, by the IUE 'MEGA' campaign[29] on hot-star winds. IUE has truly been a unifying force in astronomy.

[25]Large Magellanic Cloud

[26]Hubble Space Telescope

[27]ROSAT IUE All Sky Survey

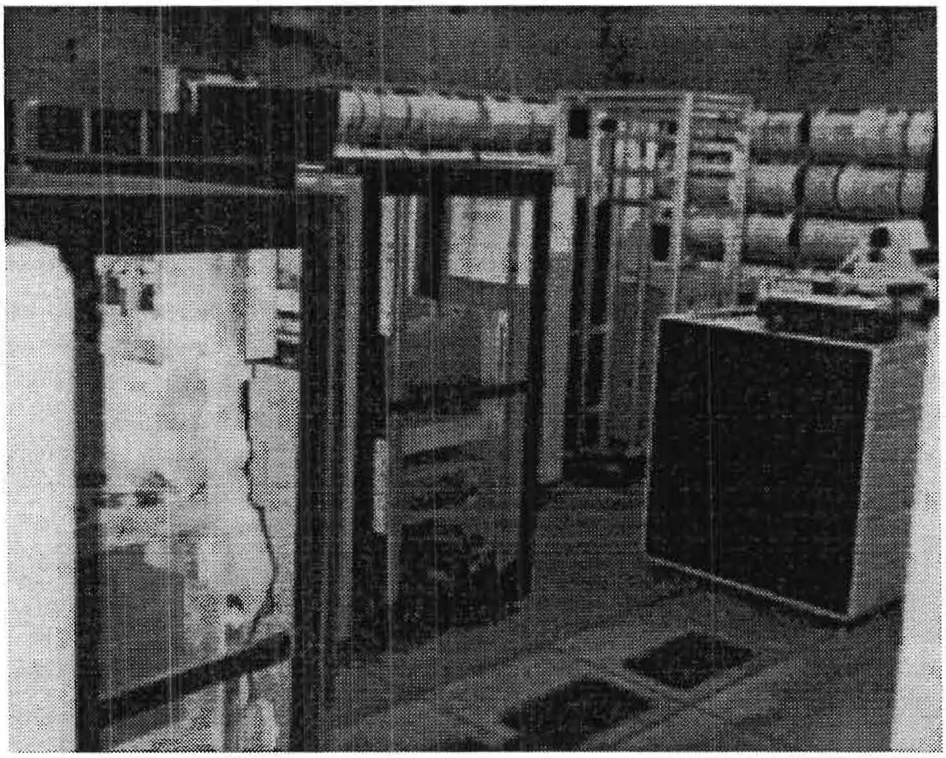
[28]Active Galaxy Nuclei

[29]Wind Variability and Rotation in Early-Type Stars, see Massa, D., et al., 1995, ApJ, 452, L53

It would certainly be remiss of me not to mention the *future* impact of IUE. The IUE Project has provided a wonderful model for the systematic archiving of data, and for the release of those data to the community. The archive must continue to be properly developed, maintained, and managed, for there is no doubt at all that it provides a scientific legacy which will continue to be of enormous benefit for decades to come. We know this because archival research with IUE data already outstrips research from some continuing missions!

Finally, of course, IUE has had a *personal* impact on many astronomers, technicians, and engineers. The statistics speak for themselves: some 2000 guest observers, and 500 PhD theses, of which mine was an early example. I saw tears in the control room as the 'EXEC ALLOFF' command was issued and completed, so I am quite sure that I am not alone in feeling a personal sense of loss today.

That loss is present in much more tangible form for many of the technical staff who have lost their jobs today. Since I'm here as a representative of the user community, both as an observer and through my association with the time allocation committee, let me take this opportunity to extend my thanks to you all. It has been your professionalism and commitment which have made IUE the continuing success which we, as astronomers, have enjoyed for almost two decades.



Picture: Dismantling of the IUE R/T computer 'Telefile-85' - December 1996
(Front left: rack still holding T-85 CPU; Right: Microvax II (the old DB machine - node MAX) with RA82 and R81 disk drives; Back: rack with I/O processor)

The Last Guest Observer

Renée Prangé

Orsay Institut d'Astrophysique, France

First of all, I wish to state that I fell extremely honoured to be here today, meeting together with so eminent persons in order to emphasize the unique importance of the IUE project, and to tell how indebted the scientific community is to all of you. I have had the feeling that I have been invited by Willem Wamsteker to talk as the "Last of the Mohicans". Am I correct? Well, officially, the program says the "Last Guest Observer". This may not be that different... Although I have been the last observer here, with a program which lasted almost 6 weeks, and although I have been quite faithful to IUE during six years, I am afraid that I remain an atypical observer, and as such, maybe, not quite representative of the whole family.

Actually, I have long been anything but an astronomer, and not even an astrophysicist. I have started my career in nuclear physics, but I found people there so quiet and activities so routine, that I could not imagine I could spend my life with them. Almost by chance, I met the director of a space science laboratory. People there were young and enthusiastic - among these young and enthusiastic people, there was Roger Maurice Bonnet - and research topics looked new, exploratory and exciting. Soon I had become a space science researcher, but I was not yet an astrophysicist. Rather a geophysicist in earth magneto-spheric plasma physics. I still only believed in particles that you can measure locally, that you can actually touch, I would say. I did not trust photons. It took me another five years before I started to be interested in the magnetospheres of other planets. And since there are so few opportunities to have an instrument on board a deep space mission, I started to find photons more and more attractive, even though you are never quite sure of where these guys really come from, nor of what they have actually done on the way before you catch them. Carefully enough, I did modeling on other people's data. Some data came from Voyager, and a vast amount of them, from IUE. I needed five or six years more before I dared to take the plunge. I thus came to VILSPA for the first time in December 1990, very late in IUE's life. The station is not easy to find, and of course, I got lost in the middle of nowhere. When, finally, I reached the top of the hill, with the impressive view of the "Castillo", I thought I had arrived to some campsite. Actually, it was VILSPA!! I must confess that it has been one of my secret dreams - I am not sure the director of the station would have liked it - to come once with my tent, and to camp on the white sand below the green trees. I have never done it unfortunately. I have been very lucky, and for my first experience, IUE offered me an outstanding event as welcome gift: the brightest ever observed aurora on Jupiter. I started also to get familiar with the observer tasks, and to enjoy sharing this collective work with the local resident astronomers and telescope operators. I had caught the virus! I have never recovered since then, and I have regularly returned to VILSPA, generally several times a year.

During the first three years, I came for a few shifts only, and, as I am slightly paranoid, I concluded that selection committees seemed to find the solar system too close, just a suburb of the earth, and as such, not of major importance. However, I must acknowledge the constant and friendly support we have always received from Willem Wamsteker. Maybe, we reminded him of his early studies of Jupiter's moon Io, and of the pioneer results he had found concerning its sulphur environment. During these years, we have mainly studied the polar aurorae of Jupiter, Saturn, Uranus, and the moon Io, participating in the long term database started by our American colleagues, still the only one existing at the moment. Then came comet Shoemaker-Levy 9 (in 1994), and the interest for solar system planets increased accordingly all over the world. We submitted a proposal coordinated between the American and European teams, and we were allocated about 50 shifts, an incredible first opportunity for us to start systematic studies of Jupiter's atmosphere, magnetosphere and moons in the farUV. This was a very exciting period, with a very heavy work load, and many real time decisions to make. Everybody at the observatory contributed enthusiastically, at his own level, to make the adventure be a real success. The first evidence of the presence of metallic ions in the impact plumes, and of the rapid darkening of the clouds during the first hours after impact due to recombination of molecular species came from IUE, and more precisely, from VILSPA. We have been busy with the analysis of these data for the last two years, and yet, we are not completely finished.

Our program this year, the last one ever executed with IUE, is a direct follow up of the Shoemaker-Levy observations, in that we wanted to analyze what remains from the impact clouds, a very thin diffuse haze, only visible at the limb of Jupiter, and we needed more data on the "normal" atmosphere to complete the analysis of the 1994 collisions. It also puts IUE in a unique position for the study of the Jupiter's magnetosphere. The Jovian aurorae are -like the aurorae borealis and australis on earth, - polar lights excited by charged particles flowing down from the magnetosphere and guided by the magnetic field. These Jovian aurorae were first detected in the farUV wavelength range, and almost simultaneously by Voyager while it was travelling through Jupiter's magnetosphere, and by IUE from the earth's vicinity. This was in 1979. The very last targets of IUE have also been Jupiter's aurorae, but now, with Galileo being in the Jovian magnetosphere and performing in-situ measurements of particles and fields. The IUE long term database which covers the whole period, is the only link which will allow to relate the measurements of these two missions, 17 years apart, more than one and a half solar cycle.

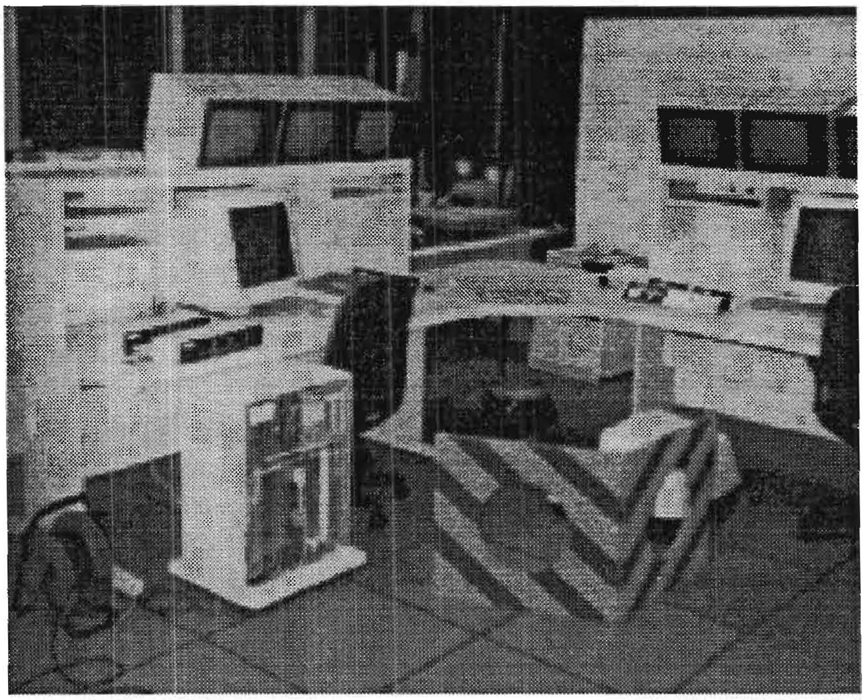
We have been offered more than five weeks of observations, out of which 8 days of round-the-clock operations. The standard schedule was based on two shifts a day, 16 hours, as VILSPA had taken the lead on the former US1 shifts in the frame of the "Hybrid operations", a considerable effort for everybody. We now come up with almost 700 images - maybe the largest IUE record - to study for the last time, and in great details, the Jovian system. We have repeated spectra of the four Galilean moons, these small dots displayed in the FES for tracking purposes. In fact, these moons are like small planets, each one has its own personality, and they have been the subject of a previous program executed last May with an American team. We were ourselves particularly interested in Ganymede, as the S/C Galileo has discovered last July that it has its own magnetosphere, and very long exposures, 16 hour in a row, were dedicated to a search for any aurora on Ganymede. We were also very interested in Io, whose volcanos sustain an atmosphere of sulphur and oxygen. Precisely Galileo has also detected a new volcano which did not exist last May, and we have taken as many spectra of the volcano as we could. These molecules can escape Io's atmosphere, some are broken in electrons and ions, and trapped by the rotating magnetic field of Jupiter to form the well-known Io plasma torus. This torus is of major importance for the magnetosphere as it is one of its major source of plasma. The mechanisms are far from being understood so far, and key information could be gained if we could more precisely describe the torus asymmetries, in particular in longitude and in local time. Having such an extended continuous program has allowed us for the first time to built a systematic monitoring of the torus by selecting the periods during which the "interesting" regions were crossing alternatively the dusk and dawn side of Jupiter. This torus, as I said, is finally the major source of ions for the Jovian magnetosphere. We cannot visualize the magnetosphere as its density is far too low, but some of the charged particles ultimately fall onto the atmosphere, and excite the polar lights. Monitoring these aurorae tells us a lot about what is happening in the magnetosphere. IUE had since long highlighted that the strength of the aurorae can vary substantially. Having been able, for the first time, to target the aurorae almost every day has immediately revealed that the timescales is of the order of a few hours to a day. This will be important when comparing with other related magnetospheric and solar wind processes. If I remind you of the atmospheric part of the program, as a follow-up of the Shoemaker-Levy collision, then I hope I have made clear that the title of our proposal: *"Completion of IUE Jovian studies"* was not any boasting. Its objective have been largely fulfilled, and only IUE could have provided us such a comprehensive, integrated study of the Jovian system as a whole.

I have two more things to emphasize. Firstly, my experience as an astrophysicist and an observer has been rather short, and I have long underestimated the difference between observing a typical astronomical object, which is fixed with respect to the tracking star and which is most often a point source, and observing a solar system target, which is by nature a moving target whose distance to the tracking object - star or Galilean satellite - varies constantly with time, often quite fast, needing constant updates of the tracking object coordinates in the FES. I had not thought either that our requirements in terms of tracking accuracy, at the very limit of IUE's capabilities, and due to the size of our planetary sources, were uncommon for other observations. I have thus realized only recently how demanding we had been to the RAs and TOs, requesting a permanent, stringent control of the tracking, hours after hours. They have all accepted these uncomfortable constraints without complaining (well,...almost without complaining...), and I want to state that I am conscious how much this professionalism counts in the quality of our data. Secondly, I have had to deal now with the new generation of space observatories, such as HST or ISO. This had led me to realize, very recently also, that IUE itself was probably "the last of the Mohicans" too as far as observing conditions are concerned. These new observatories, so sophisticated and powerful, are quite rigid. You have to define your program in the very last details at least two months prior to the execution of the observations. They are uploaded to the spacecraft several weeks in advance, and if anything happens, there is nothing you can do to modify anything. In addition, you have very few contacts with the operation team, except when you e-mail your coordinator...Observing with IUE was quite different. You were in the observatory room, with the local team, looking at the last spectrum downloaded from the spacecraft five minutes ago, discussing results or problems, or any unexpected event in real time, making a common decision and adapting the next observations to the new situation. This was *Real Time Science*, exciting and irreplaceable in certain circumstances, and we will all miss it.

Now although French and English are the official languages of ESA, I wish to conclude in Spanish, if I can.

"Quiero decirles en castellano, no solamente de parte de los "guest observers", pero también de todos los científicos en el mundo que han utilizado IUE o van a utilizar los archivos del IUE, muchísimas gracias a todos por su esfuerzo tan decisivo para el exito de este projecto. Yo quiero también dirigirme a cada uno de vosotros para desearos el mejor futuro posible, que por vuestra contribución les sería debido; y diciendo eso, yo pienso especialmente en los que van a perder su empleo hoy. Personalmente, yo no olvidaré el sitio de Villafranca, tan tranquilo que parecía de vacaciones, ni la magia de sus noches rosadas encima de las antenas, esas antenas blancas que parecen hablar al cielo. No olvidaré tampoco las largas horas - tan largas que no se sabía

si era de día o de noche, a parte del cansancio - pasadas con todo el equipo en el observatorio, haciendo juntos la ciencia en tiempo real."



Dismantling of the ESA IUE Observatory - December 1996
(Telescope Operator Consoles)

IUE's Role in ESA's Science Programmes

Prof. R.M. Bonnet

ESA Director of Scientific Programmes

Dear Friends, Colleagues

and others who have been associated with the IUE Project over the past 18.5 years, be it in the context of the original collaborations to bring the IUE Project into being, be it in your association with the Science operations in its widest context here at VILSPA, be it in the actual Spacecraft Operations itself, be it in the many support functions which are needed to make such a Project feasible, or be it in your capacity as Guest Observers or member of the Time Allocation Committees, I want to start with congratulating all of you on the exceptional job you have done in this remarkable Project named the International Ultraviolet Explorer IUE. It is clear that not all of those who have had relations with the IUE Project in any of these functions can be present here, if only because the dynamic nature of the IUE Project has made that many of those have moved on to other activities, in engineering, academic science, or administrative functions.

However in what I am going to say here, you can be assured that even though I will direct myself principally to those present at this historic occasion, all I say is also valid for those who have, through their efforts at other times, contributed equally important parts to the IUE Project. It is actually disappointing to me, that after having been here less than a year ago to celebrate the successful launch and start of operations of the ISO Project, we have to gather again for a completely different occasion, namely the end of the IUE Operations.

As ISO marked the opening of a new window for Space Astrophysics, one could say that the current occasion marks the end of an era. This era I would like to classify as the era in which Space Science has matured and become a major aspect of the observational capabilities for the Astronomical community. In the context of ESA's Scientific programmes it is interesting that IUE has always been in the realm of the Astronomical Working Group and has not entered the domain of the Solar System studies. This, even though some major contributions to the study of solar system objects such as Comets and the Jovian magnetosphere with IUE, have profoundly changed our views of the Solar System and the bodies and plasma processes thereof. As many of those who have talked before me have already addressed the more dramatic impact of the IUE Project on Astrophysics, and this is also well described in the various reports contained in the material supplied by the Project at this occasion, I will not dwell too long on these matters.

Let me first highlight that although you all may feel disappointed that the IUE Project has been brought to an end, and about the manner in which this has been done, one should also realize that the IUE Project has out-lasted three Directors General of ESA, and when I took up my function as Director of Scientific Programmes of ESA, nobody would have dared to predict that I would have had to attend a ceremony of this nature in 1996, where we end a project which is still in large demand by the scientific community and which still continues to supply excellent scientific results, as illustrated by the remarkable IUE Final Science Program in the past 9 months. Remember that IUE existed before the "Horizon 2000" and has lived into the conceptions of the "Horizons 2000" programs which supply the space science directions of ESA for the first quarter century of the next millennium. One can say that your efforts in the IUE Project have shown that the saying: "Old soldiers never die, they just fade away" is not always true.

A comparison with the last stages of operation of many other scientific satellites has shown that the lifetime of a satellite is always driven by imponderables. In some cases it is the condition of the spacecraft whereby a spacecraft simply terminates itself. In other cases a long life has been dragged out to obtain the last drop of data from the spacecraft, even though its instruments had lost sensitivity and it was like maintaining the spacecraft on life-support machines.

For the IUE Project neither of these modes has occurred. The spacecraft has on many occasions failed in ways that have terminated other Projects, but every time, your ingenuity has overcome the problems and the IUE usually returned stronger and better than before from many of these occasions. So we have not kept the spacecraft "plugged-in", the science program of IUE has been kept until the last day of operations as dynamic and vital as it was on the day of launch 18.5 years ago. IUE has in many ways been the first Project that has shown that Space is an experimental area for all scientists and not only for those few who have a great interest in building hardware. The general concept of Space Observatories has taken a strong place in the space science community as is clearly illustrated by other important missions in the ESA Science programme such as EXOSAT, ISO, XMM, FIRST, and even HIPPARCOS, although somewhat different in concept.

This concept of observatory missions has been very important for the definition of these projects, since IUE has shown that a well conceived observatory mission will supply enough data for the whole community and single P.I.'s would simply be flooded under the information content of such missions.

To keep the IUE Project operational as long as we have done has been an effort for all of you involved in the Project, especially since IUE has never been an integral part or Cornerstone of the long term planning in the ESA Science Programme. However, the dynamic nature of the science of the project driven by an exceptional interaction between the very large scientific community and the highly competent project staff, resulted always in extremely high ratings in the evaluations of IUE by the Agency's advisory bodies. As a project, IUE has always been very important for the ESA Science Programme, since it has allowed to make sure that new generations of astronomers were for the first time extremely conscious of the possibilities supplied by the access to space for astrophysics. This has made it possible that the community support for ESA's Science Programme has always been very high, and the scientific community supporting our programme has not only been growing because of the new projects, but more importantly, through the entry of young scientists with space awareness. No observatory ever has been able to have such a large number of Doctoral thesis contributions. The total of 500 theses with IUE results, illustrates clearly that the next generation of astronomers all have been in direct contact with results from IUE and therefore can be considered Space Astrophysicists.

Also the existence of the uniquely conceived and managed IUE Archive will make sure that, in the future, the legacy of IUE will stay with us. The building up of the Archive during operations, has already, at this moment, resulted in the value of the project extending far beyond the direct observations: the IUE Project with its 114,000 spectra has already supplied these data five times to requesters from all branches of astrophysics. This proves without doubt that IUE has been for the community as effective as any other observatory would have been after 70 years of operation and as you all know, there are only very few observatories, established 70 years ago, which are still valid observing sites.

You can all be also very proud of the other permanent record which your efforts in the IUE Project will leave behind, namely the more than 3,500 publications based on IUE data which represent a permanent record of the progress in knowledge which your efforts have brought to mankind. This is a record which is not equaled by any other observatory and is one of the best illustrations that your efforts have been fully recognized by all scientists in the world, and you can be assured that the results of your efforts will remain with us for a long time to come.

The future for Ultraviolet Astronomy does not seem to bode a very promising outlook, with only FUSE, a mission of limited duration and scope, foreseen to be launched before the year 2000 by NASA. Any other follow-up in the Agency planning does appear to be only remotely possible in the later part of the Horizons 2000 Plan. I would also like to highlight that a very important element in the stimulation of international cooperation in science has disappeared with IUE. No other project has been so successful in the stimulation and expanding of the general spirit of collaboration, which is essential for progress in Space Astrophysics. I also see that the creation of future science projects with world-wide collaboration, are not going to be made easier by the paths taken by our partner Agencies and the definition of their future activities.

Before I stop, I would like to highlight the exceptional work done by the whole VILSPA staff in the implementation of the "hybrid" operations mode. In this you have clearly shown that the synergy, which has been created within the ESA IUE Observatory at VILSPA, supplies an extremely important value to ESA's Science Programme. It clearly demonstrated that scientific programmes benefit enormously from this extreme flexibility in operations, where staff is applied at optimum efficiency and where staff motivation can be kept very high, even in very difficult conditions. Very significant savings can be accomplished, not foreseen at the time of the design of a project, only with the expertise associated with science operations of observatory-like missions. The demonstration that so much innovation can be done under normal operational conditions, shows the importance of the concepts developed over the years within the IUE Project. Since in the case of the "hybrid" IUE operations most of the savings have benefited the community and our partner Agencies, rather than representing a visible cost saving for ESA, not everybody has realized the importance of what has been done, but you can be assured that this has been noted very well by me. I would like to express my gratitude for the way in which you have made this complete revision of the IUE Project possible. I expect that future projects will implement the many important aspects which, for you within the IUE Project, have become a normal way of life. I am sure that it will become clear in the future that the success of the IUE Project has been in a large part due to its extremely efficient and dynamic operations concepts, and the capabilities to adjust to changing conditions both in the spacecraft, as well as in the community needs and requirements. Such a model needs to be taken into serious consideration for future missions.

In association with this, and now that ESA is going through a profound restructuring, it is important that we do not lose sight of the fact that the influence of the Transformation Programme should not only be evaluated at the level of major programmatic impact, but that also significant changes can be foreseen which will affect sites as the Villafranca Station and activities as Science Operations. Both of these represent only a small fractions of the overall programme structure of the Agency, but have an important effect on the public image of ESA. Examples of such changes can be easily seen in the site-dependence of the cost evaluation of activities to be done by ESA. It is important to invoke already at an early stage in the planning of future projects, the operational experience, not only from the side of direct spacecraft operations, but even more so from the science operations side, where you all have shown to have such an extraordinary efficiency.

Such arguments have also been the reason for the agreements on the future activities in the context of the recommendations of the "Villafranca Working Group". I was very pleased to be informed that first discussions have already taken place to explore coordination between the IUE Archival work and that required for the future ISO Archive. Similar discussions on the structure and functionality of our future Astronomy Missions XMM and FIRST will start in the near future. I am confident that through these focused activities at Villafranca, ESA will continue to support the scientific community in an equally effective and flexible way as has been done over the past 18 years for IUE. The expedient implementation of the "Transformation Programme" gives to these issues an additional urgency. The increased developments in the Spanish national environment for Space Science activities at the Villafranca site, mainly associated with the LAEFF, are obviously of critical importance for the completion of this promising vision of the future of the Villafranca site.

Allow me to wish you an equal success with the remaining tasks in the preparations of the IUE Final Archive, although, as you all must be aware, this is foreseen to last 18 months rather than 18 years! I hope that you will be able to build forward into the future at VILSPA on the successful past along the lines I have just outlined, and I hope that the preparations for the IUE Archive, as well as the preparatory work for the Science Operations Center for XMM, will proceed as efficiently as we have become used to expect from the staff at the Villafranca Station.

Let me finish with expressing my heartfelt thanks for the nearly 19 years in which you have dedicated your full professional capacity to the ESA Science Programmes in which the IUE Project represented a major part. Together with my colleague Mr. Felix Garcia Castañer, I have the pleasure to present the **ESA Certificates of Recognition** for a job extremely well done, in the name of **Mr. Luton**, Director General of the European Space Agency.

GOOD BYE, IUE !

The Calibration of the IUE Final Archive: A Progress Report

Rosario Gonzalez-Riestra

ESA IUE Observatory

The IUE Final Archive (IUEFA) will represent a major reference for other UV space experiments. For this reason a special effort has been devoted to the improvement of all calibrations, both for the wavelength and the flux scales. Also, the accuracy and internal homogeneity of the archive have been a major goal. The experience accumulated along the years and a better understanding of the characteristics of the instruments have allowed much more accurate determination of the instrumental parameters.

The improved photometric calibration relies on the derivation of new Intensity Transfer Functions (ITFs) for the three cameras and in the definition of a revised flux scale. Other parameters that affect the flux calibration (e.g., camera response times, aperture trail lengths, transmission of the small aperture, dependence of the cameras sensitivities on time and temperature ...) have been re-derived. The previous Boxcar extraction profile has been replaced by an optimal extraction technique (SWET) intended to provide a higher signal-to-noise.

The initial IUE Flux scale (as used in IUESips) was based on the flux of the bright standard star Eta UMa only. Along the years, there was an increasing evidence of systematic wavelength-dependent discrepancies between the IUE flux scale and models of objects of very different astrophysical nature (e.g. white dwarfs, BL Lac objects...). All this led to the need of a totally different approach for the definition of the IUEFA flux scale. Hot White Dwarfs were chosen as the most suitable objects for the relative flux calibration, since they have no lines other than Lyman alpha in the IUE wavelength range and the continuum is well understood, so that they and can be modeled with a high accuracy. The hot DA White Dwarf G191 B2B was chosen as primary standard to define the relative flux scale.

Several alternatives were considered for the definition of the zero point of the absolute flux scale. The direct use of the WD model atmosphere absolute fluxes was excluded due to the poor knowledge of the implied stellar parameters. The normalization of the model fluxes to optical spectrophotometry was excluded as well, to avoid the amplification of errors induced by the extrapolation over such a wide spectral range. The final choice was to define the zero point from OAO-2 measurements of some of the brightest IUE standard stars in the spectral band 2100-2300 , where previous space experiments agree best.

High quality low resolution, large aperture SWP and LWP observations of G191-B2B and standard stars made over a short period in 1991 (to minimize the effects of camera degradation), plus the normalization factor to OAO-2 measurements, were used to define absolute fluxes for a set of standard stars. These fluxes define the IUEFA flux scale, and the sensitivity curves for all three cameras and both dispersions are based on them.

For low dispersion, the above absolute fluxes are used to define inverse sensitivity functions for the three cameras corresponding to the epoch 1985. The application of the time sensitivity degradation correction provides fluxes which are directly comparable over all the IUE lifetime. Further corrections are applied to trailed and small aperture spectra to put them in a comparable scale.

The flux calibration of the high resolution data requires the detailed study of other effects with a large impact on the accuracy of the fluxes. Extraction problems are particularly important at the shorter wavelength end of each spectrograph due to the decreasing separation of the spectral orders. Differently from IUESips, NewSips subtracts a global image background. The slit size used for the extraction of the different orders has been optimized as to avoid order overlap. These two modifications have show a substantial improvement avoiding, for instance, the existence of absorption lines with negative-flux cores. The application of a revised correction for the Echelle blaze function (ripple correction) has shown an improvement in the data quality. The high resolution IUEFA spectra are also flux calibrated. The approach chosen has been to apply the low-resolution sensitivity function, plus a suitable function relating high and low resolution data.

At the time of writing, the revised calibrations are applied in the low dispersion processing for SWP and LWP. The LWR low resolution data will be processed with two different ITFs, depending on the geometric characteristics of each individual image. Therefore, two different inverse sensitivity curves are being derived.

For high resolution, the SWP software and all associated calibrations are completed. LWP and LWR ripple corrections and absolute calibrations are being determined.

IUE Final Archive Project

J.D. Ponz

ESA IUE VILSPA

Introduction

Since October 1996, when IUE operations were finished, the remaining task of the Observatory is the generation of the Final Archive. This report describes the status of the project, indicating the main activities currently in progress, together with the plans to complete the archive.

Archive production

The archive is being generated at NASA-GSFC and ESA-Villafranca is such a way that each observing station is doing the required developments in a coordinated way and processing its own data, delivering to the other site the resulting output products.

In summary, the basic elements in the archive production at Villafranca are:

(1) The raw archive, containing all observations stored on optical disks, provides input data for the processing pipeline.

(2) The image parameters, defining the main object characteristics and instrumental setup. These parameters define the calibration options, and include information describing the processing history and quality control.

(3) The pipeline, based on the new processing scheme (NEWSIPS) implemented under MIDAS. Output products are generated in FITS format, together with auxiliary information for quality control.

(4) The master archive, containing calibrated spectra and intermediate data products generated by the pipeline. It is stored on optical disks.

(5) The associated documentation, being collected and edited for future users of the archive.

(6) The archive distribution system, INES (IUE New Extracted Spectra), briefly described in next section.

Currently, the raw image archive on optical disk contains all observations collected at Villafranca and is being completed with images observed at GSFC. All the parameters associated to the images have been verified, to insure correctness and accuracy of the information stored in the database.

The pipeline production is a very automated procedure, where manual interaction is only required to schedule large job sequences and for quality control procedures. Archive production is based on two main pipelines: one for low-dispersion spectra, implemented in Ultrix, the other for high-dispersion images, based on DEC/Unix. At present, the low-dispersion pipeline is able to process LWP and SWP images, and work is in progress to complete the LWR calibration, required to process this camera. The high-dispersion pipeline is being implemented for the

SWP camera, and science verification of these algorithms have been completed with very good results.

The final stage in the complete sequence is the generation of optical disks, with images processed locally at Villafranca and received from GSFC, and the associated catalogue.

Data distribution

Preliminary requirements for the on-line data distribution have been defined. The distribution system is structured in three levels: a Principal Center, repository of the master archive version, a set of National Hosts, containing access catalogue and selected data sets, and an unlimited number of End User Nodes.

A prototype was implemented to distribute observations of the 19th Episode, and is currently being used to distribute IUEFA data. Once output products have been archived, after applying the quality control procedures, extracted spectra – both two-dimensional and absolute calibrated fluxes – are transferred to the distribution node and are available on-line in URL `http://iuearc.vilspa.esa.es/`.

The distribution system is based on the WWW architecture, so that scientists are able to access the archive using standard browsers. After registration as archive users, it is possible to perform queries to the catalogue filling a simple form. A subset of the catalogue with the selected objects is then displayed in tabular form and the scientist can then continue the selection of the objects, plot the calibrated spectra or transfer the desired observations to the remote node for further analysis.

Software tools have been developed under IDL and MIDAS to allow for an easy analysis of the spectra.

Project status at Villafranca

At the time of writing, some of the major milestones have been completed, i.e. the raw image archive has been written to optical disks and the image parameters have been verified for the complete catalogue.

More than 60% of the low-dispersion spectra collected at Villafranca have been processed, archived, and are available on line. In addition, more than 50% of the low-dispersion spectra collected at GSFC have been archived and are accessible to the scientific community from the distribution node at Villafranca (see Yurrita & Barylak, pg. 34).

The high-dispersion processing software has been completed and has been tested for the SWP camera.

In addition, a new data distribution concept is being defined.

Future activities at Villafranca

During the coming months, all the effort will be dedicated to the following tasks:

- Completion of low-dispersion code, to include the absolute calibration for the LWR camera (see González-Riestra, pg. 29).

- Completion of high-dispersion code for LWP and LWR cameras, including the determination of ripple correction algorithm and absolute flux calibration for these two cameras.
- Process and archive the remaining low-dispersion images, 8,165 images have to be reprocessed, and the complete high-dispersion set, nearly 10,000 spectra.
- In the area of data distribution, based on the experience with the prototype, the distributed archive concept will be developed and deployed to the National hosts.

Picture: Dismantling of the IUE R/T computer 'Telefile-85' - December 1996
(Front right: rack still holding T-85 CPU; Back: backside of the racks holding the magtape drives)

Access to the ESA IUE Data Server

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ESA IUE VILSPA

Introduction

The ESA IUE Data Server (EIDS) provides access to NEWSIPS[30] to the international user community. EIDS currently provides the following services:

- IUE 19th. episode data distribution (user observation programs)
- IUE Final Archive catalog access
- IUE Final Archive data distribution

EIDS services are only available to registered users. To this date, registracion is done upon request.

EIDS can be accessed since January 1996 at URL:

`http://iuearc.vilspa.esa.es`

Data availability

The following Final Archive products are currently available for on-line retrieval (status: Jan. 1997):

Group	Obs. Date range	Camera	VILSPA Data	GSFC data
Set-1	01-Apr-78 to 31-Dec-89	LWP	LOW disp (86%)	LOW disp (26%)
		LWR	-	-
		SWP	LOW disp (91%)	LOW disp (55%)
Set-2	01-Jan-90 to 14-Mar-93	LWP	LOW disp (75%)	LOW disp (40%)
		LWR	-	-
		SWP	LOW disp (79%)	LOW disp (61%)
Set-3	15-Mar-93 to 30-Sep-95	LWP	-	-
		LWR	-	-
		SWP	-	LOW disp (13%)
IUE19	01-Oct-95 to 30-Sep-96	LWP	-	-
		LWR	-	-
		SWP	-	-

[30]NEW Spectra Image Processing System

The Server's Environment

Hardware

A major software/hardware upgrade has been applied to EIDS in January 1997. It consists now of:

- a DEC Alpha 2100 4/275 running DEC/UNIX V4.0B. The machine has 256Mb RAM and holds 92 Gb of disk space (planed 115.2Gb)
- The IUEFA production data base (PDB) under ORACLE 7.2
- The WWW server, running NCSA httpd[31] version 1.4.2

The new disk space will allow to hold all extracted and line-by-line IUEspectra both high and low dispersion on line.

Server software

The server implements the following basic features:

- User registration and authentication.
- Single image / multi-image download. Several compression schemes are used to save bandwidth.
- A catalog access is provided. It is fully integrated with download system.
- Feedback capability at any point.
- Full database integration (catalog, session logs, registration)
- On-the-fly generation of plots under a simple plotting package.

All the server software was locally developed at VILSPA in the C language, making an extensive use of the ORACLE Call Interfaces. HTTP[32] interaction is done with CGIs[33].

Database Design and Implementation

The IUEFA PDB follows the same model as the data base of the 19th episode (which was under ORACLE 7.1 on a DECsystem 5900; Ultrix 4.4) established in autumn 1995 (see Barylak, ESA IUE Newsletter No. 46, pg. 46).

The definition of several new catalogs to be implemented under the "IUE New Extracted Spectra" (INES) distribution system has been terminated. The building and implementation of these catalogs i.e. the Master catalog (to control and maintain the IUEFA), the New IUE Merged Log, and the Science Image Access (SIA) catalogs from the current production database is in progress. The IUEFA production processing is on-going together with the implementation of the Astronomical Server URL (see `http://vizier.u-strasbg.fr/proj/asu.htm`) which is being developed using `ORAPERL` under `PERL v5.003`.

[31] hypertext transport protocol damon

[32] HyperText Transport Protocol

[33] Common Gateway Interfaces