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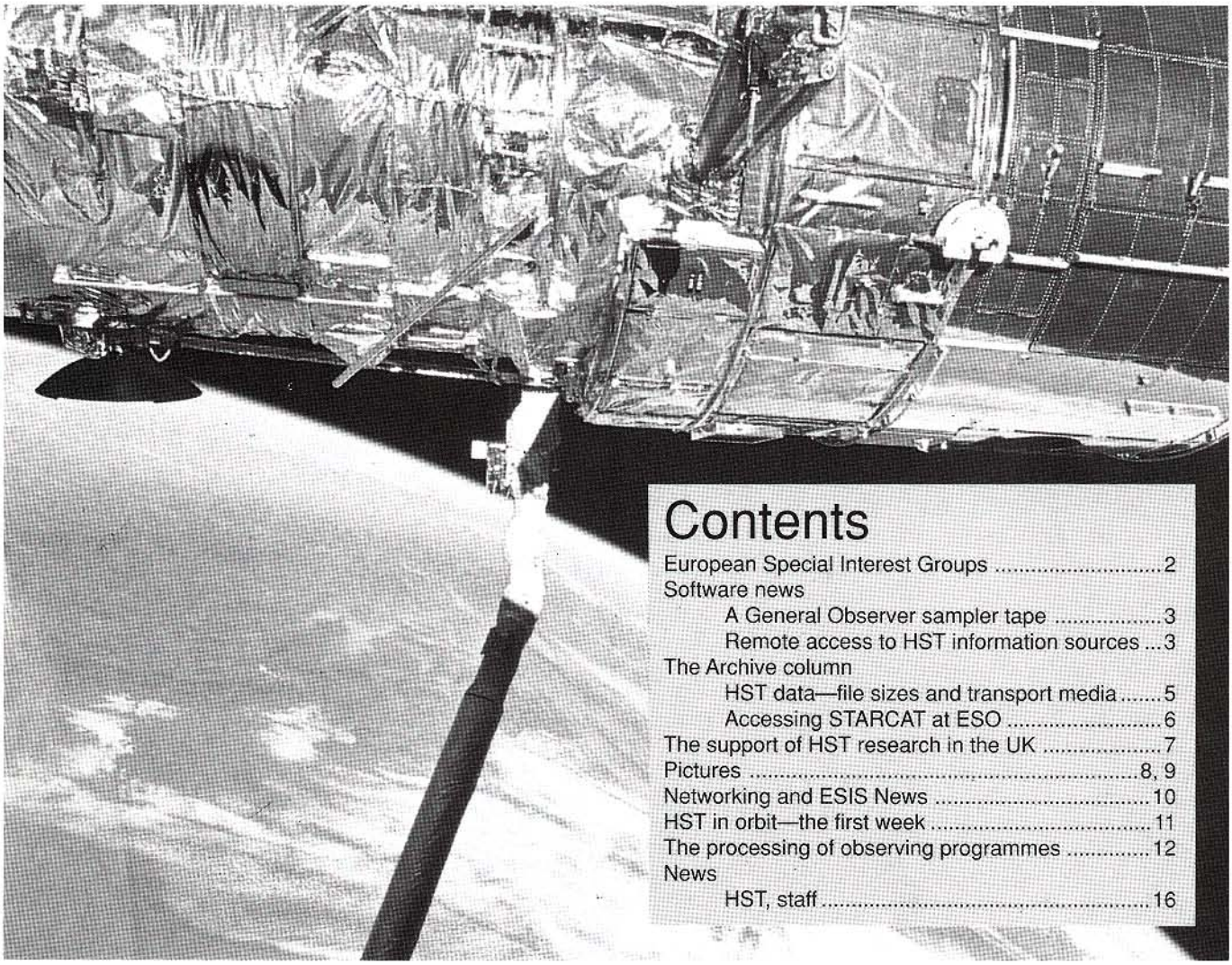
ST–ECF Newsletter

Space Telescope — European Coordinating Facility



Contents

On Wednesday the 25th of April 1990, the Hubble Space Telescope was manœuvred from the cargo bay of the orbiter Discovery. A day after launch from Cape Canaveral, there followed a tense and fascinating seven hour period during which the solar panels and high-gain antennæ were deployed and the telescope released from the Remote Manipulator Arm into its final 330 nautical mile orbit.

The Hubble Space Telescope comes to life

European HST Special Interest Groups

To prepare for the flood of information which will start to flow during the Orbital and Science Verification programmes, the ST–ECF has set up three SIGs—attached initially to the WFPC, the FOC and the two spectrographs—to ensure that the first General Observers are well prepared to exploit their data.

Robert Fosbury

Following the selection of programmes for the first (yearly) cycle of General Observers and the submission of detailed 'Phase II' proposals, the next step is to ensure that the users are prepared to receive data and perform the appropriate scientific analysis. Towards the end of March, the ST–ECF organised and hosted a working meeting to which members of the teams having accepted Cycle 1 proposals were invited, together with the European Investigation Definition Team (FOC IDT). The task was to review the situation as it stands now and to form Special Interest Groups (SIG) to follow developments and contribute to the provision of further software tools and information. There were more than forty participants, many of whom were being exposed for the first time to the complexity of the HST data structures. The purpose of this article is to review the contents of the meeting and to give some details about and the composition of the SIGs which were formed as a result.

The HST is a complex, general purpose observatory with many different instrument configurations and operating modes and so considerable post-launch experience will have to be gained before there is much stable 'turnkey' software for more than rather primitive calibration and analysis. The General Observers (GO)—in contrast to many of the Archival Researchers (AR) who will come later—can be expected to pioneer many of the specialised procedures they will need in order to complete their own programmes. The aim of the ST–ECF is to attempt to make precise assessments of the needs of GOs in order both to help satisfy them and to coordinate the work that they do which may be of general use to others.

The initial assumption of the meeting was that the GOs basically know what they want to do and how to do it but need to obtain a number of basic items of information, e.g. how to read their data into *their* system, whether and how to recalibrate, about particular characteristics of the instruments and any special problems they may have and where to find out about pertinent software which may have been written by other groups. The emphasis was placed then on the hardware, software and information needs of GOs for data ingest and organisation and basic recalibration and reduction. Questions of advanced data analysis and the provision of tools for archival research, while certainly legitimate subjects for the consideration of the SIGs, will be considered only during later meetings.

In order to set the scene, a general review was given of the 'pipeline' processing of data which will be carried out as routine by the STScI in Baltimore before the data are archived or sent to the GO. This is a non-interactive process, controlled by keywords in the headers of the data files, running in a system which is not portable outside the STScI. The routines, however, are available outside the pipeline as calibration programs (called CAL<*instrument*>) running in STSDAS/IRAF. These still rely on keyword communication but at least they offer the possibility of examining intermediate results and so are, in some limited sense, interactive.

The calibration routines need Calibration Reference Data which, during routine operations, will be generated at the STScI from calibration observations. They consist of both calibration *files* and *parameters* which will become available in the HST Archive and Catalogue.

For European users, facilities for recalibration will exist at the ST–ECF. The standard procedure will be running the CAL<*instrument*> routines from STSDAS using calibration files and parameters retrieved from the local archive via the STARCAT user interface. Some facilities in MIDAS can be expected by the time the first GO data become available. Particularly for the spectrographs, much software is available in IDL (Interactive Data Language)—a commercial product used extensively by the IDTs and also widely available in Europe.

Although users can—and will be encouraged to—perform recalibration operations using ESO/ST–ECF facilities, the local resources are insufficient to perform routine recalibration of *all* HST data. After investigating possibilities and making experiments, the users are expected to continue working at their home institutes. Since a number of groups had requested advice about hardware systems suitable for dealing with HST data processing, some advice was given about platforms which are *known* to work with STSDAS, MIDAS and IDL.

The use of the HST Catalogue and Archive, with special reference to the retrieval of calibration information, was explained. A STARCAT demonstration was given, again concentrating on the 'screens' which have been developed for HST. The 'dataset' resulting from an HST exposure can contain many individual files with names which, although precisely and logically defined, do not reveal their contents to the observer's consciousness with overwhelming clarity. Both to warn the GOs and to suggest ways of alleviating this problem, there was a special session on the subject of 'data organisation'. Intelligent data readers for the different data analysis systems should be developed to shield users from the worst excesses of the HST data formats—indeed, such a system has already been developed by the GHRS IDT.

Following a series of instrument oriented 'readiness reviews' held at the ST–ECF earlier this year, surveys of the calibration and data handling plans were given in splinter meetings for the two spectrographs (FOS and GHRS) and the two cameras (WFPC and FOC). Where appropriate, these included demonstrations of procedures for accessing the data and of calibration software.

Instrument	ST–ECF convener
WFPC	S Jörsäter
FOC	S di Serego Alighieri
FOS/GHRS	J Walsh

During and after the splinter meetings the consensus emerged that the instrument oriented divisions were, at least during the Science Verification (SV) phase, the most sensible way of forming the SIGs. This could change in subsequent cycles when

Software News

Remote access to HST information sources

A review of the current—but rapidly evolving—state.

Richard Hook

Now that HST is in orbit it is vital that information at all levels is easily accessible to anyone who needs it. There are many sources of such intelligence and they vary greatly in level of detail and freshness. This note summarises the ways in which information can be obtained from both the ST–ECF and the STScI with particular emphasis on facilities accessible over computer networks.

ST–ECF facilities

STDESK is a mailing address for enquiries concerning details of instrument performance, proposal submission problems and other technical matters. This account is checked very regularly by a member of the ST–ECF Science Instrument Information group and so a fast response is guaranteed. Mail may be sent either to ESO::STDESK over SPAN or STDESK@DGAESO51 on Bitnet/EARN. Note the change in the ESO SPAN address—see the article on networking in this Newsletter for more details. This service should not be used for more general enquiries such as telescope status news or public relations information.

The STINFO account runs on both the ESO VAX Cluster and the new ESIS microVAX machine and provides a remote bulletin board service. It may be accessed over SPAN (to nodes ESO or STESIS) or PSI from some sites. The account is 'captive' (no password) and an electronic bulletin board devoted entirely to HST news and status is started up as soon as you login. Someone at ST–ECF is always responsible for keeping this current. Much of the information is extracted from the *News* system which runs on computers at STScI and contains HST and instrument status information updated several times per day. We will also be in regular contact with ST–ECF staff members visiting the STScI and who will be able to provide further detailed information. These items will be sorted and edited to make them easier to digest (some information is rather technical and verbose). In addition to these reports a weekly overview of HST activities is produced.

STScI facilities

The STScI is currently implementing an electronic information service for HST users. It will provide a wide variety of information including schedules, status, instrument performance etc. This system is based on anonymous file transfer of files at STScI and is described in detail in the March 1990 edition of the STScI Newsletter. Unfortunately this system, being accessed from machines on the Internet TCP/IP network, is not directly accessible for most European users. To try to circumvent this problem, the ST–ECF intends to copy important documents from this valuable and fast-growing database and keep them installed here. In addition it is possible, although less convenient, to access these files from SPAN using the SPAN/Internet Gateway (SPAN node EAST) at Goddard Space Flight Center. As an example a listing of the directory structure of this database may be obtained from a SPAN node using the command:

```
$ type
    east"stsci.edu!anonymous
    name"::"STEIS.DIR"
```

where 'name' should be your name. Other VMS commands (e.g. DIRECTORY and COPY) may be used in the same way but it is important to note that—as this is a UNIX machine—filenames are case sensitive and that the directory delimiter is a slash '/' character. For more details please contact us.

STScI NEWSLETTER

The Space Telescope Science Institute publishes a Newsletter at regular intervals (3–4 times per year). The STScI Newsletter contains information of interest to proposers, including updates on the status of the HST and its instruments. Subscriptions are available at no cost to all interested scientists; requests to be added to the mailing list should be sent (by regular or electronic mail) to the User Support Branch at the following address:

User Support Branch
Space Telescope Science Institute
3700 San Martin Drive
Baltimore, MD 21218
USA

E-mail: scivax::usb (SPAN)
usb@stsci.edu (Internet)
usb@stsci (Bitnet/Earn)

Requests should also specify whether the subscriber wishes to receive future Calls for Proposals.

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the emphasis shifts towards advanced analysis topics but for now, while the most pressing questions centre on calibration and instrument performance issues, three SIGs were formed. The conveners (see table) can be contacted by e–mail, either directly or via STDESK.

In addition to the specialised questions raised within the groups themselves, there were several general issues which are of direct relevance both to preparing data analysis procedures and preparing future observing proposals. Amongst these are the rapid dissemination of information about the HST point spread function gained during the SV phase, a description of the astrometric performance of the telescope in the various instrument configurations and the plans for calibrating standard filter passbands. The ST–ECF undertook to keep the groups informed of the status in these and other areas.

In conclusion, it was agreed that the SIG conveners would keep their groups appraised of developments in their areas of interest and would prepare and distribute lists of issues and jobs to be done. Although the groups are free to meet at any mutually convenient place and time, the next *joint* meeting will be held at the ST–ECF around October 1990 which is towards the end of the SV phase.

An HST General Observer sampler tape

Richard Hook & Jeremy Walsh

Most HST General Observers (GOs) will receive their data on 1/2 in 9-track magnetic tape. In the future other media will also be used but these are less standardised at present. Here we describe the format of the typical GO FITS tape and how it may be read using some common data analysis systems. We have compiled a sampler tape by extracting representative files for the main HST instruments from tapes supplied by the STScI. These were produced during Ground System Test (GST) 7 but unfortunately many of the files do not contain meaningful data. This tape is available on request from ST–ECF along with a more detailed document describing its contents.

The tape format

Most GO tapes will be written in FITS format (Refs 1–4). This is an international standard for astronomical data and FITS readers are available in all major astronomical data analysis systems. However, the latest FITS standards allow for various extensions to the original simple scheme and some of these are used when writing the GO tapes. In addition the way in which the data are 'grouped' before being written to tape is not obvious and some explanation may be useful.

All data from HST will be passed through 'Routine Science Data Processing' (RSDP) at the Space Telescope Science Institute. The disk files manipulated by this system are in a format called GEIS. These files have a format similar to a disk version of 'group FITS'. There is a header file (ROOT.ABH) and an associated data file (ROOT.ABD) which may contain several related data arrays (groups) of the same size (e.g. the four WF/PC sub-images). Each group in the data file has associated 'group parameter block' (GPB) information which is also stored in the data file. The GPB contains information which is specific to each group, e.g. the relative position and orientation of the sub-images in the WFPC case. The separate header file contains information which is common to all the groups. The 'ROOT' part of the name encodes information about the instrument, the programme during which it was taken and so on. The first two letters of the file name extension ('AB') encode the type of data the file contains. A detailed explanation of these conventions is given in Reference 5.

Data from most of the science instruments are stored as GEIS files having multiple groups. Before being written to tape the data groups are combined to form a single data set with a higher dimensionality (e.g. the four WFPC frames are combined into a single data cube). The GEIS header file is written as the FITS header and the GPB information is appended to the FITS binary data as an ASCII table.

Reading the tape

'GO FITS' tapes may be read using the FITS readers in any data analysis package which supports the FITS table extension. Portable MIDAS will read a GO tape: the data are stored as a BDF and the GPB information is written into a MIDAS table. Within STSDAS there are applications which have a similar effect, the data being written as one of the standard IRAF data formats and the GPB information stored as an STSDAS table.

Using MIDAS: The steps required to read an HST GO format tape into portable MIDAS are the same as for any other FITS tape. These are briefly described here, for more details consult the comprehensive MIDAS documentation. Note that 'old' (VAX/VMS) MIDAS *cannot* read these tapes properly.

Assuming that the tape has been loaded (on drive 'tape0') and that portable MIDAS has been started the command is:

```
Midas 001> intape 1-999 test
    tape0 SOY
```

which will read the first 999 FITS files (or all the files if there are less than that number). Files named 'testnnnn.bdf' (the data plus header information), and 'testnnnn.tbl', a MIDAS table containing the GPB information will be created. 'nnnn' starts as 0001 and is incremented for each new file read. The table files have as many columns as there are items in the GPB and as many rows as there are groups. The three character flag 'SOY' specifies that a short listing is produced, the files preserve the original tape datatype (real or I*2) and a history file is appended to the header. It should be noted that filenames (but not commands) under the UNIX versions of portable MIDAS are case sensitive.

Using IRAF/STSDAS: STSDAS is a large body of HST related software written (at STScI) to run within the IRAF environment. It is invoked via IRAF and, to a large entent, uses the same data structures, user interface, graphics, etc. There are FITS tape reading routines within IRAF itself but it is recommended that the special, HST specific, ones in STSDAS are used in preference. Once IRAF has been started (by typing 'cl') the sequence of commands is as follows:

```
cl> stsdas
st> fitsio
fi> alloc mta
fi> unlearn strfits
fi> strfits fits=mta file=1-10
    iraf="" oldiraf=yes
fi> dealloc mta
fi> logout
```

This will read the first ten files on the tape and create disk files in IRAF format which have the same names as they did originally before being written to tape. The GPB information is written into a file with the same name as the data with which it is associated but with the extension .TAB appended. Both commands and filenames are case sensitive in IRAF and STSDAS (even in the VAX/VMS version).

Recreating the original data format: The files created by reading the tape will retain the 'high dimensionality', i.e. WFPC data will still be datacubes 800 x 800 x 4. In MIDAS standard utilities may be used to extract the component images, the MIDAS documentation should be consulted for details. In STSDAS there is a command designed to recreate the original GEIS format data file. It may be run as follows:

```
cl> stsdas
st> fitsio
fi> xdimtogf xdimfile
    groupfile
```

This will convert the file 'xdimfile' to the GEIS, multi-group file 'groupfile'.

Concluding remarks

Prospective HST users are encouraged to get a copy of the sampler tape and verify that they can read it using their own data analysis facilities before the arrival of 'the real thing'!

References

[1] Wells, D.C., Greisen, E.W. & Harten, R.H., 1981. FITS: A flexible image transport system. *Astron. Astrophys. Suppl. Ser.*, **44**, 363

[2] Greisen, E.W. & Harten, R.H., 1981. An extension of FITS for groups of small arrays of data. *Astron. Astrophys. Suppl. Ser.*, **44**, 371

[3] Grosbøl, P., Harten, R.H., Greisen, E.W. & Wells, D.C., 1988. Generalized extensions and blocking factors for FITS. *Astron. Astrophys. Suppl. Ser.*, **73**, 359

[4] Harten, R.H., Grosbøl, P., Greisen, E.W. & Wells, D.C., 1988. The FITS table extensions. *Astron. Astrophys. Suppl. Ser.*, **73**, 365

[5] STScI, 1990, Post-Observation Data Processing System to Space Telescope Science Data Analysis System Interface Control Document, ICD-19

The Archive column

HST data—file sizes and transport media

*Fabio Pasian, Benoît Pirenne & François Ochsenbein**

In several months from now, the first HST data—from the Science Verification phase and so principally related to instrument calibration—will become public and, in slightly more than a year from then, the first of the GTO and GO science data will start to appear to the ordinary archival researcher. It is reasonable to expect that archival research with HST data will become of increasing interest and importance to scientists, especially since there will be a rather low ratio of accepted to proposed observations. The access to the HST catalogue and archive has been described in its generalities previously [1]. Some remarks about the distribution of data should be made at this point with particular reference to the size of the dearchived data files and, consequently, to the medium to be used for their transport. Such considerations are needed for a timely evaluation of the storage and computing requirements for receiving, storing and analysing data at a user's home institute and for planning cost-effective local solutions.

HST data and their sizes

It is to be understood that all data from the HST will be archived and will therefore be accessible to the user: this includes raw, 'edited' and calibrated science data, astrometry science data, calibration data, engineering data and on-board computer dumps. The quantity of data being ingested daily by the HST archive varies between 1 and 2 GB, amounting roughly to one 12 inch WORM (Write Once Read Many times) optical disk per day.

Using the HST catalogue through STARCAT, the user should be capable of selecting readily from this huge quantity of information the exact data required. Following such a selection, it must be appreciated that the product of an observation is not a single data file but rather an entire set of files—called a 'dataset'. The generic dataset is composed of several files: some (about 10) are related to the uncalibrated observation (edited science data packets, standard header packet, binary packet errors file, bad packet data, message artifacts file, DG2 data, trailer file, data log). The number of files produced after calibration varies from instrument to instrument: 7 for the FOC, 9 for the WFPC, 12 for the GHRS, 14 for the HSP, and 18 for the FOS. Details can be found in [2].

The file sizes, naturally, vary from instrument to instrument and also depend on the specific instrument configuration used. As an example (see [3]), the sizes of WFPC files for a specific observation are listed in the table.

FILE	SIZE (MB)	FORMAT
WF/PC standard dataset:		
Raw science image	10	800x800x4 R*4
Raw science image data quality file	5	800x800x4 I*2
Extracted engineering data	0.18	14x800x4 R*4
Engineering data data quality file	5	14x800x4 I*2
Standard header packet	0.09	—
Calibrated science image	10	800x800x4 R*4
Calib. science image data quality file	5	800x800x4 I*2
Histograms of calibrated science image	0.20	—
Saturated and missing pixels file	5	800x800x4 I*2
Reference files for (re)calibration:		
Static mask	5	800x800x4 I*2
A/D lookup table	0.13	—
Bias level	10	800x800x4 R*4
Bias level data quality file	5	800x800x4 I*2
Preflash	10	800x800x4 R*4
Preflash data quality file	5	800x800x4 I*2
Charge transfer efficiency	10	800x800x4 R*4
Charge transfer eff. data quality file	5	800x800x4 I*2
Super purge	10	800x800x4 R*4
Super purge data quality file	5	800x800x4 I*2
Dark	10	800x800x4 R*4
Dark data quality file	5	800x800x4 I*2
Flat field	10	800x800x4 R*4
Flat field data quality file	5	800x800x4 I*2

WFPC data are obviously the bulkiest but it should be noted that 50% of the approved proposals for Cycle 1 of GO observations make use of the WFPC. Typical sizes for datasets related to different instruments are listed in the following, making a distinction between calibrated data and raw data plus reference files needed for (re)calibration:

WF/PC: 20 MB calibrated, 15 MB raw data +95 MB reference files
FOC: 6 MB calibrated, 2 MB raw data +17 MB reference files
GHRS: 100 kB calibrated, 80 kB raw data +350 kB reference files
FOS: 50 kB raw + calibrated +150 kB reference files (1 mode)
HSP: varies, depending mainly on the length of observation.

It is clear that storing and analyzing HST data on a computer system at the scientist's own institution could be a major problem in terms of storage and computing power. Such problems should be faced and solved *before* the data are requested.

Transport media

Another topic of great importance is the selection of the medium to be used for data distribution to the archive user. Magnetic tapes have been the most popular data transfer devices and it can safely be assumed that each institution has the capability to read and write them. Therefore, HST data distribution will always be supported on magnetic tapes or, in some special cases, may occur also on QIC and DEC TK tape devices which are popular on workstations. However, devices allowing denser data storage and better performance have recently been made

* ESO

available by the computer industry. The use of denser media has a number of obvious advantages if compared to magnetic tapes: optimization of physical storage space, lower cost per MB stored, lower cost of shipment. These lower costs have direct relevance for the archival researchers since they might be asked to cover part of the costs of distribution for large dearchival requests.

The format for HST data distribution has been selected to be FITS but currently this standard transport format has formally been defined only for magnetic tapes. However, in the European FITS committee meeting held on 26 April 1990, a discussion on FITS for blocked devices (disk, 8mm and DAT cartridges) took place and it is reasonable to expect that a formal decision will be taken very soon on the subject. Besides magnetic tapes or cassettes, eventually also $5^1/_4$ inch Maxtor WORM optical disks, 8mm (Exabyte) and DAT cartridges could be used, since the hardware facilities already exist at the ST–ECF or will shortly be purchased.

Some information on these new media has been given earlier [4]. In the following we review their main characteristics which should be compared with those of traditional magnetic devices. Magnetic tapes can hold up to 240 MB (3200 ft, 6250 bpi) and their speed depends on the specific drive used. Magnetic cassettes have device-dependent capacity (QIC-24 holds 60 MB, QIC-120 holds 120 MB, TK50 holds 70 MB, TK70 holds 220 MB) and are all very slow.

The $5^1/_4$ inch Maxtor WORM optical disks hold a total of 800 MB on two disk sides. They use a laser optical technique from which the WORM name is derived and therefore, from the ST–ECF archive user's point of view, they are basically read-only media. The main advantage is fast file seeks since the device is random-access. Drawbacks are the need to be formatted (the chosen format, in the absence of an industry standard, is HST-specific), vendor-dependency—there is no standard for media and only the Maxtor device is supported at the ST–ECF—and a certain media fragility. These characteristics make WORM optical disks rather unsuitable for data transport but quite satisfactory for applications using random access to a small local archive.

DAT and 8mm cartridges are more suited for data transport, being conceptually similar to magnetic tapes.They use the helical scan tape technology and therefore are erasable. The devices are sequential, yielding slow random file seeks, certainly not comparable to random access devices such as magnetic or optical disks. Advantages are a very low price per MB of data stored—currently the 8mm cartridges hold 2.3 GB, while DAT cartridges hold 1.3 GB. Plans to increase capacities are in their final stages: a new model of 8mm device holding 5 GB is being made available, while DATs will soon expand to 2.15 and even 4.3 GB due to longer tapes with no variation in the recording geometry.

8mm cartridges are already widespread as computer peripherals since they are often used for backup purposes and are therefore a *de facto* standard. On the other hand, the DDS (Digital Data Storage) format for DAT offers a number of advantages (improved error rates is the most important) and is rapidly becoming an industry standard. A drawback for DATs is the need to format the cartridge before using it although this feature does allow faster random file seeks and, furthermore, more recent models using 4 read-write heads are able to format the cartridge while writing on it for the first time.

An in-house benchmark test comparing DAT and 8mm devices, carried out on a SUN 4/110 workstation, showed substantial equivalence in rewind time and file writing. The 8mm device was slightly better at handling large files with small blocking factors but was twenty times slower reading small files. The DAT device was also superior, due to its preformatting, in random file seeks.

These considerations are our contribution to an open forum discussion we should like to start in the pages of this Newsletter.We invite all potential users of the ST–ECF archive to contribute their own ideas and experiences on the distribution of HST data and on media for data transport.

References

[1] F. Pasian, B. Pirenne, "Accessing the HST catalogue and archive at the ST–ECF", *ST–ECF Newsletter No. 12*, January 1990

[2] STScI, *PODPS to STSDAS Interface Control Document, ICD-19*, January 1990

[3] G. van Moorsel, "WF/PC calibration using calwfp under IRAF/STSDAS", *ST–ECF internal document*, February 1990

[4] B. Pirenne, F. Ochsenbein, "New media for data distribution and exchange in astronomy", *ST–ECF Newsletter No. 12*, January 1990

Accessing STARCAT at ESO

Benoît Pirenne & Fabio Pasian

By the time you read this announcement, the "Launch Version" of STARCAT will be available for the consultation of the HST catalogue and of several astronomical catalogues and remote astronomical databases. It also provides access to the HST data archive. While the access to the catalogue is unrestricted, access to the archive is limited by the observer's proprietary rights on the data files.

To make sure that virtually anybody running any system can access our data,we have set up several versions of STARCAT accessible from the widest possible number of computer networks and, of course, also in house. STARCAT is accessible:

- on the ESO/ST–ECF local area network (VAXes and SUN workstations),
- remotely for people using SPAN, PSI (from VAX VMS machines),
- remotely for people using Internet (from UNIX or VAXes),
- remotely through the ESIS (European Space Information System—see *Network News*) user shell.

New STARCAT manuals are also available. They describe the use of this new version of STARCAT as well as all the information accessible from the STARCAT catalogue screens, specifically in-

Machine	Operating system	Missing capabilities	Local access	Remote access	Network and remote address	
ESIS microVAX	VMS	none	no	yes	SPAN PSI ESAPAC	STESIS (28771) 0262458900924 299022010600
ESO in-house workstations	UNIX	Remote d-bases Bulletin board	yes	no		
ESO VAX cluster	VMS	none	yes	no		
available later this year						
ECF SUN	UNIX	Remote d-bases Bulletin board	no	yes	TCP/IP UUCP	ecf.hq.eso.de ecf

The support of HST research in the UK

We are keen to hear of any new national plans to provide resources for HST research and undertake to publish short descriptions in this Newsletter. Also, if there are meetings being organised which will have a significant HST-related content, they could be advertised here.

*Alan Penny**

The UK is, like other European countries, preparing itself for the wealth of data expected from the Hubble Space Telescope. In the first year or so, British involvement will be in the form of the successful UK principal and co-investigators of the first General Observer cycle, in the four UK Guaranteed Time Observers (Boksenberg, RGO; Disney, Cardiff; Longair, ROE; Mackay, Cambridge) and the two groups at Cambridge and Durham who are part of the large Medium Deep Survey (MDS). In later years, this will grow to other GOs and all those who will be using the archive.

In response to this, the UK astronomical community has been developing plans to deal with the data reduction requirements which result. The following actions have been taken:

- The Starlink network has set up an HST Special Interest Group (SIG), chaired by Mike Disney at Cardiff with Bob Thomson at Cambridge as secretary (who described the SIG in an article in *ST–ECF Newsletter* No. 9). This SIG coordinates the Starlink response and serves as medium of communication on HST matters between the Starlink users. Starlink at the moment uses a VAX/VMS based system with its own environment and there is little use of IRAF or MIDAS, both of which are concerned with HST data reduction. Starlink has, for this reason, supported an HST SIG programmer to help in the porting of outside software into Starlink and the production of relevant new Starlink programs.
- The use of IRAF and STSDAS on Starlink machines is growing with a number of sites (e.g. Cambridge, Cardiff, RAL and the RGO) becoming active users. The Starlink STADAT machine, available to many in the Starlink system, also has IRAF installed.
- The UK funding bodies have specifically supported the Guaranteed Time Observers with hardware and manpower for their data reduction and have just likewise supported the two MDS teams. Since they are working in close cooperation with US colleagues who will be developing software, some of which inevitably will be SUN specific, they have acquired their own SUN systems.
- The UK funding bodies have further announced their intention to support two HST 'experts'. Their task will be, in coordination with the ST–ECF and the STScI, to disperse through the UK knowledge of the current performance and capabilities of the HST and its instruments and knowledge of the status of the various HST data reduction packages which are available. They will also help to make these packages available on the computers which are being used by UK astronomers and help UK to exploit the HST science archive. These people will be based with groups active in HST research at locations yet to be determined.
- The possibility of further support in the UK for HST research is being kept under review. One instance of this is the concept of an advanced re-processed archive which has been proposed by Mike Disney (see *Starlink Bulletin* No. 4, p. 10).

The UK Medium Deep Survey team's acquisition of non-VMS hardware is the first evidence of an anticipated move away from VMS for the reduction of HST data. Starlink has aimed, for some time, to move to a more portable environment and the HST data reduction possibilites are lending extra impetus to this. The beginning of the HST era will be one of the drives towards the development of a more diverse UK astronomical computing scene and Starlink is being much exercised to ensure that this is done in the optimum manner.

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cluding the HST screens. These manuals have been sent to most known STARCAT users as well as to European HST principal investigators. Those who would like their own copy are invited to send a request to the ECF.

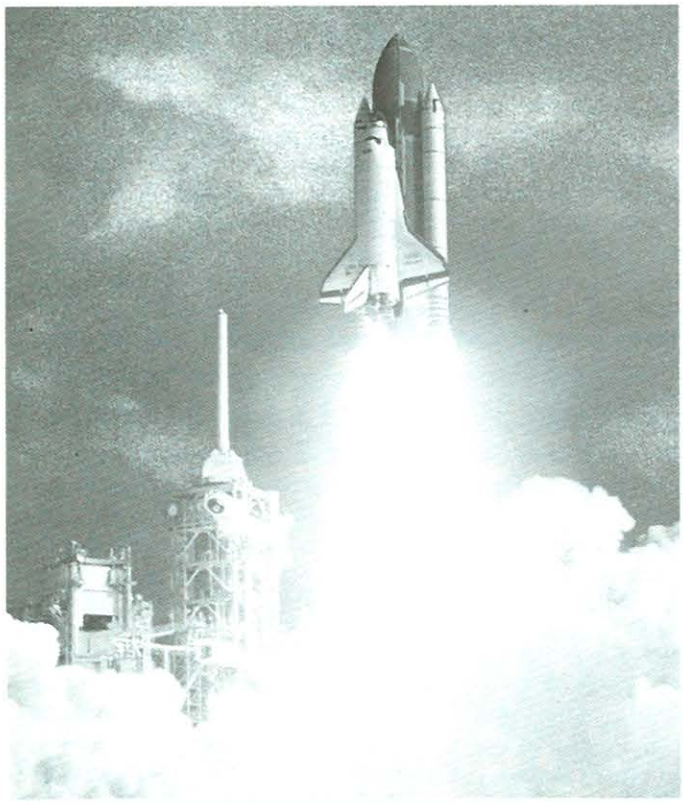
The table presents the STARCAT configuration which will be in place at ESO headquarters about one month after launch: It basically shows which implementation to use depending on where you are working and your particular network connectivity. Note also that, depending on ESO/ST–ECF computer configuration changes, this setup will be subject to evolution.

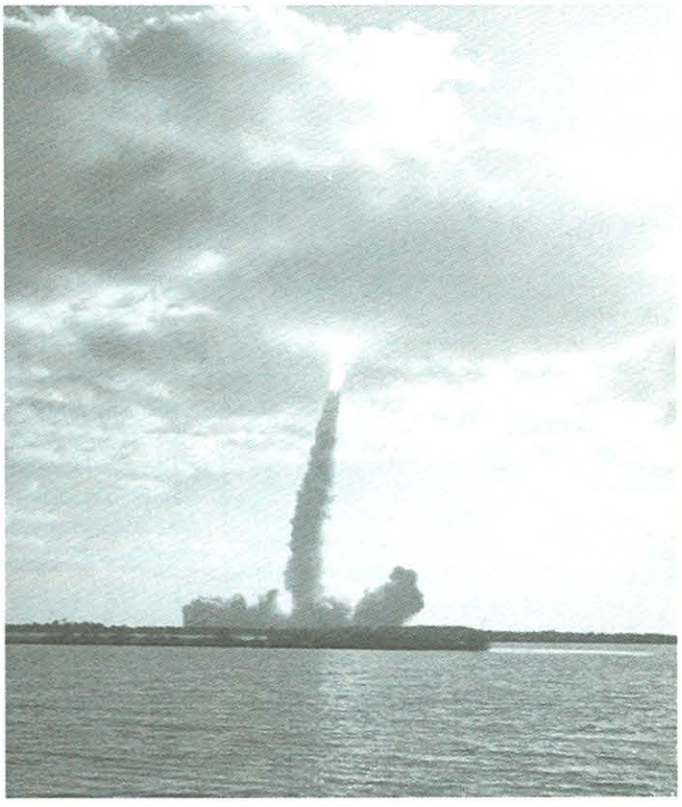
To gain access to the first machine listed in the table, you will have to login to ESO/ST–ECF using commands such as 'SET HOST STESIS' from a VAX computer using SPAN or 'SET HOST 28771' from a VAX not having SPAN tables configured. Once ESO is a member of the Internet, it will also be possible to login using 'telnet ecf.hq.eso.de' from another Internet machine.

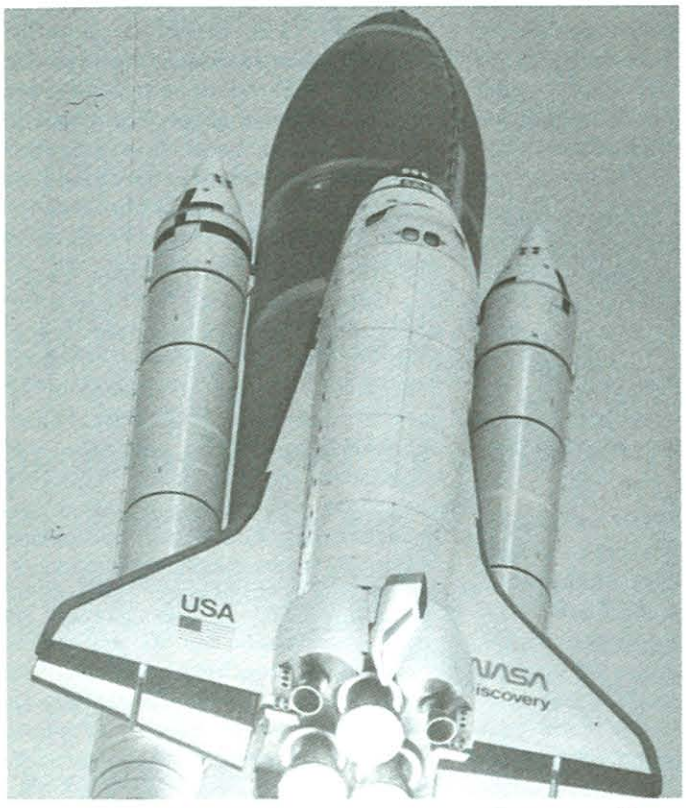
On the remotely accessible versions of STARCAT, a special captive account has been set up. It can be used by typing "starcat" at the login prompt as soon as the connection with the ESO/ST–ECF machine has been established.

For the remotely accessible versions of STARCAT, you are required to provide basic identification for statistical purposes.

* Rutherford Appleton Laboratory, UK



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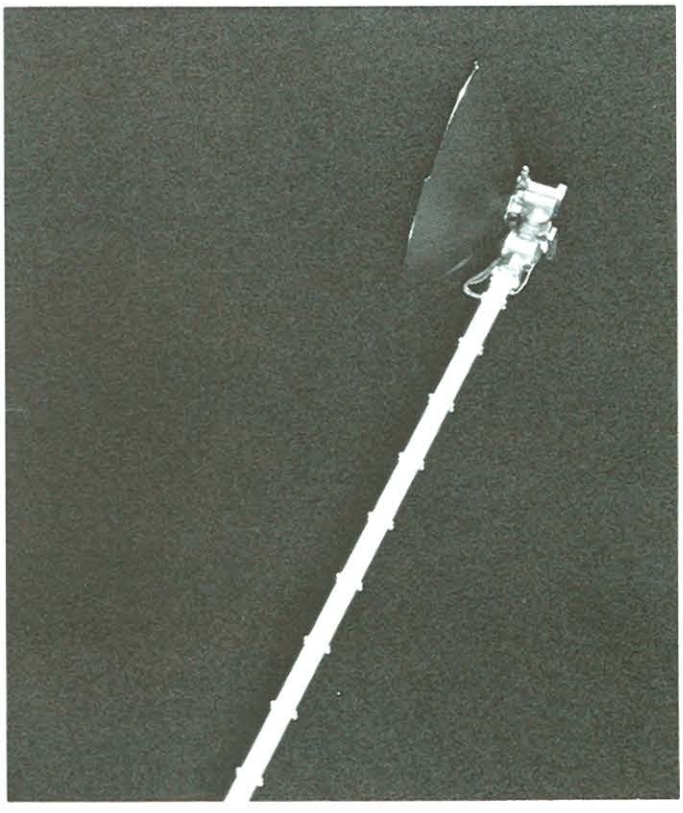
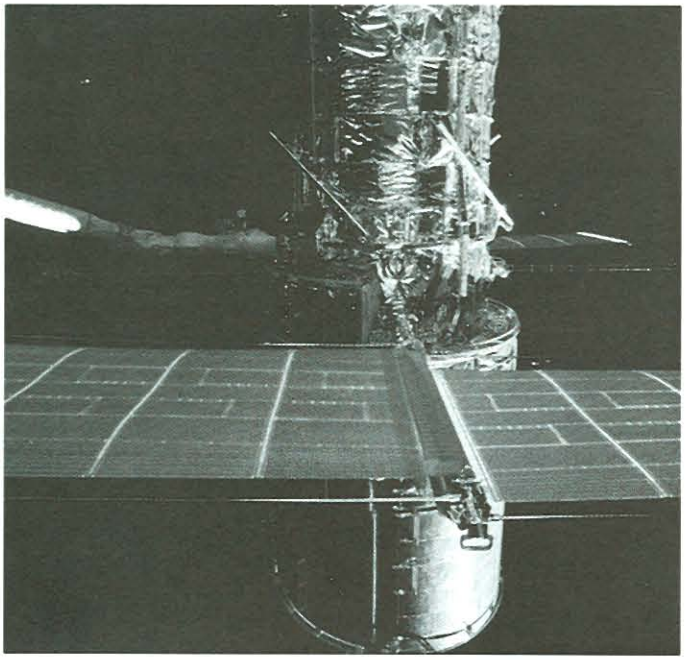
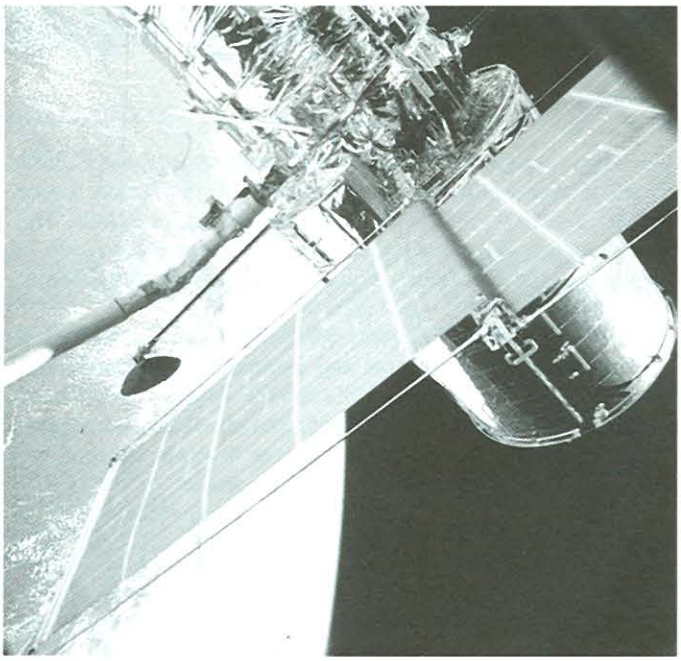
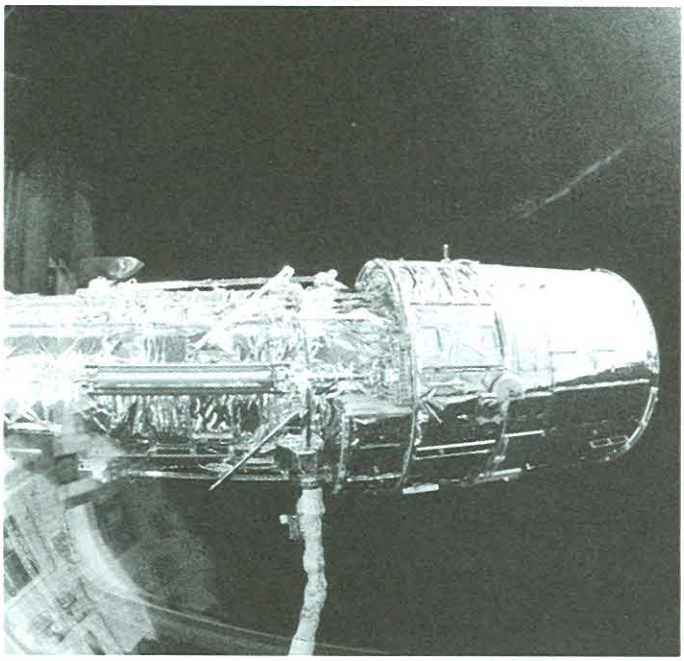
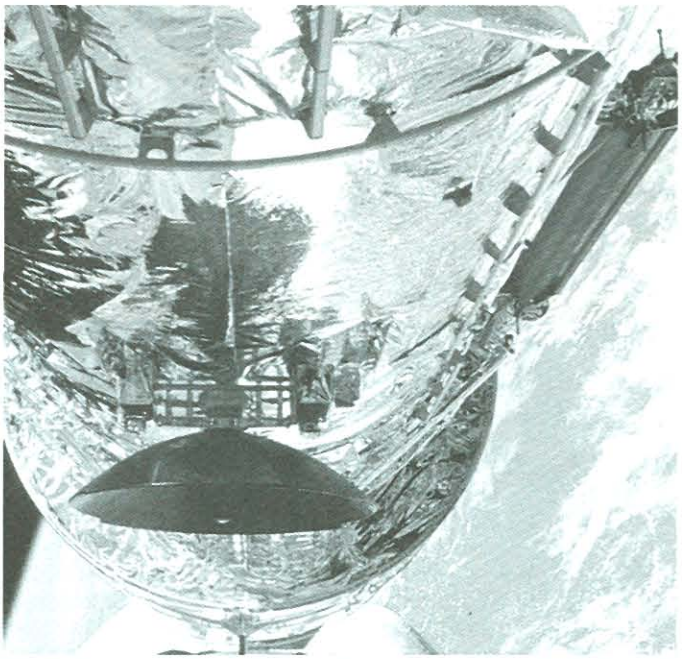
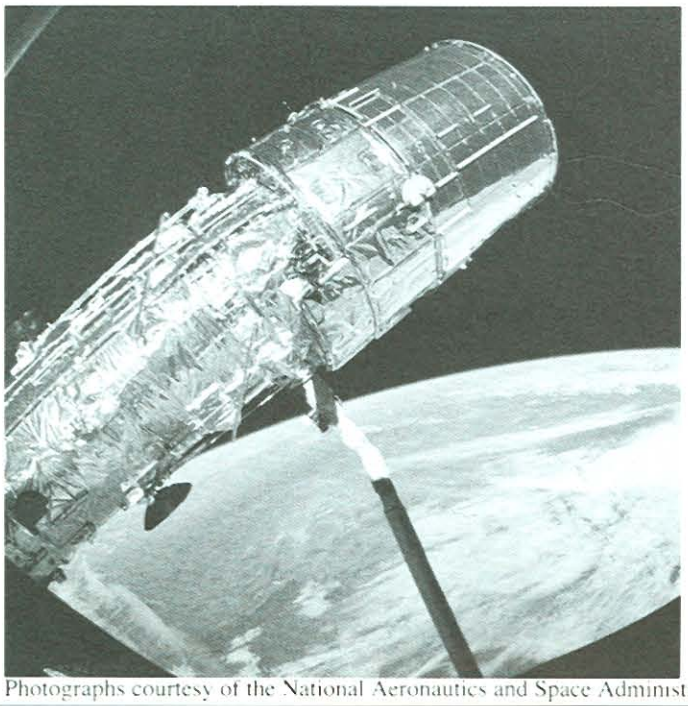


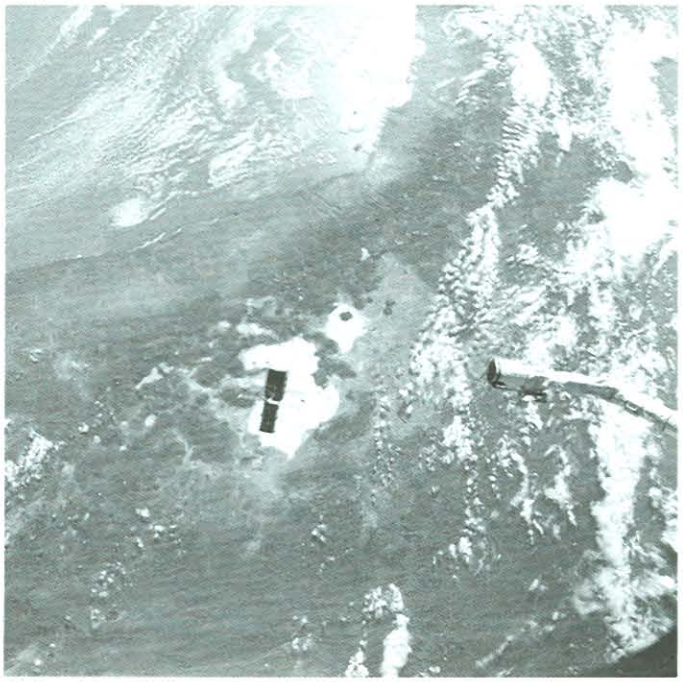












Photographs courtesy of the National Aeronautics and Space Administration

Networking and ESIS News

Richard Hook

There have been several changes to the networking links to ESO/ST–ECF over the past few months but all the former routes (BITNET/EARN, SPAN etc) remain working as before. This note describes what is new and how the connections will be changing in the near future. We now have faster access to some networks and access to new networks.

The longer term ESO plan is for an increasing quantity of network traffic, both internal and external, to use the TCP/IP protocol. Most of the newer ESO and ST–ECF computer hardware is UNIX rather than VAX/VMS based and does not support DECnet. As a result, ESO is moving towards being a full member of the international Internet community and TCP/IP will gradually take over some of the traffic now using EARN/BITNET and SPAN. The initial TCP/IP physical links have already been installed by ESA/NASA, specifically for higher speed connections between ST–ECF and ESOC in Darmstadt and, subsequently, to the STScI. The only currently active external TCP/IP links from ESO/ST–ECF are between machines here and at the STScI. This connection, which will be used for the daily copying of the HST catalogue updates, runs at 38 kbit/s. Unfortunately, security requirements imposed by other users of the trans-Atlantic sector of this link prevent it being opened up fully to give access to all Internet sites. During the summer, additional physical lines connecting ESO with the local Max Planck Institutes will give us unrestricted access to the full Internet.

A microVAX 3400 system supplied as part of the ESIS project (see box) has been installed at ESO. This machine has the primary task of running the ESIS 'Service' and 'User' shells to provide remote users with access to STARCAT and the HST archive and catalogue. It will also act as a network gateway machine for SPAN and PSI access to ESO as a whole. This machine is connected to ESAPAC, a European Space Agency X.25 network, as well as the public data networks (the German PTT's DATEX-P service). It may be accessed as SPAN node 28.99 (STESIS). Other services, such as the ST–ECF HST Bulletin Board (STINFO), will move from the VAX cluster to this machine in the near future.

The link from ESO/ST–ECF into SPAN has moved from a DATEX-P link to the SPAN area 28 router (ECD1) at ESOC in Darmstadt to a connection to ESAPAC as described above. In the medium term, this will offer improved bandwidths into SPAN and to the ESIS sites. Users may still be contacted exactly as before at SPAN node ESOMC1 but it is now strongly recommended that the node name ESO (28.88) is used instead. This is currently a 'cluster alias' for the ESO VAX cluster but will remain the correct ESO SPAN address after ESOMC1 comes to the end of its useful life. If you find that this node (or STESIS) is not defined at your site please contact your system manager and ask that it be set up.

If you have difficulty contacting ST–ECF from your site or have any other comments concerning networking please do not hesitate to contact me. Please note also the revised contact addresses on the last page of this *Newsletter*.

European Space Information System ESIS

ESIS is a five year pilot project to establish a Europe wide system for the exchange of information between astronomical centres and to provide a convenient, distributed environment for users to access remote databases. It is managed by a team at ESRIN, Frascati, Italy led by Alessandro Ciarlo. ESIS will provide access to observational data (in particular space science data archives) but also such additional information as spacecraft and instrument parameters, more general astronomical catalogue data and bibliographic information. ESIS software will bring all these components together in a flexible manner and provide further facilities such as bulletin boards and directory services. The pilot phase has two more years to run and hence is currently in a partially completed state with some facilities not yet available.

The major sites forming parts of ESIS are as follows. The sites connected during the pilot phase are:

- The IUE Observatory at VILSPA, Spain for access to the IUE archive.
- The EXOSAT Observatory at ESTEC, the Netherlands, for access to the EXOSAT archive.
- The ST–ECF at ESO, West Germany, for access to the HST archive and the STARCAT system.
- The Centre des Données Astronomiques de Strasbourg (CDS) for access to the SIMBAD system.
- The Rutherford Appleton Laboratory in the UK for access to the Geophysical Data Facility (GDF) system.
- Electronic Conferences and bibliographic facilities at ESRIN, Italy.

The system has been implemented gradually, starting with the establishment of the communications network between the major sites using the ESAPAC X.25 backbone network. Most of these links are in place and, where they are not, alternatives using SPAN or public X.25 networks are available. In addition to improvements in networking, the ESIS project has provided several microVAX class machines at some sites to run the ESIS software efficiently.

The software products for ESIS are being written by contractors and fall into two classes, the 'Shells' and the 'Query environments'. Firstly a 'User Shell' provides the user interface to the system and runs on the user's own computer. This system is built from the TermWindows terminal windowing system and is flexible and user-friendly. It has been implemented at the participating sites and is at version 1.1. As a complement to this, 'Service Shells' will run on the remote machines to handle the requests coming over the network from the 'User Shells'. These are not yet fully implemented. The second class of software products is intended to allow a user of ESIS to query the databases in a very flexible manner, using a discipline rather than computer specific language. The first of these is the 'Astronomy Query Language' which is being defined under contract at the CDS. This will be followed by a 'Space Physics Query Language'—defined under contract at the Rutherford Appleton Laboratory—and a 'Correlation Environment'. The last of these will provide tools for correlating information between different databases and archives. Two working groups, on Astronomical Databases (chair: F Pasian) and on Space Physics (chair: W Baumjohann) have been set up with the purpose of advising the ESIS project on all matters relating to the respective information requirements of the two communities.

HST in orbit—the first week

This is a first summary of the state of the HST in orbit. As News, it will be stale. We do, however, intend in this Newsletter to present regular summaries of events which will have an ever-broadening perspective.

Robert Fosbury

The Hubble Space Telescope's first week in orbit has been extremely hectic—a fact which will come as no surprise to anybody, least of all the team responsible for the Orbital Verification (OV) of the spacecraft. They must have amassed rather little sleep during this period! From the wealth of information about events which has emerged from the Space Telescope Operations Center at the Goddard Space Flight Center and the Space Telescope Science Institute in Baltimore, we have attempted to prepare an overview of what happened between launch and the end of April. This will, of course, be stale news by the time this Newsletter is mailed but nonetheless probably worthwhile, especially for our readers who are not enmeshed in the web of electronic communications whose bulletin boards can react almost instantly to developments.

Since we are so close to the events following launch and deployment, it is difficult to form a wide perspective from which the potential scientific performance of the observatory can be predicted. The situation does, however, look very promising. There have been difficulties of course: with such a fantastically complex machine that is what one expects. At the moment though, none of these problems looks particularly serious and, indeed, many have already been either solved or circumvented. Perhaps the most significant event, occurring just a week after launch, was 'first light' in the three Fine Guidance Sensors (FGS) which gave the first confirmation of the spectacular quality of the telescope optics.

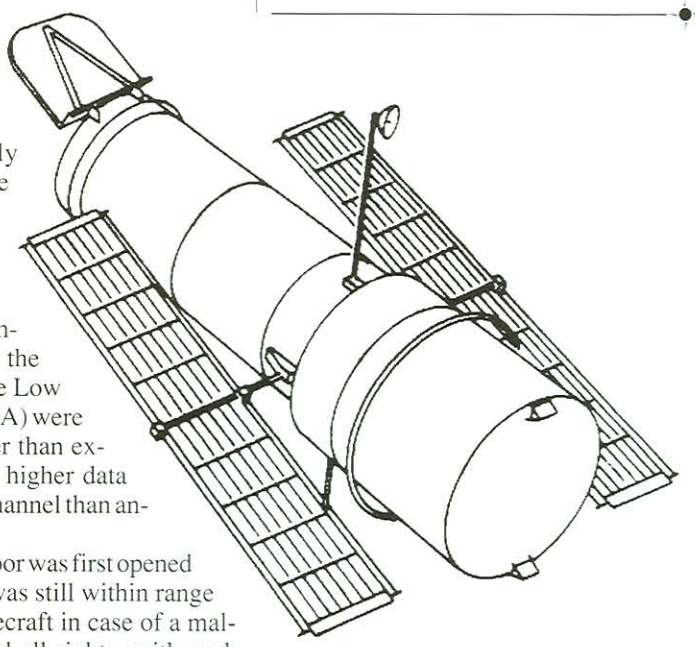
During the deployment exercise which started just one day after launch, the most critical event was the unfurling of the telescope's wings—the solar arrays which provide the several kilowatts of electrical power to the spacecraft and its batteries. Since HST was now unplugged from the orbiter's power, the process had to occur within a limited period (some eight hours) or the telescope would freeze and die. Watching all this happening live on superb quality TV from Discovery was an enthralling opera. It worked; there were hiccups but the engineers watching the real-time plot of the state of charge of the batteries saw: "A wonderful change in slope from negative to positive when the first array deployed and a further change when the second array made it." In fact, the power situation appears to be very good with plenty of capacity in the arrays and a large decrease in the spacecraft's energy budget resulting from its lower than expected heating requirements.

The communications problems received much press coverage when it was realised that one of the two High Gain Antennæ—the little dishes on the ends of poles emerging at right angles to the solar array masts and called HGAs—was sticking and thus losing contact with the Tracking and Data Relay Satellites (TDRS). Following much frantic research, the examination of photographs and even the construction of a toy model, it was realised that this was being caused by the antenna counterweight snagging a cable harness which sticks out from the supporting mast. Once this was appreciated and the antenna was 'jiggled' free it was possible to formulate procedures which avoided the problem (in principle it affects both antennæ) by restricting the range of travel. The 'zone of avoidance' now appears to be smaller than originally feared; only about 10% of the expected prelaunch TDRSS visibility. During this period, it was discovered that communications with the spacecraft using the Low Gain Antenna (LGA) were considerably better than expected allowing a higher data rate through this channel than anticipated.

The aperture door was first opened while Discovery was still within range to revisit the spacecraft in case of a malfunction. It opened all right—with such enthusiasm that, on hitting the end stop, it wobbled the telescope enough for the gyro system to object and trigger a 'software generated V3 sunpoint' safemode. This means that the telescope remains with its back to the sun. Since then, in fact, the operations teams have had several more unscheduled live practice runs at extracting the telescope systems from safemode. I expect they'll get pretty good at it! The pointing and control systems do appear to be behaving very well now with all the 'gyro' problems being attributed to oversensitive software.

As far as the Scientific Instruments are concerned, there is not yet much to report although there will probably have been much news by the time this is read. All have been switched on and everything appears nominal.

This report was prepared from information made available by the staff of the STScI, generally through their electronic bulletin board services, and I thank them for keeping everybody so well informed. I also thank my colleagues, particularly Richard Hook and Fionn Murtagh, for keeping track of all the stuff and feeding it to the Europeans via the STINFO bulletin board.



The processing of HST observing programmes

Hans-Martin Adorf

A General Observer's HST Phase II observing proposal, once submitted to the Space Telescope Science Institute, undergoes a complex process: it is catalogued and validated; it is expanded and, if necessary, a calibration plan is developed; it is transformed and repeatedly checked. At various processing stages intermediate results are assessed and reviewed. Eventually, each proposal is taken apart and its individual exposures are merged into 'scheduling units' which are pooled with the scheduling units of the other proposals. Long-term observing plans are constructed on a trial basis in order to assess the scheduling feasibility of all proposals together.

Several branches of the STScI work, often simultaneously, on different aspects of the proposal; they add further information and clarify problems cooperatively on various levels. Proposals with problems or errors have to be modified and fed back into the proposal processing 'pipeline' at some earlier stage. When a proposal is finally approved by the Telescope Allocation Committee (TAC), it becomes a genuine HST *programme*. A long-term observing plan is generated from which weekly segments are chopped off for detailed scheduling and the generation of the spacecraft commands which control the HST.

This article explains some of the processing/transformation steps which are needed to carry out the astronomers' observing plans as specified by the Phase II proposals. The procedures and software systems which have been put in place at the STScI to support all phases of proposal processing represent a major achievement. A general understanding of the issues involved will, in the long term, facilitate interactions between General Observers and the STScI and should help to make better use of the novel opportunities that HST provides.

Proposal receipt

The STScI was pleased to see about 90% of the 162 General Observer Phase II proposals in the first cycle being submitted electronically via the Remote Proposal Submission (RPS) system over computer networks. Upon receipt, every proposal was (once again) subject to a *validation* test checking for 'syntactical' errors, e.g. misspelled filter names or missing targets. Valid proposals were recorded in the Proposal Entry Processor entry data base (PEP EDB). Also at this early stage the SEQUENCE, REPEAT and DO FOR TARGETS loop constructs of the exposure logsheet were expanded by the validation software.

In a subsequent *verification review*, staff of the User Support Branch (USB), which supports programme selection and preparation in general, checked the compliance of the Phase II proposal against the resource (i.e., spacecraft time) allocations of the TAC.

Why is HST planning and scheduling so difficult?

In view of the enormous cost and oversubscription of HST, the construction of an optimum observing schedule is very important. It is also a horrendously difficult problem.

The general scheduling problem belongs to an equivalence class of intrinsically difficult ('NP-complete') problems of discrete mathematics, a fact long known to computer scientists. The 'combinatorial explosion' in the number of possibilities to consider is prohibitive and finding truly optimum solutions to the underlying optimization problem is generally impossible. Despite all recent efforts in algorithm research, for any realistic problem only good approximations are within reach with efforts limited by computer-cycle availability.

Compared to the geostationary IUE or the forthcoming ROSAT satellite, planning observations for HST is considerably more complicated for a variety of reasons. HST's low-earth orbit presents the telescope with rapidly changing viewing, background and straylight conditions while its slow slewing capability generally prevents the telescope observing another target during earth-occultation. Power constraints require a more or less fixed orientation ('roll angle') of the spacecraft's solar panels with respect to the sun. Due to atmospheric drag, the precise orbital position of HST depends on its detailed observational (orientation) history: recent estimates predict a three-sigma uncertainty in the orbit position of about 10% of the orbital period after three weeks. The impact of this on HST operations has not yet been fully assessed. Furthermore, telecommunication links via the Tracking and Data Relay Satellite System (TDRSS) are not always available due to the precedence of military and Space Shuttle telemetry requests, while limited on-board tape-recorder storage space does not allow continued off-line observations with a data replay at a later time.

In addition to spacecraft constraints, proposers may specify 'special requirements' (such as 'early acquisitions', 'conditionals' and 'selects') and relative timing constraints (such as 'precedence', 'time separation' and 'non-interruptability') leading to *dependencies* between different exposures. Then scheduling has to deal with parallel observations, targets of opportunity...

Prioirities could, in principle, serve as another important criterion to influence the scheduling and eventual execution of observations. Proposers may specify an 'exposure priority' for each line on the exposure logsheet. In addition, each proposal receives an STScI director assigned priority. Legal priority values are high, medium and supplemental, out of which the Telescope Allocation Committee (TAC), advising the STScI director, has used only high and supplemental so far.

The interacting operational, spacecraft and environmental constraints for HST are so overwhelming in number and complexity (Sherrill 1984; Johnston 1987; Johnston *et al.* 1990) that the observatory can only be operated in an almost completely pre-planned mode with very limited 'real-time' interaction. Novel artificial intelligence and 'neural network' based methods for constraint representation, reasoning and search (Johnston 1989b; Adorf & Johnston 1990; see also *Computers in Physics*, May/June 1989) had to be developed and were implemented in a software suite called *Spike* (Johnston 1989a, 1990; Johnston *et al.* 1990) in order to cope with the multitude of constraints, preferences and uncertainties of the ten to thirty thousand exposures per year that make HST scheduling so hard.

Next, Telescope and Instrument Branch (TIB) staff, upon a detailed reading of the Phase II proposal, performed the so called *observation feasibility review*. The availability of adequate calibration data was checked and, if necessary, a special *calibration plan* was developed. (Calibration of HST's science instruments will be largely request-driven.) Science Instrument and Optical Telescope Assembly health and safety conditions and the feasibility of target acquisition were also checked.

In an attempt to detect proposed observations aiming at the 'same scientific goals', all proposals were mutually compared with each other and checked for similarity, i.e. same instrument parameters, similar exposure times and approximately identical target position (within the area of a WF/PC frame). 'Same science' *duplication checking* is being carried out by an expert system implemented in the OPS5 rule-based language (Jackson *et al.* 1988). All proposals suspected of aiming, at least partially, at the 'same science' were reviewed manually in order to resolve the conflicts.

Proposal preprocessing —'pre-planning'

Staff of the STScI's Science Planning Branch (SPB—formed just two years ago), are now busy constructing a long-range plan for HST science and calibration operations and identifying and correcting errors or problems that stem from the proposals. The first major proposal processing step performed and supervised by SPB is *proposal transformation*. The functionality provided by transformation is both critical for the performance of HST and difficult to grasp. During transformation the observational requirements of the proposal's exposure logsheet are effectively translated into HST 'machine language' instructions. The astronomer specifies *what* to observe, transformation specifies *how* to implement the observations. In a staged process, exposures from individual proposals are merged into 'scheduling units' that are later to be placed on the timeline as indivisible entities.

The term transformation actually refers to both the *process* of converting proposal information from the PEP internal database representation into specific data structures that make a proposal schedulable with the Science Operations Ground System's Science Planning and Scheduling System (SOGS/SPSS) and to an *expert system* (Rosenthal *et al.* 1986; Miller 1989) that automates the task. As a welcome side-effect TRANS, as the expert system is often called, catches many semantic errors which cannot be detected during the proposal validation phase.

Originally, proposal transformation was perceived as a process that could be performed manually by 'operations astronomers', i.e. users and operators of SOGS/SPSS. TRANS, replacing these for this task, has over the years matured into a unique repository of proposal transformation expert knowledge. Still growing, TRANS currently comprises more than 280 rules expressed in a special language on top of its implementation language *Lisp*.

TRANS also comprises a resource usage estimator (Miller 1989) which is more sophisticated than the one included in the Remote Proposal Submission system. In order to detect potential guide star problems at the earliest possible stage, TRANS requests guide star pairs from the Guide Star Selection System. A number of further tests, including the *bright object alerting* and the *scheduling feasibility checks* conclude the so-called 'pre-planning' phase in the lifecycle of a proposal.

Planning HST observations

The process of planning and scheduling HST observing programmes proceeds in two major steps called long-range planning and short-term scheduling. HST long-range planning consists, simply stated, in placing observations (more precisely 'scheduling units') at optimum times onto a year-long timeline. The objective is to optimize the spacecraft's overall efficiency to the benefit of the whole community. This obviously important task is also challenging, given that a year-long schedule for HST observations comprises some 10,000–30,000 exposures which are subject to numerous and, what is more, interacting scientific, operational, spacecraft and environmental constraints (Sherill 1984; Johnston 1987).

The extreme difficulties of long-range planning for HST (see box "Why is HST planning and scheduling so difficult?") had been underestimated for a long time. Only a recent dedicated and indeed very successful rescue operation carried out by STScI's Operations Software Branch (OSB) could overcome the problem of HST's science efficiency being severely limited by the shortcomings of the SOGS/SPSS planning and scheduling software. The result of this effort is *Spike* (Johnston 1989a; Johnston *et al.* 1990 and references therein), which is now used by SPB staff for the long-range planning of HST observations. The novel automatic search and commit algorithms of Spike are fast enough to synthesize several long-range plans, the best of which is retained. The selected plan, typically comprising a year of HST observations assigned to weekly segments, is finally reviewed and approved by the STScI director. Whether it will also be published or become remotely accessible is currently under discussion.

Weekly segments of the long-range plan are handed over to the SOGS/SPSS system which is executing the short-term scheduling of HST activities. Being reworked and heavily supported by the PEP/TRANS/Spike suite of proposal processing tools, the SOGS/SPSS system has now acquired sufficient throughput capability to carry out an efficient scheduling of HST observations—at least as long as it is restricted to scheduling one-week segments.

Genuine errors in proposals, ground system deficiencies, spacecraft problems or lost transmission links may render some exposures unschedulable or non-executable. When such problems occur, the cause of failure will have to be analysed in each case. In a re-planning phase, a decision will be taken whether and where to resubmit the exposure into the planning loop. An STScI internal Transformation Working Group, created to facilitate cooperation between those branches participating in the long-range planning activities, will also take care of problematic cases. How exactly re-planning will be carried out will be defined when some experience with HST is gained.

Interactions

Many investigators will wish to know as soon as possible when the first and last exposures of their HST programme will be taken and when the data can be expected. The latter information is particularly important for joint proposals submitted by collaborative groups who will have to coordinate their data analysis efforts before the limited data proprietary period expires. Publication of the long-range plan may help in this respect.

Proposers who have used 'special requirements' (early acquisitions, conditionals, selects and real time contacts) and those with questions related to limitations of ground-system capabilities, guide star availability, target acquisition, roll-angle constraints, calibration requirements and potential instrument problems may require interaction with the STScI. A coarse understanding of the flow of proposal information through the STScI, as presented here, may facilitate this kind of interaction.

Open questions and remaining difficulties

HST efficiency. One of the big unknowns in HST operations is the overall efficiency that HST will achieve. 'Science efficiency' is defined as the ratio of time spent on doing scientific observations to total elapsed time; it is affected by orbital constraints (60–65% loss) comprising earth occultations (47%), the South Atlantic Anomaly (10%) and bright limb constraints (5–10%). Add to this the pro-

A brief scheduling glossary

absolute constraint — a constraint upon a single activity that is independent of whatever else is scheduled; such constraints may be derived from physical phenomena (e.g. *sun exclusion, moon exclusion, South Atlantic Anomaly restrictions, orbital viewing*) or from proposer specifications (e.g. *proposer windows, orientation*).

alignment — a set of one or more HST **PEP exposures** that can be taken without moving the telescope

artificial neural networks — a recent computing paradigm modeled on biological brains; one of the automatic commitment algorithms of **Spike** is based on a stochastic variant of a neural network.

exposure — a term commonly used for both **PEP exposures** and **SPSS exposures** where the context helps to discriminate between the two; in general, there can be a many-to-many mapping between **PEP** and **SPSS** exposures.

merging — the basic process implemented by **Transformation** to produce **scheduling units** from **PEP exposures**, in other words the process of aggregating exposures together to produce **alignments**, **obsets** and **scheduling units**.

observation set (obset) — a set of HST **alignments** that can be carried out with the same pair of guide stars

PASS — PORTS Application Software System; uses the **SMS** to generate the HST computer commands.

PEP — Proposal Entry Processing system storing the original and modified observing proposals

PEP exposure — a collection of data from a target using a specified instrument setup. (If an exposure logsheet line invokes a sequence or uses the DO FOR TARGETS, REPEAT or PERIODIC special requirement, then the line will create multiple exposures, otherwise each PEP logsheet line creates one PEP exposure.)

relative constraint — constraint that depends on whether or when other **exposures** are scheduled; examples include sequential, sequential offset, max time separation, contiguous sequential, same orientation, and repeat set links.

scheduling — mathematicians and computer scientists usually make a distinction between the terms *planning* and *scheduling*. Generally, planning is the process of deciding *what* to do and scheduling is the process of deciding *when* to do it.

scheduling unit (SU) — the smallest (indivisible) entity, consisting of **observation sets**, that **SPSS** can place onto the HST timeline

science efficiency — the ratio of time spent on scientific observations to total elapsed time

Science Mission Specification (SMS) — the ultimate output product of the STScI for consumption by **PASS**; it specifies all the HST activities for typically one week.

Science Program Selection Office (SPSO) — an office within the STScI director's office in charge of policy and procedures related to proposal selection; runs Telescope Allocation Committee meetings and forwards their recommendations to the director for approval prior to public release.

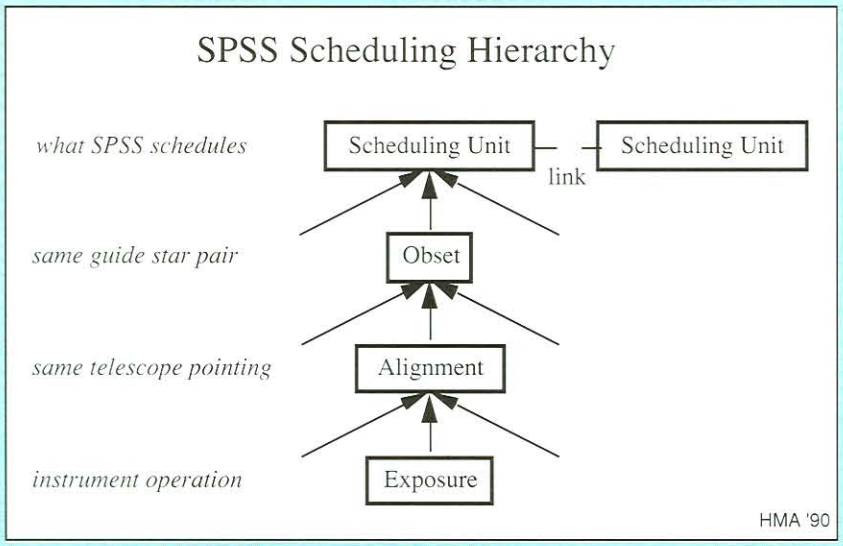
Spike — HST's long-term planning and **scheduling** system developed at the STScI; a key ingredient of Spike is the use of artificial intelligence software techniques in order to accomplish the complex set of objectives within a reasonable development time and effort. They include new programming paradigms such as **artificial neural networks**.

SPSS — HST's Science Planning and Scheduling System, takes care of the short-term **scheduling** task

SPSS exposure — the lowest element in the **SPSS scheduling hierarchy**; the scheduling unit is the entity that SPSS ultimately schedules as a whole.

SPSS scheduling hierarchy — a decomposition of SPSS scheduling units; a **scheduling unit** consists of **observation sets** (obsets) which consist of **alignments** which consist of SPSS **exposures**.

suitability function — a domain-independent framework used by **Spike** for representing and reasoning with disparate sources of **scheduling** knowledge. The approach is designed to consider simultaneously a wide variety of external **constraints** and mutual interactions, both strict and preferential, that may depend on time or on the current state of a partial schedule. (The suitability function measures how good it is to start a scheduling entity as a function of time. A value of 0 indicates that the entity is strictly forbidden to start at that time; a value < 1 means less suitable; a value of 1 indicates nominal suitability; a value > 1 means a more favourable suitability.)



Telescope and Instrument Branch (TIB) — provides, within the STScI, expertise in the areas of science instrument usage and calibration; monitors science performance of the observatory; also responsible for maintaining close links to the Investigation Definition Teams; presently heavily involved with Science Verification planning in addition to other areas above.

Transformation (TRANS) — refers to both (a) the process of converting the information in the **PEP** database into the **SPSS scheduling hierarchy** and (b) the expert system software which automates this process. By **merging** scheduling entities as far as possible TRANS expresses a proposal in terms of **scheduling units** and other data structures in the **SPSS scheduling hierarchy**. As a welcome side-effect, TRANS catches many errors not detected during the proposal validation phase.

User Support Branch (USB) — STScI's centralised user support services: documentation and information services, proposal and programme processing, on-site logistical support to visiting users, conduit to other STScI 'expert' groups.

gramme dependent observatory overhead times, i.e. Fixed Head Star Tracker updates (5 min each), guide star acquisition (8–20 min each), target acquisition (0–25 min each) and science instrument overheads (0–3 min) and a variety of other potential operational overhead times.

Up to 2 real-time contacts can be handled per day (Macchetto 1989). Real-time interactive acquisitions will require approximately 30 min in addition to the guide star acquisition (so plan for the best part of an orbit).

Based on current HST planning and commanding capabilities, the achievable science efficiency is estimated to be 18%. With future improvements it may potentially be raised to 30% ± 3% (Stockman 1989). Despite these figures, current policies call for optimism in order to avoid empty holes in the schedule. Consequently the telescope is oversubscribed by a certain (unknown) amount, i.e. more proposals are being accepted than can possibly be executed within the cycle duration.

Parallel observations. Although HST was designed with parallel observations in mind, observing proposals requesting parallel observations may present a difficulty for HST operations. The reason—call it a feature, call it a design flaw of HST (see Waldrop 1989)—is this: when a low- and a high-data rate instrument simultaneously try to read out their data, HST will go into 'safe mode'. Recovering from safe mode is a very expensive operation that could significantly disrupt the scheduled observations.

Current efforts concentrate on circumventing the hardware problem in software: sophisticated spacecraft command sequences are being designed to avoid data clashes. The problem is difficult to resolve since the state of the spacecraft has to be fully predicted in advance. Implementing a full parallel observing capability is one of the STScI's top priority items and it is hoped to have a full parallel mode capability for HST ready for the second half of Cycle 1. Parallel observations using low data-rate instruments only or the FGS as the primary instrument will however be available already early in Cycle 1 (Macchetto 1989).

Exposure time adjustments. The duration of an exposure is an important low-level parameter influencing scheduling decisions. Currently, the ground system provides no flexibility in changing exposure times, e.g. in order to fill holes in the schedule or to cut the time of an exposure that just does not fit into a remaining time slot.

Left-overs. It is an important question how left-over exposures belonging to incomplete programmes from previous cycles will be treated: those from supplemental programmes will most likely be dropped; those from high-priority programmes will presumably be carried over into the next cycle—unless there are too many of them.

Conclusion

The combination of the number and versatility of its instruments, its low earth orbit and a strong dependency on telecommunication via the Tracking and Data Relay Satellite System (TDRSS) make the Hubble Space Telescope stand out as the most difficult civil satellite to schedule and operate. To the benefit of the HST users, STScI has put in place both an infrastructure and a set of advanced planning tools that cope with the complexities of HST planning and scheduling.

The analysis of the Cycle 1 General Observer proposals has revealed that they are generally simpler than the Science Verification or Guaranteed Time Observer proposals and, fortunately, usually reasonably well behaved under proposal processing. From the limited experience gained so far, a few general rules for future cycles can already be extracted in order to facilitate proposal processing and to off-load the burden carried by the STScI:

- General Observers are well advised not to write overcomplicated or much constrained proposals; in particular, they should not try to micro-schedule their observations by using lots of timing and other special requirements.
- It is not advisable to attempt too much in one go (e.g. to observe the centre of a galaxy with the WFPC and simultaneously one of its globular clusters with the FOC).
- Real-time interactions with the telescope and links between exposures should be minimised as much as possible.
- Repeated short observations with data set sizes comparable to the data transmission limits—the maximum daily data rate is 2 Gigabits or about 40 WFPC frames—should be avoided.

The STScI staff continue to work hard on implementing or refining methods to handle priorities, special requirements and resource constraints, to establish procedures for feeding back flawed proposals or non-executable exposures, etc. and to develop suitable commanding sequences for parallel observations. Understandably, with tens of thousands of exposures per year to be processed, the STScI will find it difficult to allocate substantial resources to tackle difficult problems associated with individual exposures.

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News

Piero Benvenuti

April 24th and 25th were memorable days at the ECF: we were able to follow the launch and deployment of HST in real-time thanks to a direct TV link with the NASA Select channel which was organized by ESA through the Canadian Department of Communications. The reception and re-transmission in Europe used the ESA Olympus satellite. The date and time of launch nicely coincided with the opening of the ESO/ECF Data Analysis Workshop, therefore quite a number of European colleagues as well as friends from the nearby Max Planck Institutes shared with us the emotions of this historic event. On Wednesday evening, a champagne toast marked the (finally!) successful opening of the second solar panel and the delivery of HST to its own free space.

The interest in the telescope, following its launch and the beginning of the Orbital Verification phase, has grown considerably in Europe as we can judge from the number of enquiries we are receiving daily, both by astronomers and by the news media. The ECF has organised a service to keep the relevant information up to date: since news are delivered daily, the only practical vehicle for disseminating them is the electronic bulletin board which is remotely accessible on the ESO special account STINFO (no password needed). Please check it regularly to find out what's happening and to get advice on using additional sources of information which may become available (e.g. the schedule of Orbital and Science Verification—OV and SV—activities).

During OV, we will obtain information from the STScI principally by electronic means. Later, when SV begins, several ECF staff will spend extended periods at the STScI in order to gather first-hand data on the performance and calibration of the Instruments.

The second cycle of General Observer time applications will begin late in May with the distribution of the Announcement of Opportunity by the STScI. The director has determined that the Cycle 2 proposal deadline will be no earlier than 1990 Nov. 15, contrary to the previously announced August date.

Our Archive group started immediately with operational work: the first catalogue information is already being transferred routinely from the STScI to the ECF and soon the first optical disks, containing data, will arrive. Appropriately, we welcome this month the ECF/ESO Archive Operator, Susan Hill: she was working before at ESOC as a computer operator and she seems very happy to start her new job during such a hectic and exciting time.

We should like this Newsletter to reach as wide an audience of European astronomers as possible. If you are not on the mailing list but would like to receive future issues, please write to the editor stating your affiliation.

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