The Hipparcos and Tycho Catalogues

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The Hipparcos and Tycho Catalogues

Astrometric and Photometric Star Catalogues

derived from the

ESA Hipparcos Space Astrometry Mission

A Collaboration Between

the European Space Agency

and

the FAST, NDAC, TDAC and INCA Consortia

and the Hipparcos Industrial Consortium led by

Matra Marconi Space

and

Alenia Spazio

European Space Agency
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Cover illustration: an impression of selected stars in their true positions around the Sun, as determined by Hipparcos, and viewed from a distant vantage point. Inset: sky map of the number of observations made by Hipparcos, in ecliptic coordinates.

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Volume 2

The Hipparcos Satellite Operations

Compiled by:

M.A.C. Perryman & K.S. O'Flaherty (ESA–ESTEC)

D. Heger (ESA–ESOC) & A.J.C. McDonald (ESOC/Logica UK Ltd)

with the support of

The Hipparcos Science Team,

M. Bouffard (Matra Marconi Space),

and

B. Strim (Alenia Spazio)

Launch of the Hipparcos Satellite by Ariane 4 Flight V33, 8 August 1989 (Photo: CSG Kourou)

Volume 2: The Hipparcos Satellite Operations

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Foreword

The Hipparcos astrometry mission was accepted within the European Space Agency's scientific programme in 1980. The Hipparcos satellite was designed and constructed under ESA responsibility by a European industrial consortium led by Matra Marconi Space (France) and Alenia Spazio (Italy), and launched by Ariane 4 flight V33 on 8 August 1989. High-quality scientific data were acquired between November 1989 and March 1993, and communications with the satellite were terminated on 15 August 1993. The Hipparcos and Tycho Catalogues, representing the most accurate and comprehensive astrometric and photometric star catalogues compiled to date, were finalised within three years of the end of the satellite operations—almost exactly corresponding to the schedule anticipated by the scientific consortia before the satellite launch. All of the scientific goals motivating the mission's adoption in 1980 were surpassed.

An enormous effort—scientific, technical, and managerial—was devoted to the satellite design, construction, testing and calibration, in a commitment extending over approximately eight years; in parallel, teams of European scientists worked closely with ESA to prepare a complex chain of computer programs ready to process nearly 1000 Gbits of satellite data in what amounted to the largest single data analysis problem ever undertaken in astronomy.

Ultimate success was not easily won. After a nominal launch, the failure of the apogee boost motor left the satellite in an unplanned, highly eccentric geostationary transfer orbit. A mission which was designed to have a single ground station, operated in a geostationary orbit for 24 hours a day, turned out instead to consist of a satellite in contact with the ground station for less than 10 hours a day, repeatedly crossing the harsh radiation environment of the van Allen belts. Further ground stations were brought into the telecommunications network. ESOC, in collaboration with Matra Marconi Space, developed new operational procedures to accommodate the new orbit, the revised data to be sent to the scientific data reduction groups, and contingency procedures to maintain the flow of scientific data. The payload and spacecraft subsystems all worked within their design specifications, the satellite was eventually operated for more than the 2.5 years nominal mission duration, and scientific data of extremely high quality were acquired.

This volume is intended as a detailed description of the manner in which the scientific data were collected. In addition, it provides a summary of the satellite and payload performances, and a record of the technological investigations and resulting knowledge derived from the operation of the Hipparcos satellite. It includes details of the major spacecraft and payload subsystems, the radiation environment, understanding of the payload evolution, perturbing torques acting on the satellite, and details of the development of two- and zero-gyro operational procedures implemented as gyro failures threatened to terminate operations prematurely.

The material in this volume has been based on the pre-launch technical description, published in 1989 as ESA SP-1111 Volume I, combined with the ESOC Operations Report produced by the Operations Team at the end of the mission. Significant parts of the report are taken from the Matra Marconi Space 'In-Orbit Performance Verification Report' prepared under ESA contract. Other material was taken from technical notes compiled throughout the satellite operations phase.

Significant additional material was included as follows:

- material in Chapter 5 is based on Davies, P.E. & McDonald, A.J.C., 1991 *Results of the Hipparcos In-Orbit Payload Calibration*, Journal of the British Interplanetary Society, Vol. 44, 37;

- material in Chapter 7 is based on Crabb, R.L., 1994 *Solar cell radiation damage*, Radiat. Phys. Chem. 43, 93–103; Nieminen, P.J., 1995 *Standard radiation environment monitor detector design and simulations*, ESTEC Working Paper 1829; Section 7.4 is from Daly, E.J. et al., 1994 *Radiation-belt and transient solar-magnetospheric effects on Hipparcos radiation background*, IEEE Trans. Nucl. Sci. NS-41, 6, 2376;

- parts of Chapter 10 are from Lindegren, L. et al., 1992 *Geometrical stability and evolution of the Hipparcos telescope*, Astronomy & Astrophysics, 258, 35, and updated by L. Lindegren and F. van Leeuwen;

- material in Chapter 11 was taken from Crabb, R.L. & Robben, A.P., 1993 *In-flight Hipparcos solar array performance degradation after three and a half years*, Proc. European Space Power Conference, Graz, Austria, ESTEC/XPG-WPP-054;

- parts of Chapter 14 were taken from Batten, A.J. & McDonald, A.J.C., 1989, *Hipparcos precise attitude determination: methods and results*, Int. Symp. Space Dynamics, Toulouse, France;

- material in Chapter 15 is based on Auburn, J.H.C., Batten, A.J. & McDonald, A.J.C., 1991 *Hipparcos attitude determination with two gyros and a star mapper*, Proc. 3rd International Symp. Spacecraft Flight Dynamics, Darmstadt, Germany, ESA SP-326, 213.

The composition of the ESA-ESOC Launch and Operations Teams are given in Appendix A to this volume. The key personnel involved from Matra Marconi Space (the satellite Prime Contractor) and Alenia Spazio (responsible for the spacecraft and for the satellite integration), along with the industrial sub-contractors, are given in Volume 1. Detailed acknowledgments are also included in Volume 1.

The Bibliography covers all aspects of the Hipparcos mission published up until 1996, including scientific papers referring to the construction of the Hipparcos Input Catalogue and to the data analysis tasks, and published progress reports, in both refereed journals, conference proceedings, and the popular press.

We take this opportunity to attribute the overall success of ESA's Hipparcos space astrometry mission to the scientific and political groups who encouraged and supported the possibilities of space astrometry from the project's origins in 1967 through to the ESA advisory structure which ultimately ensured its completion; to the ESA Project Team which supervised all technical aspects; to European industry under the leadership of Matra Marconi Space and Alenia Spazio which turned concept into reality; to the ESOC Operations Team for meeting a seemingly impossible challenge of maintaining satellite operations for more than three years; and to the Hipparcos scientific teams for their relentless pursuit of milliarcsec astrometry.

M.A.C. Perryman, Hipparcos Project Scientist
D. Heger, Hipparcos Spacecraft Operations Manager