THE GUIDE STAR CATALOG. III. STRUCTURE AND PUBLICATION, STATUS AND PLANS.

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Abstract: The current structure and content of the Guide Star Catalog (GSC), as well as future enhancements in this area are described. An overview of the forthcoming publications is given, both with regard to scientific papers and electronic media.

I. INTRODUCTION

The astronomical resources, plate scanning, image processing, and photometric as well as astrometric calibration, leading to the object-specific information contained in the Guide Star Catalog (GSC), are described in the first and second parts of this series of presentations. This part describes the GSC entries derived from the catalog construction process as well as the properties of the GSC as a whole.

II. STRUCTURE AND CONTENT

Access to the GSC has to be accommodated by identification as well as by celestial area. Together with the expected volume of data, this led to the formulation of a structure which would allow fast access, but would not require inordinate amounts of storage space nor specific software components.

The GSC is organized into 10,000 regions; each region therefore holds a few thousand individual object entries. In order to account for the varying population of the catalog as a function of galactic latitude, the region size is not fixed, but varies, so that the number of objects per region is nearly constant.

Each object in the GSC carries a 10-digit number as identification. The first five digits encode the region number; the last five specify the number of the star within the particular region. Since only a few thousand objects are contained in each region (leaving some room for future expansion), this identification scheme is noncontiguous, *i.e.*, there are many 10-digit numbers which do not correspond to an entry in the catalog.

Although this nomenclature as such does not encode coordinates, the region structure of the GSC would provide a hidden coordinate-encoding if the region boundaries were fixed;

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assuming coordinate updates, this would lead to the well-known problems of coordinate-related nomenclature techniques. Therefore, an additional feature has been adopted for the GSC regions: they are not (primarily) defined by their celestial coordinates, but by their *content*. In other words, once an object has become a member of a region, it remains part of it regardless of position updates. Therefore, the maximum and minimum coordinates of regions may overlap slightly, once updating activity has occurred.

Each region is thus characterized by its center (reference) position and extent, as well as by the number of objects it contains. (Back-pointers to the individual plates from which objects appear in the region as well as several organizational items are available in addition.) For each entry the following information is contained in the GSC:

- Identification (GSC Number).
- Position, in the form of offsets (ξ, η) to the region reference position.
- Position standard deviation (*one* per position).
- Magnitude band descriptor.
- Magnitude and magnitude standard deviation.
- Object classification (star versus non-star) and quality.
- Source plate (or catalog) identification.
- Various flags.

Note also that object data derived from different plates (*i.e.*, for objects appearing on more than one plate) are stored separately, but with the *same* identification.

III. PUBLICATION

The publication of the Guide Star Catalog is scheduled for 1988; it will consist of a descriptive part in a number of papers in the astronomical literature, and the bulk of the data will be published in electronically readable format. The papers will contain detailed descriptions of all aspects related to the GSC, specifically:

- Background information about the GSC and the Guide Star Selection System in the context of the Space Telescope mission.
- Astronomical data (plates, catalogs).
- Software system used for catalog construction.
- Hardware system used for plate scanning.
- Image processing algorithms.
- Calibration (photometry, astrometry).
- Catalog structure.
- Description of data formats and access software.

In addition, these publications will contain detailed error analyses and extensive statistical information on all aspects of the GSC, the processing, and the various reference materials used in the derivation of the data.

The catalog data themselves, as well as the statistical information mentioned above, plus basic access software and user information in the form of text, will be made available in computer-readable form. The following table may serve as a brief sample of the information provided in the main part of the GSC:

GSC ID	α	δ	σ_{pos}	m	σ_m	B	C	*Plate*	N	*Flags*
8016 0798	23 32 16.07	-42 05 57.5	0.3	14.30	0.44	0	01	00CW	2	FFFFFFTF
8016 1092	23 30 05.86	-42 07 01.3	0.4	13.35	0.44	0	02	01LP	2	FFFFFFTF
8016 1092	23 30 05.83	-42 07 00.9	0.3	13.60	0.44	0	02	00CW	2	FFFFFFTF
8016 0771	23 31 34.64	-42 07 10.1	0.5	11.94	0.44	0	02	01LP	2	FFFFFFTF
8016 0771	23 31 34.62	-42 07 09.4	0.4	12.06	0.44	0	01	00CW	2	FFFFFFTF
8016 1229	23 30 27.29	-42 08 01.1	0.4	15.33	0.47	0	01	01LP	1	FFFFFFFF
8016 1073	23 31 31.65	-42 08 51.2	0.4	11.07	0.44	0	30	01LP	2	FFFFFFTF
8016 1073	23 31 31.65	-42 08 50.6	0.4	11.17	0.44	0	30	00CW	2	FFFFFFTF
8016 1209	23 32 13.84	-42 08 47.0	0.4	15.52	0.48	0	01	01LP	1	FFFFFFFF
8016 1014	23 30 39.25	-42 09 19.1	0.4	12.86	0.44	0	01	01LP	2	FFFFFFTF

In this example, B is the encoded plate passband, C the encoded object classification, N the number of entries (from different plates) for the given object; several flags serve as indicators for cross-identification and house-keeping functions.

The volume for the entire set of data is expected to be in the range of one to two Gigabytes. Therefore, distribution on magnetic tape would require up to 20 rolls of tape (even at high density and large blocking); the associated effort with regard to tape duplication is prohibitive for mass distribution, and may only happen in exceptional cases. Currently, compact optical disks (CDs) seem to be the medium of choice; the data would require two or three platters; both the manufacturing and distribution process are comparatively simple, and readers for compact optical disks are available at low cost. However, details of volume and file structure need to be addressed before publication.

At ST ScI, the Guide Star Astrometric Support Program (GASP, McLean *et al.* 1988) has been modified to use a sample compact optical disk containing portions of the GSC as well as image information, and has thus demonstrated the feasibility of this approach.

IV. ENHANCEMENTS AND PLANS

At the time of this symposium, the Guide Star Catalog is complete to more than 90%. The number of objects in the complete catalog will be somewhat larger than 20 million.

Plans for enhancements in the image processing and calibration areas, as well as with regard to the incorporation of new surveys, have been described in the previous parts of this series. From the organizational (data base) point of view, we anticipate an enhanced catalog structure for the future, which will, however, retain the basic GSC nomenclature and region scheme. This new structure is based on the need to:

- preserve raw data (image features) obtained directly from the underlying plates;
- perform re-calibration of selected plates without affecting the rest of the catalog;

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- provide corrections in an orderly and trackable way; and
- provide cross-references to other catalogs.

To achieve this goal, it is expected that the main part of the catalog will contain object names, image features, and other information, directly derived from the plates, but without any additional calibration. A second part will contain these constructs, *e.g.*, plate solutions and photometric transformations. Addenda and error corrections will be carried in a third part. Cross-references to other catalogs (as well as the catalog data themselves) will also be added to the new structure. The various pieces of information related to one object would be combined by a software module — the catalog server — upon demand, *i.e.*, upon a request by a user for data from the catalog. This enhancement would allow the efficient incorporation of new survey data, and also of other catalog data as they become available in the community.

ACKNOWLEDGEMENTS

Due to the very nature and size of the Guide Star Selection System project, which contained — as an integral part — all the efforts leading to the generation of the Guide Star Catalog, a large team of scientists, software professionals, engineers, operators, and (last but not least) managers, was required to cover all the different areas of expertise needed. Therefore, this series of papers reflects the efforts of all the past and present staff members of the Space Telescope Science Institute who have been and still are involved in this endeavor, as well as the contributions from a number of distinguished colleagues in the international astronomical community; we would like to extend our gratitude for their help to all of them.

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Discussion:

SEIDELMANN Do you plan to develop a catalogue of corrections to the Guide Star Catalogue?
JENKNER The optical GSC (i.e. the one actively used in ST operations, not the one baselined for the published GSC) will contain a flag used to indicate the existence of ST history information in other files. This information may include unsuccessful acquisition (eg. because of a binary nature) a successful acquisition with updated intensity and position data. The enhanced catalogue structure, as described in the papers, allows us to incorporate and track corrections as well as new data. From time to time, new versions of the GSC will be published, incorporating these updates.
WHITE Is there to be a form of distribution of the catalogue so that small institutes, and workers who need only a small amount of data, can have access without specialized equipment and knowledge? Will there be hard copies, or microfiche copies, or a mechanism whereby small amounts of data can be distributed by STSI?
JENKNER To see the difficulty of paper, do note that we are dealing with a data volume about 100 times the SAO, i.e., about 20 meters of bookshelf. Microfiche is possible but unattractive because of the relatively high cost and small demand. We highly recommend the use of optical disks and will make magnetic tapes available when scientifically necessary. Additionally, small-scale users, say those who generally need a few 10 arc-min field, will be able to obtain this material from us over any of the existent computer networks.
DE VEGT Storage of scans should be considered because of availability of better reference star catalogues in the near future.
JENKNER As the scans are one of the prototype entries into the ST archive, they are truly being preserved. Access to the scans will be possible eventually; the methods and data-sharing policies are being developed now for this archive. The "publication" of the scans (on about 500 optical disks) would be prohibitively costly at present and must await further technical progress. For those astronomers who only wish to re-reduce the positions and magnitudes and not reprocess the images from the raw scan data, the plate constants and photometric solutions will be published for each plate. These can be used to recover the original data (i.e. x.y, log integrated intensity) for a new reduction.

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