STARLINK

SCIENCE & ENGINEERING
RESEARCH COUNCIL

Starlink is providing the astronomical community in the United Kingdom with unsurpassed facilities for rapid and effective analysis of the vast amounts of data captured by telescopes throughout the world or on satellites, thus providing essential support to research which probes the furthest reaches of space and time.

The region of sky in the constellation of Orion, containing the famous 'Horsehead' Nebula, reconstructed in true colour by D. F. Malin from three original U. K. Schmidt photographs in three primary colours.
(Copyright: Royal Observatory Edinburgh)

STARLINK

The Science and Engineering Research Council has launched Starlink to provide and co-ordinate image processing and data reduction facilities for use by the UK astronomical community.

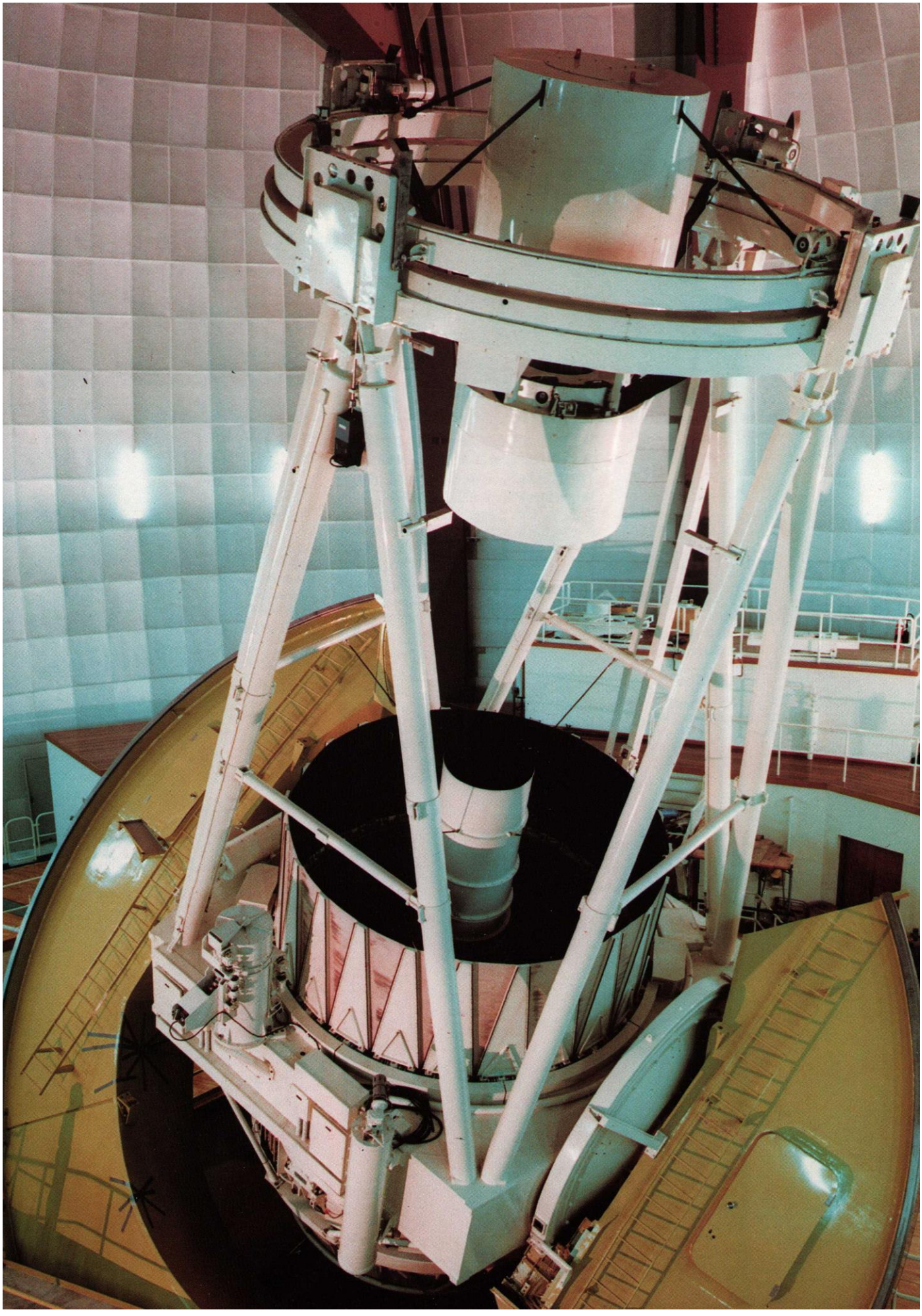
The project provides a network of powerful computer systems located at centres of astronomical research.

The hardware and software are co-ordinated from the Rutherford Appleton Laboratory.

Astronomers in Britain now have access to a wide range of observational instruments both on the ground and in space. Most of these are producing data in the form of large digital arrays, and the requirement for powerful data processing facilities has become critical.

There have hitherto been very limited facilities in the UK for performing scientific analysis of observations. Astronomers have had either to reduce the data manually or devise their own ad hoc data processing facilities. Even the modest facilities which existed could be used by only a few astronomers and were heavily over-subscribed, particularly where effective interaction with the reduction process was demanded. In the 1980's, the vast majority of astronomy will be done using data in digital form and adequate image processing facilities are essential.

STARLINK is the SERC response to these problems and is in line with its policy to maintain the UK in the forefront of astronomy.



UK Astronomy

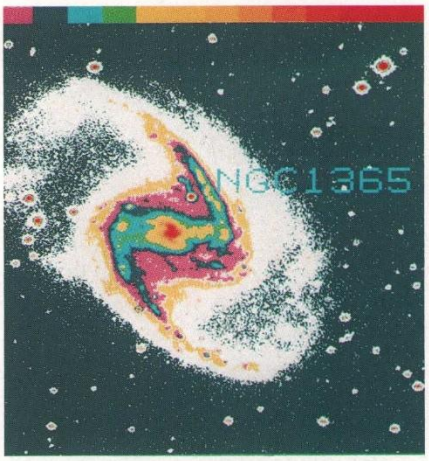
SERC contributes to a number of first class ground based observational facilities, including the Anglo-Australian Telescope, foremost in the world in its design, performance and instrumentation, and the UK Schmidt Telescope, a special purpose photographic instrument currently engaged on surveys of the sky to extremely faint light levels. Both telescopes are sited in the southern hemisphere (in Australia) and in the coming years will be augmented by similarly powerful optical telescopes being erected by SERC at the new La Palma Observatory in the northern hemisphere. Notable amongst SERC supported space experiments are the International Ultraviolet Explorer satellite (for UV spectroscopy) and the Infra-red Astronomical Satellite, to be engaged on a complete survey of the sky at infra-red wavelengths. The launch of the Space Telescope will dramatically increase the observational power at the astronomer's disposal and is expected to lead to profound advances in our understanding of the universe.

In the 1980's, these facilities will provide vast quantities of information that will reach the astronomer in digital form, either directly from the telescopes' instruments or via fast, powerful photographic plate measuring machines such as COSMOS at the Royal Observatory, Edinburgh or the Automatic Plate Measuring Machine at the Institute of Astronomy, Cambridge.

Confronted with such huge volumes of data, astronomers need sophisticated and powerful computing capabilities in order to find, extract and evaluate precisely the information required. Experience has already shown that a combination of computing power and the ability to interact with the data through visual display devices enormously increases the effectiveness and speed with which important results can be obtained. Starlink will provide astronomers with this capability, which will be exploited in a variety of ways depending very much on the nature of the observational data.

In studying a typical spiral galaxy such as NGC 2997, shown here, an astronomer would first obtain one or more direct photographs (from, for example, the Schmidt telescope). These can be examined visually and then digitised to produce a two dimensional array of numbers representing the precise intensities of light being emitted from all parts of the galaxy. Several such photographs taken in different wavebands can be similarly processed and combined to provide spectral information of low resolution over the whole face of the galaxy. The ability to exhibit the digital information on a colour display device then enables the astronomer to select and study particular regions of interest. A variety of image processing techniques can be used to reveal the more detailed structure, or highlight very faint features. Shown here is a false colour representation of another spiral galaxy, NGC 1365, in which

A false colour representation of the spiral galaxy NGC 1365 produced on the Sigma Advanced Raster Graphics Display. Colours represent different intensity levels.



both the detailed structure of the (heavily overexposed) nucleus and the very faint outer extensions are revealed through image processing. It is also of interest to astronomers to superimpose contour maps of emission observed at other wavelengths (radio, X-ray) and to compare them with the optical emission: procedures easily done on an image display with the appropriate image stored in the computer.

Astronomers are also interested in obtaining much higher resolution spectral information over a galaxy in order to study its internal motions, physical conditions and chemical composition. A telescope like the AAT would be used to obtain these observations using a two dimensional detector on a spectrograph which produces simultaneously many individual, high resolution digital spectra of different points of the galaxy. These observations are reduced mainly using graphics techniques to display each spectrum, select lines of interest interactively and measure their wavelengths and intensities. The complete analyses of such observations can also be done interactively by calling appropriate model spectra from the computer and fitting to the observations. These extremely fast and powerful analysis techniques represent a great advance over earlier much more laborious methods.

Above: The spiral galaxy NGC 2997, reconstructed in true colour by D. F. Malin from three original Anglo-Australian Telescope photographs in three primary colours. The central regions of the galaxy contain old (yellow) stars, the spiral arms young (blue) stars.
(Copyright: Anglo-Australian Observatory)

Left: The Anglo-Australian Telescope on Siding Spring Mountain in Australia. The main mirror, 3·9m in diameter, is located at the bottom of the framework of steel tubes, which swings between the arms of the precisely machined horseshoe bearing.
(Copyright: Royal Observatory Edinburgh)
(Acknowledgements: B. W. Hadley)

Hardware

Starlink is based on six Digital Equipment Corporation VAX 11/780 computer systems, linked in a communications network spanning the UK.

The VAX 11/780, a high performance 32-bit multi-programming computer system, is the successor to the PDP11 range. The larger Starlink systems each have 4 Mbytes of main memory, almost 1 Gbyte of disc storage and two 800/1600 bits per inch magnetic tape decks. There are also both electrostatic and impact printer/plotters.

Each computer supports two identical image display systems – the Advanced Raster Graphics System (ARGS) manufactured by Sigma Electronics. This system allows the display of colour images consisting of a matrix of up to 512 x 512 picture elements. It can switch between such pictures, transform the colour mappings to highlight features, zoom in on parts of the picture, generate lines and other graphics and perform many other functions. In addition, there are other terminals, some with a graphics capability (for spectra, intensity plots, etc.) and some ordinary alphanumeric terminals for general control purposes and program development.

Through the network, the astronomer will also have access to devices such as larger plotters and camera systems to produce colour prints and slides of astronomical objects.

The systems are linked in a star network by leased Post Office lines. Initially, DECNET communications protocols are being used; ultimately it is intended to adopt an X25 packet switched network to connect Starlink to the large Science and Engineering Research Council network. The links, capable of transferring information at speeds up to 1,000 characters/second, are used for the distribution of software and documentation.

Software

The systems software, in particular the 'Software Environment' for astronomical data reduction, is being developed at the Rutherford Appleton site. Applications software, although co-ordinated from there, is being undertaken at a large number of sites within the astronomical community.

One part of the 'environment' consists of a Command Language with which the user of an interactive terminal can invoke applications software. Using this language a novice can receive on-line documentation and prompting to take him through the system; the experienced user will be able to express operations in a concise and natural way.

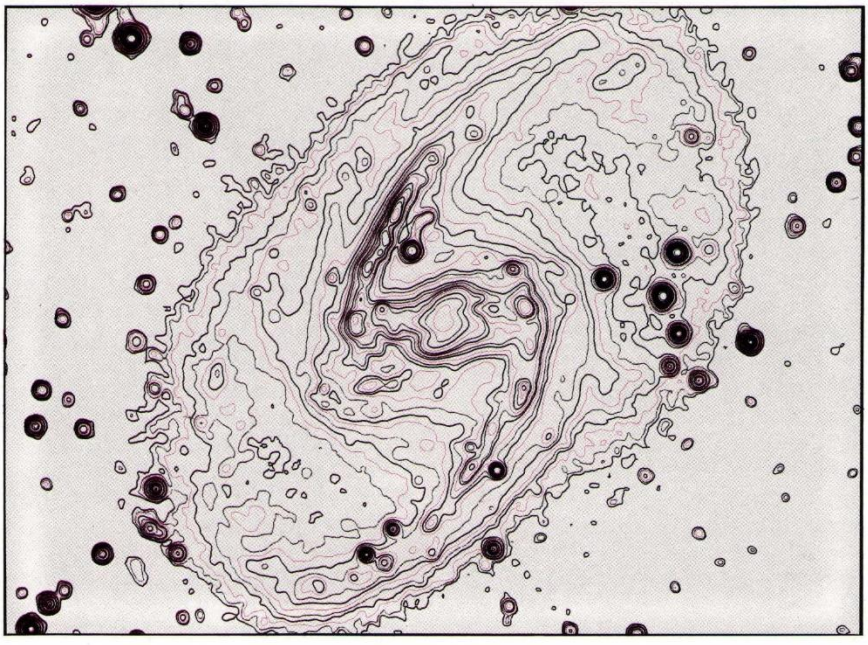
Also specified is a set of program interfaces which give astronomical programmers easy and efficient access to command parameters, images and other bulk data, graphics devices etc. This will allow the build up of compatible sets of applications software.

Although much of this is being implemented by Starlink staff, it is the intention that in many cases software being produced by astronomers in the course of their own research will eventually be taken over and supported by Starlink.

Wherever possible, generally accepted software and standards are being adopted. Thus the Fortran 77 Programming Language, the Numerical Algorithms Group (NAG) mathematical library, the device independent Graphics Kernel System (GKS) for graphics devices, and the Flexible Image Transport System (FITS) have been adopted as Starlink standards.

Above: The Starlink VAX computer at the Institute of Astronomy, Cambridge. (Acknowledgements Dr. C. A. Robinson)

Below: A graphical representation of NGC 1365 in which different intensity levels are represented as coloured contour lines.



Starlink nodes are as follows:

Rutherford Appleton Laboratory
(address below)

Royal Greenwich Observatory
Herstmonceux Castle
Hailsham, Sussex
BN27 1RP

Royal Observatory Edinburgh
Blackford Hill
Edinburgh
EH9 3HJ

University College London
Department of Physics and Astronomy
Gower Street
London
WC1E 6BT

Institute of Astronomy
Madingley Road
Cambridge
CB3 0HA

University of Manchester
Department of Astronomy
Oxford Road
Manchester
M13 9PL

How to Use Starlink

Research astronomers with a requirement for interactive data reduction may apply to use Starlink. Application forms may be obtained from the Starlink Site Manager at any Starlink node, or from the Starlink Office below. Every Starlink site manager will be pleased to discuss requirements. Completed forms should be either submitted with a SERC grant application or sent to the Starlink Project Manager at the address below.

Formal correspondence, general enquiries, requests for papers etc. should be addressed to:

Starlink Office
Rutherford Appleton
Laboratory
Chilton
Didcot
Oxon
OX11 0QX

Above: User terminals at Rutherford Appleton Laboratory.
Below: Herstmonceux Castle, site of the Royal Greenwich Observatory.
(Acknowledgements: D. A. Calvert)

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