HIPPARCOS - ACTIVITIES OF THE INPUT CATALOGUE CONSORTIUM

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ABSTRACT. The Input Catalogue Consortium (INCA) is in charge of selecting the 100 000 stars to be observed by Hipparcos. In this paper the organisation of the Consortium is described, and the technical requirements to be met by the Input Catalogue for optimal scientific return are summarised. The various tasks of this long collective work are then reviewed including the identification process of the proposed stars, the progressive construction of a list without redundancies, and the definition of the 'survey'. The final selection of the stars which will be observed by Hipparcos is being made using a numerical simulation which takes into account the observing constraints of the satellite, and a parameter called the 'pressure' which is calculated for each star. Finally, the organisation of working groups set up to deal with special objects (multiple stars, variable stars, minor planets, stars in dense areas, and stars for linking the Hipparcos system to an extragalactic reference system) are described. New photometric and astrometric programmes undertaken for stars with unsatisfactory precision on magnitudes and/or coordinates, a major part of the Consortium's work, will be presented elsewhere.

1. INTRODUCTION

The 100 000 stars to be observed by Hipparcos must be selected, in advance of launch, on the basis of sometimes conflicting criteria - choice of the stars is influenced not only by the astrophysical and astrometric interest of proposed programmes, but also by the observability of those stars, taking into account the requirements from the satellite operations, as well as instrumental and data reduction limitations. Some of these aspects have already been addressed by Perryman (1985).

After a huge work of cross-identifications, involving the construction of a non-redundant list of 210 000 stars out of some 700 000 stars submitted to ESA by the world-wide astronomical community, the Input Catalogue Consortium is entering the second phase of its task.

J.-P. Swings (ed.), Highlights of Astronomy, 683–690.

This involves:

- iterative optimisation of the contents of the Input Catalogue with respect to the expected scientific return and technical constraints, by means of numerical simulations of the mission;
- use of the first simulation results for a better selection of stars needing new ground-based observations before the mission (errors should not exceed 1.5 arcsec for positions and 0.5 for magnitudes). This part of the work is now underway and is described in further detail by Requième (1985) and Grenon (1985) respectively;
- detailed studies on the problems raised by some special objects, such as multiple and variable stars, minor planets, stars in very dense areas, and objects to link the Hipparcos reference frame to the extra-galactic reference system.

2. THE INCA CONSORTIUM

The INCA Consortium includes astronomical institutes from Belgium, France, Germany, the Netherlands, Spain, Switzerland, and the United Kingdom, as well as individual astronomers from Argentina, Australia and U.S.A.

The Consortium is led by C. Turon (Observatoire de Paris-Meudon); and the main responsibilities and the structure of the Consortium are shown in Fig. 1. A detailed description of the Consortium and of its activities is given by Turon (1983, 1984, 1985), Turon & Requième (1984), and in the Proceedings of the INCA Colloquium held at Aussois (France) in June 1985 (INCA 1985). Moreover, an 'INCA Newsletter' is regularly issued, as well as progress reports in the 'Bulletin du Centre de Données Stellaires' (Strasbourg, France).

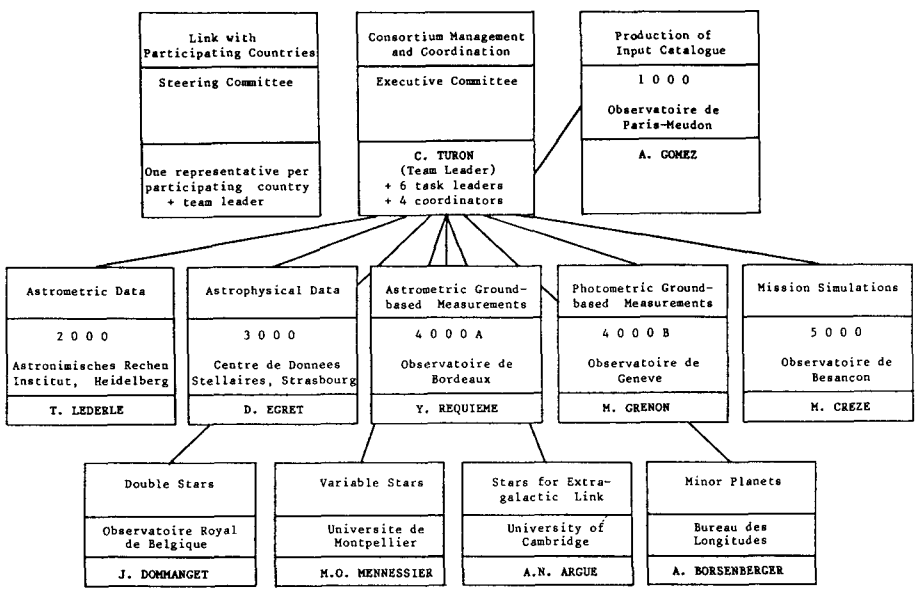

Figure 1. The organisation of the Input Catalogue Consortium

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3. CONSTRUCTION OF A UNIQUE MERGED LIST FROM ALL PROPOSED STARS

In answer to an ESA Announcement of Opportunity, with a deadline of 1 October 1982, 219 observation proposals including some 700 000 stars have been submitted by the world-wide astronomical community. These proposals have been rated from Priority 1 (stars to be included in the Input Catalogue if technically possibile) to Priority 5 (not to be taken into consideration), by an ESA-appointed Scientific Selection Committee.

There are basically two types of scientific programmes:

- 'astrophysical programmes', dealing with stellar evolution, galactic structure, nearby stars, peculiar stars, clusters and the distance scale;
- 'reference frame programmes', dealing with fundamental catalogues, minor planets, stars on the paths of the moon, planets and minor planets, radio stars, and stars around quasars for the link to an extra-galactic reference frame.

A basic list of nearly 60 000 bright stars, called hereafter the 'survey', has been added to this set of stars for the purposes of satellite operations, data reduction and future statistical uses of the Catalogue.

The survey has been defined as including all stars brighter than a specified limiting magnitude, this limiting magnitude being a function of both galactic latitude b (so as to have an almost constant star density all over the sky) and of spectral type (in order to reduce the otherwise excessive proportion of red giants). Accordingly, stars were automatically selected in the SIMBAD* Data Base up to the following limiting magnitudes:

$V_{lim} = 7.9 + 1.1 \sin|b|$ for spectral types $\leqslant$ G5
$V_{lim} = 7.3 + 1.1 \sin|b|$ for spectral types $\geqslant$ G6

3.1. Cross-Identification Procedure

Proposed stars and survey stars have been progressively included in seven successive provisional versions of the Input Catalogue. At each step, considerable attention has been paid to avoid the inclusion of redundancies (one star included under two different identifications) and to detect any errors. For star identification and deletion of redundancies the SIMBAD Data Base has been used very intensively. The successive steps of the procedure are the following:

(a) SIMBAD interrogation using the identifications given by the proposers. If the star is found in SIMBAD, positions and magnitudes are checked to detect possible 'punching' errors and misidentifications. As a result of this check, the coordinates and magnitudes of nearly 10 000 stars have been verified, and in some cases modified, by exchange of

* SIMBAD = Set of Identifications, Measurements and Bibliography for Astronomical Data (Centre de Données Stellaires de l'Observatoire de Strasbourg, France). This data base is complete to about V = 9 mag.

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correspondence with proposers when necessary;

(b) if the first identifier used was not found in SIMBAD other identifications, where given by the proposers, have been used. In addition, all of the 200 bibliographic references quoted by the proposers have been checked;

(c) if steps (a) and (b) failed, an automatic positional search has been performed in SIMBAD, involving a search of all stars within a 10 arcmin radius around the given position. The nearly 24 000 stars processed in this way have then been examined by hand and sent back to the proposers in doubtful cases. 14 000 of the stars were found to be in SIMBAD;

(d) stars not found in SIMBAD (only 5 000 stars after deletion of redundancies) have been included using data given by the proposers, after elimination of any redundancies.

3.2. Present State (October 1985)

All processed proposed stars (i.e. nearly 520 000 stars, the others being either unusable, or proposed only as a source of additional information) are now included in an 'INCA Data Base', containing all SIMBAD data for SIMBAD stars and all Hipparcos-generated data. This data base has been built as a sub-base of SIMBAD, with the same structure and the same interrogation and updating software. All newly compiled and observed data, as well as simulation results, will be included in this data base.

The result of this huge work of cross-identification and verification is a set of about 210 000 stars, almost without redundancies (over the 30 ESO Sky Survey plates already scanned for new position measurements, only 7 redundancies have been found among 2 141 entries). The repartition of stars versus magnitude and ESA-allocated priorities is given in Table 1. From this table it can be seen that more than 100 000 stars have Priority 1. Further details of the work are given by Gomez & Crifo (INCA 1985), Morin & Arenou (INCA 1985) and Crifo et al. (INCA 1985).

Table 1. Distribution of proposed stars versus ESA priority and V magnitude (L3-II list, July 1985)

ESA Priority	V < 9	9-11	11-13	> 13	Total
1	85 900	24 800	3 900	2 200	116 800
2	3 900	6 200	600	500	11 300
3	1 000	6 800	900	200	8 900
4	9 300	37 000	3 300	1 000	50 500
5	4 000	16 400	1 400	400	22 300
TOTAL	104 100	91 200	10 100	4 300	209 800

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4. OPTIMISATION OF THE INPUT CATALOGUE

About 100 000 stars will be selected from the 210 000 which have been proposed. This choice will be influenced both by the allocated scientific priorities and by the technical limitations - as mentioned previously these may, in certain cases, be two confilicting constraints.

The first step consists in an estimation of the competition for observing time around each star. For this purpose a parameter, called the 'pressure', is computed for each star. It is the ratio between the observing time for the target star and the stars of higher priority (or brighter within the same priority level), and the available observing time, within a circle of 0.6 degrees around the target star. It is an estimate of the amount of competition for observing times, so that it represents a probability of a given star being selected for observation by Hipparcos - the lower the pressure, the higher the chance of eventual inclusion. Stars may afterwards be selected at various pressure levels given their ESA priority.

The distribution of the 210 000 stars versus ESA priority is given in Table 2, as well as a possible Input Catalogue in which stars are kept up to the indicated pressure level. In this table the letters A, F, R, S indicate sub-levels in Priority 1 stars. 1F is at same level as 1A, but indicates an observability problem. 1R indicates that the proposal's priority might be revised. 1S indicates stars required for the survey and not required in proposals rated 1A, 1F, 1R.

The main conclusions of this preliminary study are the following:

- a high percentage of Priority 1 stars are observable. However, it will not be possible to observe all Priority 1 stars;
- the fraction of observable stars falls very rapidly with ESA priority, even within the sub-levels within Priority 1;
- the fraction of observable stars falls drastically with increasing

Table 2. Distribution of stars versus ESA Priority and 'Pressure' (L3-II list, September 1985).

ESA Priority	Pressure < 1.0	< 1.5	< 2.0	> 2	Total	Possible catalogue P_{lim}	N*
1A	56 663	62 106	64 199	3 249	67 448	2	64 199
1F	3 600	5 309	6 344	1 842	8 186	2	6 344
1R	10 293	14 652	16 827	2 700	19 527	1.5	14 652
1S	10 928	16 201	18 802	2 879	21 681	1.5	16 201
2	2 215	4 838	6 930	4 383	11 313	1	2 215
3	961	2 527	4 081	4 769	8 850	1	961
4	3 387	9 632	16 953	33 548	50 501	1	3 387
5	4 017	8 703	12 615	9 651	22 266	1	4 017
1A+1F+1R+1S	81 484	98 268	106 172	10 670	116 842		
1+2+3+4+5	92 064	123 968	146 751	63 021	209 772		111 976

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apparent magnitude. This is particularly unsatisfactory for Priority 1 stars fainter than magnitudes 9-10;

- the 'survey' is not satisfactorily fulfilled.

This first static and local simulation does not take into account the field superposition and the scanning law, nor the observing strategy within one field of view. These results have therefore to be confirmed by more complete simulations.

A second simulation takes into account the two fields of view and the scanning law, but only a simplified version of the observing strategy. It has been developed for the purpose of simulating the whole mission on a complete tentative Input Catalogue and tests any possible local difficulties. Preliminary tests performed on simulations of 180 days of mission operations have shown that the 'pressure' is a good parameter for star selection. This second simulation is however quite computer time consuming and cannot be systematically used to test various selection hypotheses.

A third and more detailed simulation system has been developed, using the nominal observing strategy but operating only on three test zones covering about 22 square degrees, and on the conjugated fields of view. The observability index in this case is defined as the ratio between the target accuracy on parallaxes and the actually derived accuracy. This detailed simulation has shown, for example, that the above ratio is very well correlated with a 'static' parameter computed for each star of a tentative programme, using only the neighbouring stars. Using this new parameter, it has been shown that only about 2 500 stars from the possible Input Catalogue quoted in Table 2 are under-observed. On the contrary, if the observation of all Priority 1 stars is artificially forced, the number of under-observed stars would grow to nearly 20 000. This last simulation also allowed a detailed study of the observing strategy performance to be made. Further details of the simulation work are given by Crézé (INCA 1985), Nicolet & Crézé (INCA 1985), Turon et al. (INCA 1985) and Feaugas (INCA 1985).

5. WORKING GROUPS ON SPECIAL OBJECTS

Minor Planets: About 50 minor planets will be observed by Hipparcos near their quadratures. A special part of the Input Catalogue will be devoted to them, and Chebychev polynomial representations of ephemerides will be given for their positions and magnitudes. Systematic meridian circle observations and plate measurements are being performed in order to improve their orbital elements. The first results are very encouraging when compared with the required accuracy (the same as for the stars). Further details of this work are given by Bec-Borsenberger (INCA 1985).

Double and Multiple Stars: These objects are an important source of problems in the Catalogue's preparation for two main reasons: (i) observational data are very incomplete and are only partly in machine-readable form, and (ii) because of the Hipparcos detection system and the finite size of the instantaneous field of view of the image

dissector tube, the reduction of the corresponding data requires a priori knowledge of the separation ρ and the magnitude difference Δm of multiple components. The work being done involves the reorganisation of existing data and the construction of a new catalogue, mainly based on the 1976 IDS - the Catalogue of Components of Double and Multiple Stars (CCDM). This contains one entry per component, and not only one per system. This CCDM is being prepared in machine-readable form at Brussels (Belgium); it already contains 62 300 systems. Cross-identifications have been checked and sometimes corrected (IDS-ADS-DM). In addition, new observations, in particular for those Hipparcos stars with incomplete data, are being undertaken, and several observatories are participating in this work. All known information on double stars, also on components not included in the main Input Catalogue because they are too faint and/or too close to the primary star, will be given as an annex of the main Catalogue. Further details of the work are given by Dommanget (INCA 1985).

Variable Stars: Magnitudes of stars observed by Hipparcos should be known within 0.5 mag for appropriate observing time allocation. Those stars with amplitude variations larger than 0.5 mag therefore present a problem. Ephemerides will be given for predicted magnitudes all along the mission, especially for large amplitude stars such as Mira variables. This complexity will severely limit the number of such stars in the Hipparcos observing programme. However, special attention is being paid to radio stars, since these are excellent candidate objects for linking the Hipparcos reference frame to an extragalactic reference system. Because of important fluctuations in the light curves, ground-based observations will be carried on even during the mission itself. Further details of this work are given by Mennessier (INCA 1985).

Stars for the Link to an Extragalactic System: The activities of this Working Group is described in detail by Argue (1985), Argue (INCA 1985) and also in the IAU Joint Discussion on Reference Frames.

Stars in Dense Areas: The many proposals dealing with dense areas, principally open clusters and the Magellanic Clouds, have been carefully reviewed on maps by two persons bearing in mind the severe constraints due to the scanning law and the profile of the instantaneous field of view of the detector, so as to ensure the best selection of stars in these difficult and important zones. Details of this work may be found in Prévot (INCA 1985) and Mermilliod (INCA 1985).

6. COMING ACTIONS

It is now necessary to:

- act either on priority levels or on pressure level acceptance, so that the observability of a limited number of faint stars may be enhanced (e.g. for nearby red dwarf stars and white dwarfs), so that the observability of the survey may be improved, and so that the observability of some statistical proposals, presently over-observed with

respect to their ESA priority, may be a little lowered. It should be noted that each test should be performed independently from the other ones, in order to be able to detect any consequence not only on the considered proposal(s) but also on all the others;

- study in more detail the observability of some dense areas;
- study the sky repartition of programmes dealing with reference systems, galactic structure, dynamics, etc.
- study the individual observability of some 'essential' stars (radio-stars, Cepheids, etc.).

Furthermore, compiled and newly observed astrometric and photometric data, and data on double and variable stars, will be progressively included into the INCA Data Base.

7. CONCLUSION

With the complete list of non-redundant proposed stars, the INCA Consortium passed a major turning point. The work still to be done, i.e. to select from this list a real catalogue of fully observable, high-priority objects with all relevant data, is underway. It is a collective work and implies a close cooperation between specialists usually working in quite different fields.

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