# HIPPARCOS - THE TYCHO INPUT CATALOGUE

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ABSTRACT. The Tycho Input Catalogue will be used as a finding list to identify the stellar data within the stream of raw data received from the Hipparcos star mappers. It is based on an a priori list of stars, namely the Guide Star Catalogue being created for the Hubble Space Telescope at the Space Telescope Science Institute. The Guide Star Catalogue will contain positions and magnitudes for objects in the sky complete to at least 14 mag, and will contain about 20 million stars. The data for the sky complete to approximately 12.5 mag, extracted from the Guide Star Catalogue, along with some additional data from the SIMBAD data base of about 500 000 stars at the Strasbourg Stellar Data Centre, will form the Tycho Input Catalogue of approximately 2 million objects. As of the 1985 IAU General Assembly nearly 50 per cent of the plates for the Guide Star Catalogue had been measured, and 10 per cent of them were completely processed and catalogued.

## 1. INTRODUCTION

The primary advantages of using an input catalogue for the Tycho data reductions (Grewing & Høg 1985), rather than performing a completely independent survey of the sky based only on Tycho data, are the savings in data processing and the possibility to work to a fainter limiting magnitude. In addition to searching for data from all transits of the stars in the Tycho Input Catalogue in the data stream, the data reduction procedure will also save the data from all transits with a signal-to-noise ratio greater than 3. The primary source of data for the input catalogue will be the Guide Star Catalogue compiled for Space Telescope.

## 2. THE ST GUIDE STAR CATALOGUE

The construction of the Guide Star Catalogue (GSC) has been discussed in several other descriptions (Jenkner 1983, Russell 1986), and will be only briefly summarised here as a step-by-step process. The individual



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processes in the construction of the catalogue, given in Table 1 in the order in which they are executed, are as follows:

- 'Log-in': data about each plate are entered into the GSSS data base, including such things as plate type, epoch, telescope, bandpass, etc. The Guide Star Catalogue will be based on the 1500 plates described in Table 2;
- 'Check-in': this is done on a digitising data tablet, which has a measuring accuracy of 0.1 mm. The plate corners are measured and 10-20 SAO stars are identified as orientation stars for future reference. Any unusable areas of the plates are outlined with polygons whose vertices become part of the data base, as well as coordinates for any other spurious marks (e.g. satellite trails, reflection images, etc.) which are identified by the operator. Finally, a list of training set objects, such as bright stars and galaxies, which are used in classification (see below), are identified and measured;
- 'Digitise': this is the plate measuring process. Each plate is mounted onto a PDS and scanned as one large 14000 x 14000 raster of pixels. The scanning is done with a 50-micron apodised aperture and a pixel spacing of 25 microns. As of the 1985 IAU General Assembly 715 plates had been digitised;
- 'Model Sky': this determines the sky background for the plate;
- 'Inventory': this processes the raw digital image of the plate into a list of objects on it, with their approximate sizes, positions, integrated image densities and shapes of the images. It is a variation of the COSMOS program from the Royal Observatory Edinburgh;
- 'Refine': this involves determining a more precise position of the image. The algorithm used is called SuperGauss, which is a two-dimensional elliptical Gaussian fitting routine to the shape of the image, where the factor 2 normally included in the Gaussian exponent is allowed to vary as a parameter. This has been shown to be a better fit to the Schmidt plate images than a normal Gaussian function (Sanders & Schroeder 1980). This stage is the most time-intensive task in the GSC construction; as of the 1985 IAU General Assembly 191 plates have successfully been processed through it;

Table 1. Tasks within ST Guide Star Catalogue Construction

| Task | Time | Remarks |
|---|---|---|
| Log-in | 5 min | |
| Check-in | 30 min | |
| Digitize | 12 hr | +45 min for tape copy |
| Model Sky | 20 min | |
| Inventory | 3-4 hr | 5000-30 000 objects per plate |
| Refine | 4-24 hr | |
| Classify | 10-30 min | |
| Calibrate | 5-15 min | |
| Update | 1-5 min | +5 min for file tape copy |

Note: Time is wall clock time for processing

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- 'Classification': this classifies the object as stellar, non-stellar or unknown. The Space Telescope guidance system requires guide stars which are stellar and cannot use other objects, such as compact galaxies, for guidance. The classification system uses the training set objects marked in plate check-in as a guide for the plate and a Bayesian classifier;
- 'Calibration': this includes both the photometric and astrometric data reductions. The photometric solution fits the log of the integrated image intensity to photoelectric photometry for a sequence of six stars in the range 9-15 mag, generally using a second-order solution. This is applied across the plate, allowing for vignetting experimentally determined for each telescope. The astrometric solution uses an independent reduction for each coordinate and a model of 10 plate constants for each. The model allows for the known geometric distortions of the Schmidt plates and appears as a general third-order polynomial (Russell & Williams 1986). The AGK3 is used for reference where available and the SAOC in most of the southern hemisphere. The Cape Photographic Catalogue is used near the south celestial pole, where it was not included in the SAOC;
- 'Update': this last step takes the data for the plate and integrates it into the catalogue. The most complicated part of this process is to identify common stars appearing on adjacent plates so that only one identification is assigned to each star regardless of the number of plates on which it appears. As of the 1985 IAU General Assembly 149 plates had been entered into the Guide Star Catalogue.

The catalogue is organised into regions, so that the GSC identification for an object will be the region number and its sequential number in the region. The sequential numbers within the regions are assigned as each plate is entered. Since the plate data are sorted by declination, for regions wholly contained on one plate the sequential numbers

Table 2. Summary of characteristics of the GSSS survey plates

| | ESO/SRC | SRC EXT | QUICK V |
|---|---|---|---|
| Sky coverage (deg) | -90 to -17 | -17 to +3 | +3 to +90 |
| Telescope | UK Schmidt | UK Schmidt | Palomar |
| Plate Scale (arcsec/mm) | 67.15 | 67.15 | 67.15 |
| Plate size (cm) | 35 x 35 | 35 x 35 | 35 x 35 |
| Plate generation | copy | copy | original |
| Plate area (deg) | 6.4 x 6.4 | 6.4 x 6.4 | 6.4 x 6.4 |
| Plate centre spacing | 5 deg | 5 deg | 6 deg |
| Emulsion type | IIIaJ | IIIaJ | IIaD |
| Filter | GG 395 | GG 395 | Wratten 12 |
| Limiting mag | 22+ | 22+ | 19+ |
| Epoch (mean) | 1975 | 1983 | 1983 |
| Total plates | 606 | 288 | 584 |

Note: quick V plates taken after August 1984 with GG 495 filter

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will be in order of increasing declination. However, if additional plates are included for a region, the sequential numbers for the new stars are continued from the last value on the previous plate. To determine the region size, the sky is divided into approximately square areas 7.5 deg high and, depending on the star density in the area of the sky, are sub-divided into 4, 9, 16 or 25 sub-regions. The total number of regions is 9537.

The so-called operational version of the GSC will be published as soon as the whole sky has been catalogued satisfactorily for ST pointing purposes, on magnetic tape and on microfiche. Extrapolating from the current production rate for the catalogue suggests that the operational version should be completed by early March 1987 and we estimate the publication a few months after that. The Guide Star Photometric Catalogue, including the data for the photometric sequences and their finding charts, will probably be published within the year.

The accuracy of the entries in the GSC estimated to date are 0.25 arcsec relative and 3 arcsec external in position, and 0.15 mag relative error in the bandpass of the plate and 0.7 mag external in photometry. About 95 per cent or more of objects fall into the stellar/non-stellar classification.

## 3. THE TYCHO INPUT CATALOGUE

When the operational GSC is completed, a machine-readable version will be sent to CDS in Strasbourg. The catalogue will be reduced so that it contains only stars to 12.5 mag, about 2 million stars. This catalogue will then be cross-matched with the CDS SIMBAD data base to provide colours and proper motions for stars if available, primarily for the brighter stars. This is the first version of the Tycho Input Catalogue (TIC1).

The TIC1 will contain the GSC identification, position (equinox J2000), B and V magnitudes with their sources and estimated errors, and a series of flags. The flags include non-stellar object, close binary, multiple system, updated position, updated magnitude, known high proper motion, known parallax, known variable, known multiple system, reference star for astrometry, reference star for photometry, Hipparcos star, SIMBAD star, and serendipity star (see below).

After the first six months of the mission the catalogue TIC1 will be revised. The positions will be updated with the mean positions from the first six months of observations, new entries will be added for objects not in the TIC1 (serendipity stars), and stars not detected will be eliminated. The TIC2 is expected to contain about 1 million stars.

Following the end of the mission and after the completion of the data reduction, the stars will be assigned new identifications, unique to the Tycho project, as well as their GSC numbers, for publication.

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