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# The Completion of a Star Catalog for the Optical Aircraft Measurements Program

L.G. Taff

7 April 1986

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**Lincoln Laboratory**

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

*LEXINGTON, MASSACHUSETTS*



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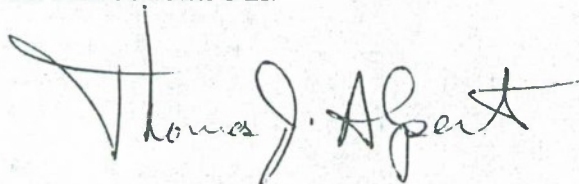
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A handwritten signature in dark ink, reading "Thomas J. Alpert". The signature is fluid and cursive, with the first name "Thomas" and last name "Alpert" clearly legible.

Thomas J. Alpert, Major, USAF  
Chief, ESD Lincoln Laboratory Project Office

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY  
LINCOLN LABORATORY

**THE COMPLETION OF A STAR CATALOG  
FOR THE OPTICAL AIRCRAFT MEASUREMENTS PROGRAM**

*L.G. TAFF*

*Group 94*

TECHNICAL REPORT 751

7 APRIL 1986

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## ABSTRACT

This report summarizes the construction of a combined astrometric-photometric, all-sky, star catalog for the Optical Aircraft Measurements Program (OAMP). In addition to discussing the sources and handling of the astrometric and photometric data, the format of the catalog, its completeness, its precision and its accuracy, I also discuss the problem of updating Besselian 1950.0 locations and velocities to J2000.0 in view of the new (1984) International Astronomical Union recommendations.

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## I. INTRODUCTION

The Optical Aircraft Measurements Program (OAMP) relies on an airplane-mounted infrared sensor to detect exo-atmospheric space vehicles of interest. In order to calibrate such a detection system infrared stars are needed. A combined astrometric-photometric catalog, akin to others prepared by the author,<sup>15,16,17</sup> seemed a useful adjunct to the Group 38 efforts on OAMP. At their request such a catalog was constructed. The catalog can be obtained from Group 38.

The report documents the construction process, the catalog itself, and reviews the procedures necessary to update the Besselian 1950.0 location and velocity information to the Julian 2000.0 epoch. This task is complicated by the changes in astrometrical calibration introduced by the International Astronomical Union in 1984.

## II. PHOTOMETRIC DATA

The desired stars are those bright in the near-infrared portions of the spectrum. The largest source of consistent photometry in this region is on the Johnson UBVRI system.<sup>9,6</sup> The R and I bands are of primary interest in this discussion. Their effective wavelengths are at 0.70 and 0.90  $\mu$ . The two most extensive collections of data in this system are the Iriarte<sup>6</sup> et al. article just referred to and a companion paper of Johnson, Mitchell, Iriarte, and Wisniewski.<sup>10</sup> The former paper had data for 1,325 bright stars north of declination  $-50^\circ$ , the latter paper covers the entire sky with 1,567 stars. However, both of these papers have a strong northern hemisphere bias. This problem was remedied by Cousins.<sup>3</sup> He observed 1,425 bright stars south of  $+10^\circ$ . Of these almost 700 were also observed by Johnson's group. Hence, the transformation between Cousins's system and Johnson's system was very well determined. Secondary sources of photometry were Mendoza<sup>11</sup> and Scharlach and Craine.<sup>13</sup>

To be easily visible to the OAMP sensor the requirement  $(R + I)/2 \leq 4^m$  seems appropriate. The actual criteria for inclusion herein was  $(R + I)/2 \leq 5^m00$ . In this fashion any improvements in sensitivity could be easily accommodated.

For stars only listed in one author's work the V, R, and I values have been incorporated as is (all workers provide transformation equations to the Johnson system or the transformed magnitudes themselves). When a star was in more than one list, almost exclusively the case for Cousins, the average values of V, R, and I were used.

### III. ASTROMETRIC DATA

As the primary requirement for inclusion in the catalog is  $(R + I)/2 \leq 5^m00$  (and known), by and large only the visually bright stars are represented. Therefore, positional catalogs specializing in bright stars seemed appropriate. The best of these is the 1,535 star FK4 (or Fourth Fundamental Catalogue; Fricke and Kopff.<sup>5</sup> The earlier version of the FK4 has a recent supplement of 1987 stars known as the FK3Supp.<sup>4</sup> This was used as a supplement in this instance too. Between these two catalogs most of the stars included on the basis of their photometry were provided with positions and precise angular velocities. The remaining positions and angular velocities were from Morgan's<sup>12</sup> N30 catalog of 5,268 stars. The N30 positions and proper motions were reduced to the FK4 system using the tables in Brosche, Nowacki, and Strobel.<sup>2</sup> The photometrically acceptable stars still without positions and angular velocities were dropped at this point. The remaining datum needed is the quotient of radial velocity with distance. When this quantity is large enough to affect the desired positional accuracy (at least 1"), it has been included. The sources were Abt and Biggs<sup>1</sup> and Jenkins.<sup>7,8</sup>

#### IV. B1950.0 TO J2000.0

In 1984 a whole new system of astrometrical computation was introduced by the International Astronomical Union. The most authoritative discussion of the refinements can be found in the "Supplement to the Astronomical Almanac 1984." The supplement occupies pages S1-39 of the 1984 edition of the Astronomical Almanac. In addition to the changes in computational methodology, the system of reference times for astrometrical data has been changed. Formerly the astronomical community utilized the Besselian solar year which relied on a secularly changing time scale fixed by the mean longitude of the Sun. Standard epochs have been 1900.0, 1950.0, and 2000.0. Hereinafter these are denoted by B1900.0, and so on to stress their reliance on the concept of a Besselian solar year. The new time scale is based upon the concept of a Julian century of 36,525 days. The new fundamental epoch is Julian Date 2451545 = January 1<sup>st</sup>, 2000 = B2000.001278, or J2000.0. So, to update a mean catalog place and proper motion from B1950.0 to J2000.0 not only involves a change in astrometry, it also involves a change of time scale and epoch. The details are on pages S34-37 of the Supplement and will not be reproduced here. See also Standish.<sup>14</sup>

## V. THE CATALOG

For each of the 1,223 stars in the catalog one can find the following information:

1. HD, BS (= HR), and DM identification numbers
2. V, R, and I listed to 0<sup>m</sup>01
3. B1950.0  $\alpha$ ,  $\delta$ ,  $\mu_\alpha$ , and  $\mu_\delta$ . Right ascensions are listed to 0<sup>s</sup>001, declinations to 0<sup>m</sup>01, and the centennial proper motions similarly
4. The product of parallax and radial velocity in units of 1000"  $\times$  km/s
5. An indicator of variability or duplicity

The precision of the resulting positions should be at the 0<sup>m</sup>1 level. Within the FK4 system the accuracy is perfect. Because there is a systematic difference between the FK4 and FK5 systems, which is known to  $\approx$  0<sup>m</sup>05, this is a reasonable figure for the ultimate accuracy.

The precision of the photometric data is generally at the 0<sup>m</sup>03 level or better. Its accuracy is of similar quality except for the reddest stars that only have Cousins photometry. For these stars it may be as poor as 0<sup>m</sup>1 owing to nonlinearities in the color transformation to the Johnson system.

The identification, photometric, variability/duplicity, and astrometric data were entered onto standard FORTRAN 80-column coding sheets. The first four columns contain the BS (Bright Star) or HR (Harvard Revised photometry = BS) identification number. Columns 5-12 contain the DM (or Durchmusterung) number. The final cross-identification is provided by the Henry Draper (HD) number in columns 13-19. This group is followed by V, V-R, and V-I (columns 20-34 in a 3F5.2 format). Next comes a blank column and then a V, S, or D for variable in brightness, spectroscopic binary, or double. Columns 37-48 contain the B1950.0 right ascension in hours, minutes, and seconds (HH\_MM\_SS.SSS). The centennial proper motion in right ascension (in seconds of time and not projected onto the great circle) follows in columns 49-55. Declination ( $\pm$ DD\_MM\_SS.SS) and the centennial declination proper motion (columns 68-74) are next. The last 6 columns contain the foreshortening term  $1000\pi v_r$  with the parallax in arc seconds and the radial velocity in km/s.

## **ACKNOWLEDGMENTS**

The catalog was typed by Marie E. Hartwell. The entries were double checked by D.M. Jonuskis and C. Terrell.

## REFERENCES

1. H.A. Abt and E.S. Biggs, *Bibliography of Stellar Radial Velocities* (Latham Press, New York, 1972).
2. P. Brosche, H. Nowacki, and W. Strobel, Veröff. Astron. Rechen-Institut Heidelberg, No. 15, 1964.
3. A.W.J. Cousins, S. African Astron. Obs. Circ. **1**, 234 (1980).
4. W. Fricke, Veröff. Astron. Rechen-Institut Heidelberg, No. 11, 1963.
5. W. Fricke and Kopff, Veröff. Astron. Rechen-Institut Heidelberg, No. 10, 1963.
6. B. Iriarte, H.L. Johnson, R.I. Mitchell, and W.K. Wisniewski, Sky and Telescope **30**, 1 (1965).
7. L.F. Jenkins, *General Catalogue of Trigonometric Stellar Parallaxes* (Yale Univ. Press, New Haven, 1952).
8. L.F. Jenkins, *Supplement to the General Catalogue of Trigonometric Stellar Parallaxes* (Yale Univ. Press, New Haven, 1963).
9. H.L. Johnson, "Photometric Systems," in *Basic Astronomical Data*, K. Aa. Strand, Ed. (Univ. of Chicago Press, Chicago, 1963), p. 204.
10. H.L. Johnson, R.I. Mitchell, B. Iriarte, and W.Z. Wisniewski, Comm. Lunar and Planetary Lab. **4** (1966).
11. E.E. Mendoza, Publ. Dept. Astron. Univ. Chile, **7**, 106 (1968).
12. H.R. Morgan, Astronomical Papers of the American Ephemeris and Nautical Almanac **13**, Part 3 (1952).
13. W.W. Scharlach and E.R. Craine, Publ. Astron. Soc. Pac. **92**, 845 (1980).
14. E.M. Standish, Astron. Astrophys. **115**, 20 (1982).
15. L.G. Taff, "A Combined Photometric-Astrometric Catalog," Technical Note 1975-66, Lincoln Laboratory, MIT (1975), DDC AD-A020966/8.
16. L.G. Taff, "The Handling and Uses of the SAO Catalog," Project Report ETS-6, Lincoln Laboratory, MIT (1976), DTIC AD-A035871.
17. L.G. Taff, "The Revised Astrometric-Photometric Catalog," Project Report ETS-7, Lincoln Laboratory, MIT (1977), DTIC AD-A037119.

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